International Journal of Plant & Soil Science

Volume 36, Issue 5, Page 173-181, 2024; Article no.IJPSS.113779
ISSN: 2320-7035

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

N. M. Vasava [a++*], J. C. Shroff [b#], S. N. Shah [c†], P. M. Parmar [d‡] and M. P. Dohat [e^]

[a] *College of Agriculture, Vaso, Anand Agricultural University, Anand, Gujarat, India.*
[b] *Department of Agronomy, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India.*
[c] *Anand Agricultural University, Anand, Gujarat, India.*
[d] *Soil Testing Laboratory, Bhavnagar, Gujarat, India.*
[e] *College of Agriculture, Anand Agricultural University, Vaso, Gujarat, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2024/v36i54514

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here:
https://www.sdiarticle5.com/review-history/113779

Original Research Article

Received: 10/01/2024
Accepted: 15/03/2024
Published: 21/03/2024

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

[++] *Agriculture Officer;*
[#] *Associate Professor;*
[†] *Associate Directorate of Research;*
[‡] *Agriculture Officer (Class II);*
[^] *Assistant Professor;*
**Corresponding author: E-mail: Vasavanil55@gmail.com;*

factors responsible for lack of productivity of linseed including crop failure. Therefore increasing productivity and 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.*; T_1: sole chickpea, T_2: sole linseed, T_3: sole fenugreek, T_4: (chickpea + linseed 2:1), T_5: (chickpea + linseed 3:1), T_6: (chickpea + linseed 4:2), T_7: (chickpea + fenugreek 2:1), T_8: (chickpea + fenugreek 3:1) and T_9: (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 (Days after sowing) and at harvest was found significantly higher under treatment T_2 (sole linseed) during the both years as well as in pooled results. Furthermore treatment T_2 (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 T_4 (chickpea + linseed 2:1) during both the years. Maximum seed yield of linseed was obtained under treatment T_2 (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 T_4 (chickpea + linseed 2:1). While the highest straw yield and harvest index of linseed was obtained in treatment T_2 (sole linseed) during the year 2019-2020, 2020-21 and in pooled results. Treatment T_2 (sole linseed) gave the highest crude protein (%) and oil content (%) during the both years as well as pooled results.

Keywords: Intercropping; linseed; chickpea growth; yield; quality; chickpea; plant height; fenugreek; seed yield.

1. INTRODUCTION

"In today's agriculture diversification and intensification of crop and their combination and sequence both in space and time is necessary. Present food base has been narrowed down coupled with the effect of climate change making it prone to frequent crop failures. As an alternative, Intercropping with adoptable and remunerative crops and their species allows crops to perform in a better way to mitigate the risk of crop failure. 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" [1]

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 nowadays. 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.

"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" [2]. "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" [3].

"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". [2]. "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 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 %). In India, it is cultivated in area of 197 thousand hectares producing 126 thousand tones with average productivity of 642 kg/ha" [2]. 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 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.*; T_1: sole chickpea, T_2: sole linseed, T_3: sole fenugreek, T_4: (chickpea + linseed 2:1), T_5: (chickpea + linseed 3:1),T_6: (chickpea + linseed 4:2), T_7: (chickpea + fenugreek 2:1), T_8: (chickpea + fenugreek 3:1) and T_9: (chickpea + fenugreek 4:2) with four replication. Each plot measured (32.4 m^2), with dimensions of 6 m in length and 5.4 m in width. All the essential cultural operations like cross cultivation, planking, opening of furrows etc. were carried out by tractor in experimental field. After removal of residues of previous crop along with weeds, the experimental field was prepared for sowing with tractor drawn cultivar followed by harrowing and smoothened by planking. Fertilizers were applied according to the recommended doses for specific crops, Chickpea (20:40:00), Linseed (60:30:00) and Fenugreek (20:40:00 kg ha^{-1}). As per recommended practices the crop was fertilized with nitrogen in split application in linseed only wherein, half dose of nitrogen *i.e.* 30 kg nitrogen/ha full dose of phosphorous was uniformly applied in furrow before sowing. Remaining 30 kg N was applied to linseed at 30 DAS (). While in chickpea and fenugreek, entire quantity of nitrogen (20 kg/ha) and phosphorus (40 kg/ha) was applied uniformly in previously opened furrows. In all the crops, nitrogen and phosphorus were applied in the form of urea and di-ammonium phosphate, respectively. Seeds were sown by drilling method at a depth of 3 to 4 cm, keeping inter row spacing of 30 cm in each treatment. Recommended rate of seed *i.e.* 60, 25 and 20 kg/ha were used for chickpea, linseed and fenugreek, respectively according to the area occupied by respective crop in particular treatment. Maintained equal plant population in all the plots by keeping 10 cm distance between plant to plant in each row. The data collected during the experimental period and after harvest of the experiment was statistically analysed employing the following statistical techniques given by [4].

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 (T_2) 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 T_2 (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 T_4 (chickpea + linseed 2:1) and T_6 (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 by Tuti *et al.* [5] under lentil and toria intercropping with wheat and Malik *et al.* [6] under pigeon pea and mungbean intercropping system.

3.1.2 Number of branches/plant

There was non-significant effect of different intercropping systems that was noticed with respect to number of branches per plant at 30 DAS during 2019-20, 2020-21 as well as in pooled results (Table 1). At 60 DAS, 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 and no significant difference with treatment T_2. The higher number of branches per plant of linseed probably due to rapid initial growth 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. [7], Poddar et al. [8], Singh et al. [9], Priya et al. [10] and Ramarao et al. [11].

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. The present findings are in agreement with results of Tanwer *et al.* [12] and Pandit [3]. 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 (Table 2). 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. These findings confirmed with the observation of Alam [13].

3.2.3 Test weight of linseed

The data presented in Table 2 showed that different intercropping systems did not influence 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. [14], Tanwar et al. [12], Poddar et al. [8] and Singh et al. [15].

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

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

Treatments	Plant height (cm)									Number of branches/plant								
	At 30 DAS			At 60 DAS			At harvest			At 30 DAS			At 60 DAS			At harvest		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Intercropping system																		
T_2: Sole linseed	17.71	17.57	17.64	60.15	57.91	59.03	68.79	66.84	67.81	5.28	5.19	5.23	11.83	11.98	11.91	12.56	12.36	12.46
T_4: Chickpea + linseed 2:1	17.30	17.48	17.39	59.73	55.89	57.81	66.83	64.25	65.54	5.21	5.17	5.19	11.58	10.83	11.20	12.09	11.29	11.69
T_5: Chickpea + linseed 3:1	16.83	16.29	16.56	56.98	53.52	55.25	58.29	56.13	57.21	5.01	5.15	5.08	9.83	9.41	9.63	9.88	9.74	9.81
T_6: Chickpea + linseed 4:2	17.21	17.04	17.12	58.99	55.88	57.43	65.57	63.04	64.30	5.10	5.14	5.12	10.16	10.25	10.20	10.93	10.98	10.95
SEm±	0.84	0.78	0.54	2.88	2.08	1.65	2.05	2.19	1.39	0.28	0.26	0.18	0.45	0.44	0.31	0.55	0.47	0.36
CD (P=0.05)	NS	NS	NS	NS	NS	NS	6.56	7.02	4.09	NS	NS	NS	1.44	1.41	0.89	1.76	1.51	1.01
Y effect	--	--	NS	--	--	NS	--	--	NS	--	--	NS	--	--	NS	--	--	NS
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 2. Yield attributes, and Yield of linseed

Treatments	Number of capsules/plant			Number of seeds/capsule			Test Weight			Seed yield (kg/ha)			Straw yield (kg/ha)			Harvest Index (%)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Intercropping system																		
T_2: Sole linseed	53.21	50.30	51.75	6.69	6.65	6.67	7.65	7.60	7.63	1600	1576	1588	2815	2787	2801	36.24	36.13	36.19
T_4: Chickpea + linseed 2:1	49.00	48.15	48.57	6.60	6.48	6.54	7.61	7.50	7.56	869	860	869	2061	2082	2072	29.29	29.45	29.37
T_5: Chickpea + linseed 3:1	43.25	43.20	43.22	6.46	6.30	6.38	7.45	7.36	7.41	754	728	754	1714	1818	1766	29.05	29.30	29.18
T_6: Chickpea + linseed 4:2	47.00	45.95	46.47	6.51	6.41	6.46	7.53	7.43	7.48	821	820	821	2020	2046	2033	28.68	28.66	28.67
SEm±	1.73	1.46	1.08	0.23	0.29	0.18	0.37	0.26	0.22	45	33	27	98	78	59	0.61	0.39	0.39
CD (P=0.05)	5.55	4.68	3.16	NS	NS	NS	NS	NS	NS	145	105	78	314	250	174	1.97	1.24	0.99
Y effect	--	--	NS	--	--	NS	--	--	NS	--	--	NS	--	--	NS	--	--	NS
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

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

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 T_4 however, it did not differ statistical over treatment T_6.The lowest seed yield in comparison to treatment T_2 was observed under the treatment T_5 (702, 754 and 728 kg/ha) during both the years and on pooled basis, respectively. Similar results were also founded by Kalaghatagi et al*.* [16], Meena et al. [17], Gupta et al. [18] and Borad [19].

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 T_2 (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 T_5 (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 T_4 to the extent of 17.32 and 1.91 per cent over treatment T_5 and T_6 on pooled basis respectively. The results are in conformity with those of Ahlawat *et al.* [14], Meena *et al.* [17] and Gupta *et al.* [18].

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 T_2 (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 T_6 (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 (T_2) 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 T_5 (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 (Table 3). Although, numerical higher value of oil content (36.37, 36.16 and 36.26 %) was recorded under treatment T_2 (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 T_5 (chickpea + linseed 3:1) during the year 2019-20, 2020-21 and pooled analysis, respectively. The present findings are in agreement with results of Amonge et al. [20] and Gangadhar et al [21,22].

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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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