Original Research Article

Effect of Legume-Legume Replacement Series of Intercropping System on Growth, Yield and Quality of Chickpea

ABSTRACT

Chickpea is major pulse crop cultivated in India. Area under chickpea cultivation has been increasing day by day. Although area of chickpea is increasing still the productivity per unit area is not increasing. There are many factor responsible for lack of productivity including crop failure. There for increasing productivity and for avoiding the risk associated with complete crop failure intercropping is the way forward. A field experiment was conducted at College Agronomy Farm, Anand Agricultural University, Anand, Gujarat during two consecutive *rabi* season of the year 2019-2020 and 2020-2021.The experiment was laid out in Randomized Block Design (RBD), consisting of nine treatment. *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. Legume intercropping resulted in better growth due to complimentary actions of the both the crop. The total equivalent yield obtained from intercropping far surpasses the yield of the sole crop in unit area.

Key Words: *Intercropping; Legume; Growth; Yield; Chickpea*

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.

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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.

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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 that the productivity of the base crop is least affected by the associated crop and the production per unit area is also increased. Fenugreek is an important multipurpose *rabi* season crop. The area under fenugreek cultivation in Gujarat is 9.01 thousand hectares with a production of 16.95 thousand MT and average productivity of 1.88 MT/hectare (Anon., 2022). Shortages of vegetables in country have focused the attention on intercropping systems which have capacity to improve the physical, biological and chemical properties of soils and gets promising for higher productivity and profitability. Proper combination of crop is very important in intercropping.

2. MATERIALS AND METHODS

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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), the 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.

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).~~

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3. RESULTS AND DISCUSSION

3.1. Growth attributes

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.

A perusal of mean data results revealed that plant height increased with advancement of crop growth and development. The data presented in Table 1 indicated that during the years 2019-20 and 2020-21 as well as on pooled base analysis, the intercropping and their row ratio failed to affect the plant height of chickpea measured at 30 and 60 DAS. However, treatment T_1 (sole chickpea) recorded numerically higher plant height of 22.57, 22.23 and 22.40 cm at 30 DAS and 42.63, 42.36 and 42.49 cm at 60 DAS during the first, second year and on pooled basis, respectively.

The significant difference in plant height was observed at harvest during both the years as well as in pooled results (Table 1). Significantly higher plant height of 53.27, 52.46 and 52.86 cm was recorded under treatment T_1 (sole chickpea) during first and second year as well as on pooled basis, respectively but it was failed to prove its significant superiority over treatment T_5 (chickpea + linseed 3:1) and T_8 (chickpea + fenugreek 3:1) during individual year and pooled results.

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. Similar, results were reported by Ahlawat *et al.* (2005) under production potential of chickpea based intercropping systems and Borad (2021) in production potential and economics of chickpea (*Cicer arietinum* L.) based intercropping system under irrigated condition.

3.1.2 Number of nodules/plant

The results presented in Table 1 showed that different treatments have significant influence on number of nodules per plant of chickpea recorded at 35 DAS and treatment T_1 (sole chickpea) recorded significantly the highest number of nodules per plant.

3.1.3 Number of Branches/Plant

An examination of data (Table 2) indicated that different intercropping systems did not showed their significant influence on the number of branches/plant recorded at 30 DAS during both the years however, in pool data, treatment T_1 (sole chickpea) recorded significantly higher number of branches/plant (3.69/plant) and it was at par with treatment T_5 (3.44/plant) and T_8 (3.65/plant).

Further, treatment T_6 (chickpea + linseed 4:2) lagged behind all the treatments and recorded significantly lower number of branches/plant at 30 DAS (3.07/plant) in pooled analysis.

It is evident from the data that, number of branches per plant recorded at 60 DAS was significantly influenced by different treatments. Data presented in Table 2 clearly indicated that significantly higher the number of branches/plant (7.14, 6.84 and 6.99/plant) was recorded under treatment T_1 (sole chickpea) during first, second year as well as on pooled results, respectively. However, treatment T_5 (chickpea + linseed 3:1) and T_8 (chickpea + fenugreek 3:1) was found at par with treatment T_1 (sole chickpea) and recorded 6.33, 6.27 and 6.71, 6.41 number of branches per plant at 60 DAS during both years while only treatment T_8 (chickpea + fenugreek 3:1) was statistically found at par with treatment T_1 (sole chickpea) with 6.56 number of branches per plant at 60 DAS in pooled results.

An appraisal of data regarding number of branches per plant at harvest presented in Table 2 showed that, significantly higher number of branches per plant of 7.74, 7.60 and 7.67 was noted under treatment T_1 (sole chickpea) during 2019-20, 2020-21 and in pooled analysis, respectively. However, treatments T_5 (chickpea + linseed 3:1) and T_8 (chickpea + fenugreek 3:1) was found statistically at par with treatment T_1 (sole chickpea) during first and second year, while in pooled results treatment T_1 (sole chickpea) was superior over rest of treatments.

Treatment T_6 (chickpea + linseed 4:2) resulted in lower number of branches per plant as compared to other intercropping systems which might be owing to the variations in the magnitude of competition among the component crops grown in various proportions. These results are in conformity with Tanwar *et al.* (2011) and Ramarao *et al.* (2020).

3.2 Yield attributes and yield

3.2.1 Pods per plant

An appraisal of data presented in Table 2 indicated that significantly higher number of pods per plant was recorded in sole chickpea which might be due to no competition from intercrops. Further, treatment T_1 was statistically at par with treatment T_5 (chickpea + linseed 3:1) and treatment T_8 (chickpea + fenugreek 3:1) during both the cropping seasons and in pooled analysis with respect to number of pods/plant. Significantly the least number of pods/plant was recorded in treatment T_6 (chickpea + linseed 4:2) during both the years and in pooled results. The higher number of pods per plant of chickpea may be due to complementary effect of fenugreek on chickpea for growth resources. The present findings are in agreement with results of Ahlawat *et al.* (2005), Poddar *et al.* (2013), Priya *et al.* (2020) and Borad (2021).

3.2.2 Seeds/Pod

An appraisal of data presented in Table 3 indicated that different row ratio on intercropping systems had significantly influenced number of seeds/pod in both the years as well as in pooled analysis.

Sole chickpea (T_1) being at par with chickpea + fenugreek 3:1 (T_8) and recorded significantly higher number of seeds/pod (1.90, 1.85 and 1.88/pod) during the year 2019-20, 2020-21 and on pooled analysis, respectively. While treatment T_5 (chickpea + linseed 3:1) was also found at par during first and second year. Significantly lower number seeds/pod was recorded under treatment T_6 (chickpea + linseed 4:2) during both the years and in pooled data.

3.2.3 Seed yield (kg/ha)

Seed yield of chickpea as influenced by different intercropping systems are presented in Table 3.

It is evident from the data (Table 3) that there was significant impact of different intercropping systems was noticed on seed yield of chickpea. Among all the treatments, treatment T_1 (sole chickpea) was found significantly superior over the rest of the treatments and recorded 2033,2015 and 2024 kg/ha seed yield of chickpea during the year 2019-20, 2020-21 and on pooled analysis, respectively. The higher yield under said treatment might be due to no competition effect, higher number of pods per plant and higher 1000-seed weight as evident from the results presented in respective Table 3 which influenced on increased in seed yield of chickpea.

Further, it was observed that treatment T_8 stood on second position and registered 238,47,361,259 and 324 kg/ha higher seed yield compared to treatments T_4, T_5, T_6, T_7 and T_9 respectively on the basis of pooled analysis. The percent increase in seed yield under treatment T_8 was to the tune of 21.75, 3.65, 37.17, 24.13 and 32.14 pooled basis per cent over the treatment T_4, T_5, T_6, T_7 and T_9, respectively.

These results are closely related to the findings of Ahlawat *et al.* (2005), Poddar *et al.* (2013),Meena *et al.* (2018) and Borad (2021).

3.2.4 Stover yield (kg/ha)

Stover yield recorded after harvest of the chickpea as influenced by intercropping systems are presented in Table 3.

Results revealed that intercropping systems significantly influence stover yield of chickpea and treatment T_1 (sole chickpea) recorded significantly the highest stover yield of 2611, 2587 and 2599 kg/ha during the both the years as well as on pooled basis respectively. Treatment T_8 stood second position with producing 1919 kg/ha stover yield and remained at par with treatment T_5 which recorded stover yield of 1866 kg/ha during the pooled results. Significantly lower stover yield of 1490, 1494 and 1492 kg/ha were recorded under treatment T_6 (chickpea + linseed 4:2) during the year 2019-20, 2020-21 and pooled result, respectively.

Sole chickpea recorded significantly higher stover yield which might be due to significantly higher plant population of chickpea per unit area as compared to plant population under chickpea intercropped with linseed and fenugreek due to replacement series (2:1, 3:1 and 4:2) of intercropping system. Similar results were also examined by Ahlawat *et al.* (2005), Yadav (2005), Poddar *et al.* (2013) and Meena *et al.* (2018).

3.3 Quality Parameter

3.3.1 Crude protein content of seed (%)

Data regarding crude protein content of chickpea as influenced by different intercropping treatment for the year 2019-20, 2020-21 and in pooled results are presented in Table 3.

Result revealed that different treatments of intercropping systems did not exert any significant variation on crude protein content of chickpea analysed during 2019-20, 2020-21 and on pooled basis. However, numerically higher crude protein content of 21.41, 21.02 and 21.21% was recorded under treatment T_1 (sole chickpea) in both the years and in pooled results, respectively. Further, numerically lower protein content of 18.84, 19.07 and 18.95% was recorded under the treatment T_6

(chickpea + linseed 4:2) during individual years and in pooled analysis, respectively. These results are supported by the findings of Amonge *et al.* (2013) and Mahfouz *et al.* (2017).

3.4 CONCLUSION

On the basis of two year field experimentations, it is concluded that growing of chickpea with fenugreek in either 4:2 or 3:1 or 2:1 row ratio produced higher chickpea equivalent yield, land equivalent ratio and economics in terms of gross returns, net returns and B:C under chickpea based intercropping system. However, growing of fenugreek with chickpea showed more compatibility and there was less competition and less adverse effect of fenugreek on chickpea.

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Treatments	Plant height (cm)									Number of nodules/ plant at 35 DAS		
	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
Intercropping system												
T_1: Sole Chickpea	22.57	22.23	22.40	42.63	42.36	42.49	53.27	52.46	52.86	11.20	11.49	11.34
T_2: Sole Linseed	--	--	--	--	--	--	--	--	--	--	--	--
T_3: Sole Fenugreek	--	--	--	--	--	--	--	--	--	--	--	--

Table 1: Plant height and number of nodules/plant of chickpea

T_4: Chickpea + Linseed (2:1)	21.97	21.37	21.67	40.67	40.34	40.50	47.81	47.53	47.68	8.75	9.10	8.93
T_5: Chickpea + Linseed (3:1)	22.12	21.52	21.82	41.73	41.41	41.57	51.77	50.52	51.14	9.15	9.43	9.29
T_6: Chickpea + Linseed (4:2)	21.52	20.92	21.22	39.38	39.21	39.30	46.12	45.97	46.04	8.23	8.70	8.46
T_7: Chickpea + Fenugreek (2:1)	21.96	21.20	21.58	39.57	39.31	39.44	46.93	46.77	46.85	8.45	9.01	8.73
T_8: Chickpea + Fenugreek (3:1)	22.39	21.31	21.35	41.82	41.56	41.69	52.26	51.53	51.89	9.45	9.70	9.58
T_9: Chickpea + Fenugreek (4:2)	22.05	21.49	21.77	40.86	40.46	40.66	47.43	47.58	47.50	8.40	8.85	8.63
SEm±	0.90	0.92	0.60	1.65	1.87	1.55	1.75	1.50	1.15	0.33	0.37	0.25
CD (*P* = .05)	NS	NS	NS	NS	NS	NS	5.22	4.48	3.32	1.00	1.09	0.71
Year effect	--	--	NS	--	--	NS	--	--	NS	--	--	NS
CV %	8.12	8.51	8.31	8.07	9.20	8.65	7.12	6.17	6.67	7.46	7.77	7.62

Table 2: Number of branches/plant and number of pods/plant of chickpea

Treatments	Number of branches/plant									Number of Pods/plant		
	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
Intercropping system												
T_1: Sole Chickpea	3.83	3.54	3.69	7.14	6.84	6.99	7.74	7.60	7.67	64.45	62.95	63.70
T_2: Sole Linseed	--	--	--	--	--	--	--	--	--	--	--	--
T_3: Sole Fenugreek	--	--	--	--	--	--	--	--	--	--	--	--
T_4: Chickpea + Linseed (2:1)	3.24	3.13	3.18	6.16	5.68	5.92	6.78	6.54	6.66	56.33	54.35	55.34
T_5: Chickpea + Linseed (3:1)	3.52	3.36	3.44	6.33	6.27	6.30	7.10	6.90	7.00	62.75	60.20	61.48
T_6: Chickpea + Linseed (4:2)	3.11	3.03	3.07	5.11	4.71	4.91	6.40	6.00	6.20	39.30	36.60	37.95
T_7: Chickpea + Fenugreek (2:1)	3.20	3.06	3.13	5.58	5.55	5.56	6.56	6.56	6.56	54.85	50.65	52.75
T_8: Chickpea + Fenugreek (3:1)	3.76	3.54	3.65	6.71	6.41	6.56	7.21	7.05	7.13	63.25	60.50	61.88
T_9: Chickpea + Fenugreek (4:2)	3.28	3.15	3.22	5.23	5.32	5.27	6.55	6.31	6.43	54.20	54.23	54.21
SEm±	0.18	0.16	0.12	0.31	0.26	0.20	0.22	0.32	0.19	2.63	2.38	1.66
CD (*P* = .05)	NS	NS	0.32	0.93	0.78	0.55	0.65	0.95	0.52	7.80	7.07	5.08
Year effect	--	--	NS	--	--	NS	--	--	NS	--	--	NS
CV %	10.61	9.88	10.27	10.38	9.07	9.77	6.29	9.55	8.05	9.31	8.78	9.06

Table 3: Yield and Quality parameters of chickpea

Treatments	Number of seeds/pod			Seed yield (Kg/ha)			Stover Yield (Kg/ha)			Crude protein content in seed		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Intercropping system												
T_1: Sole Chickpea	1.90	1.85	1.88	2033	2015	2024	2611	2587	2599	21.41	21.02	21.21
T_2: Sole Linseed	--	--	--	--	--	--	--	--	--	--	--	--
T_3: Sole Fenugreek	--	--	--	--	--	--	--	--	--	--	--	--
T_4: Chickpea + Linseed (2:1)	1.60	1.60	1.60	1141	1047	1094	1640	1631	1636	20.17	20.07	20.12
T_5: Chickpea + Linseed (3:1)	1.75	1.70	1.73	1324	1246	1285	1890	1841	1866	20.57	20.19	20.38
T_6: Chickpea + Linseed (4:2)	1.35	1.25	1.30	1007	935	971	1490	1494	1492	18.84	19.07	18.95
T_7: Chickpea + Fenugreek (2:1)	1.55	1.50	1.53	1054	1091	1073	1593	1606	1600	20.05	19.20	19.62
T_8: Chickpea + Fenugreek (3:1)	1.85	1.80	1.83	1371	1292	1332	1932	1906	1919	20.65	20.63	20.64
T_9: Chickpea + Fenugreek (4:2)	1.50	1.50	1.50	1030	986	1008	1524	1519	1522	20.50	20.12	20.31
SEm±	0.08	0.07	0.05	45	47	31	73	57	43	0.92	0.84	0.58
CD (*P* = .05)	0.22	0.21	0.14	135	140	90	216	171	132	NS	NS	NS
Year effect	--	--	NS	--	--	NS	--	--	NS	--	--	NS
CV %	9.20	8.73	8.98	7.08	7.65	7.36	8.03	6.39	7.26	9.08	8.43	8.77