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

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Authors' contributions

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

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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. Therefore, increasing productivity and for avoiding the risk associated with complete crop failure,

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intercropping is the way forward. Intercropping of legume in association with non-legumes helps in utilization of nitrogen being fixed by legumes in the current growing season, but also helps in residual build-up of nutrients in soil. Best utilization of nutrients, moisture, space and solar energy can be derived through intercropping system. Intercropping provides an insurance against calamities and helps in the maximization of productivity and profit by efficient utilization of natural resources. Hence, crop intensification is both in space and time dimensions. Selection of compatible genotype and appropriate planting pattern helps in minimizing the inter-specific and intra-specific competition for resources thereby boosting up the productivity of the system as a whole. Therefore, a field experiment was conducted at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat during two consecutive *rabi* season of the year 2019-20 and 2020-21. 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.

Keywords: 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 [1].

Intercropping encompasses two or more crop species/varieties grown together in distinct row combinations simultaneously on the same piece of land at 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 [2].

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 [3].

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 [4]. 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 [5].

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 [4]. 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 [4]. 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

2.1 Experimental Site

In order to achieve the pre-determined objectives of the present investigations, a field experiment on chickpea based intercropping systems was conducted during the *rabi* season of the year 2019-20 and 2020-21 in plot no.12 at College Agronomy farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat.

2.2 Climate and Weather Conditions

Geographically, Anand is situated at 22˚-35' N latitude and 72˚-55' E longitude with an altitude of 45.1 m above mean sea level. Anand is about 70 km away from Arabian Sea coast and hence, the climate of this region is semi-arid and subtropical (Fig. 1). Monsoon generally starts from the third week of June and retreats by the middle of September with an average annual rainfall of 880 mm, which is realized entirely from the South-West monsoon currents. July and August are the months of heavy precipitation. Practically, there is no rainfall in winter and summer seasons in almost all the parts of Gujarat except, sporadic showers in *rabi* season. Winter is fairly cold and sets in the month of November and continues till the middle of February. Summer is fairly hot and dry, which commence from mid of February and ends by the month of June. May is the hottest month with the mean temperature around 40^0 C.

2.3 Weather during Experimental Period

The observations of the meteorological parameters during the year (2019-20 and 2020-21) the period of investigations was recorded at the Meteorological Observatory of Anand Agricultural University, Anand, Gujarat and are presented in graphically depicted in Fig. 2 and 3, respectively.

2.4 Soil Characteristics

The characteristics of soil play a pivotal role in shaping plant growth and, consequently, the overall yield. The experimental field's soil is at categorized as loamy sand, with the following precise measurements: pH (7.35), EC (0.13 dsm^{-1}), Organic Carbon (0.22%), available nitrogen (171 kg ha^{-1}), P_2O_5 (38 kg ha^{-1}) and K_2O (225 kg ha^{-1}).

2.5 Experimental Details and Crop's Varieties

A field experiment conducted using Randomized Block Design with four replications. There were nine treatments combinations namely 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). Each plot measured (32.4 m^2), with dimensions of 6 m in length and 5.4 m in width.

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.

2.6 Agronomical Practices Adopted

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.

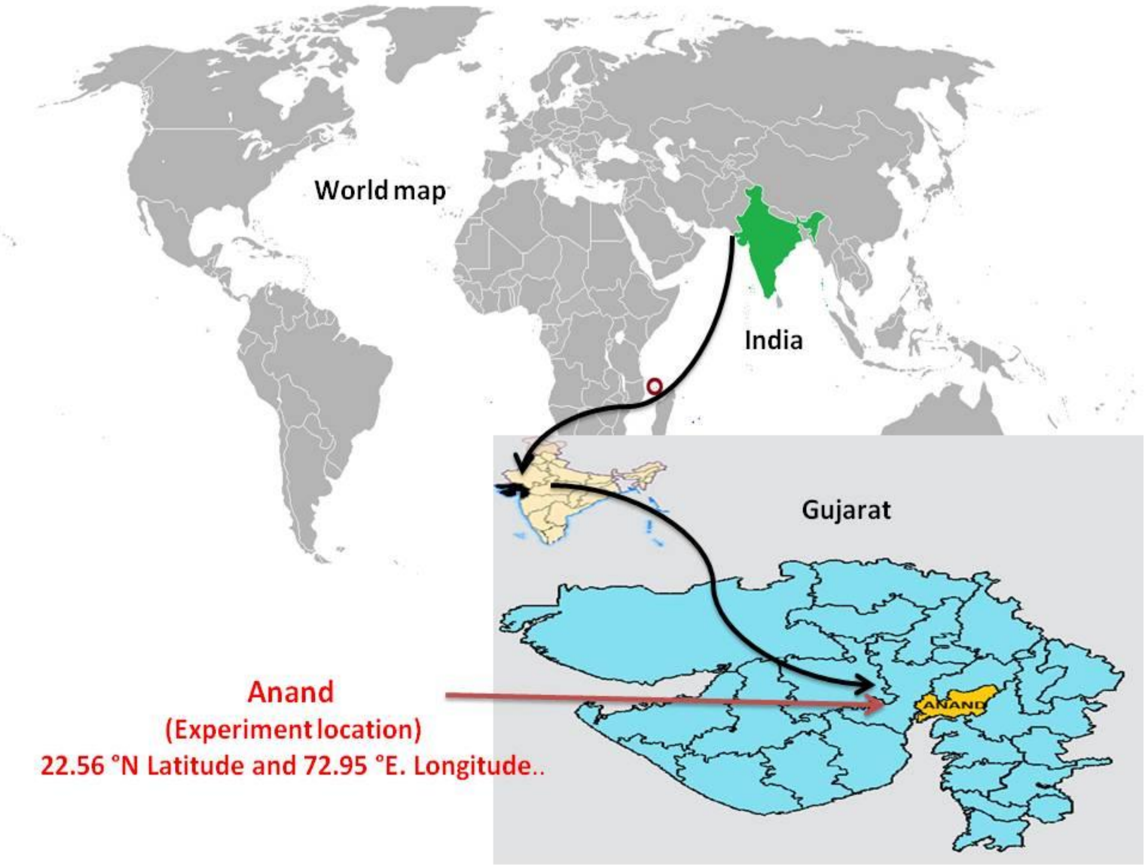

Fig. 1. Location map of study area

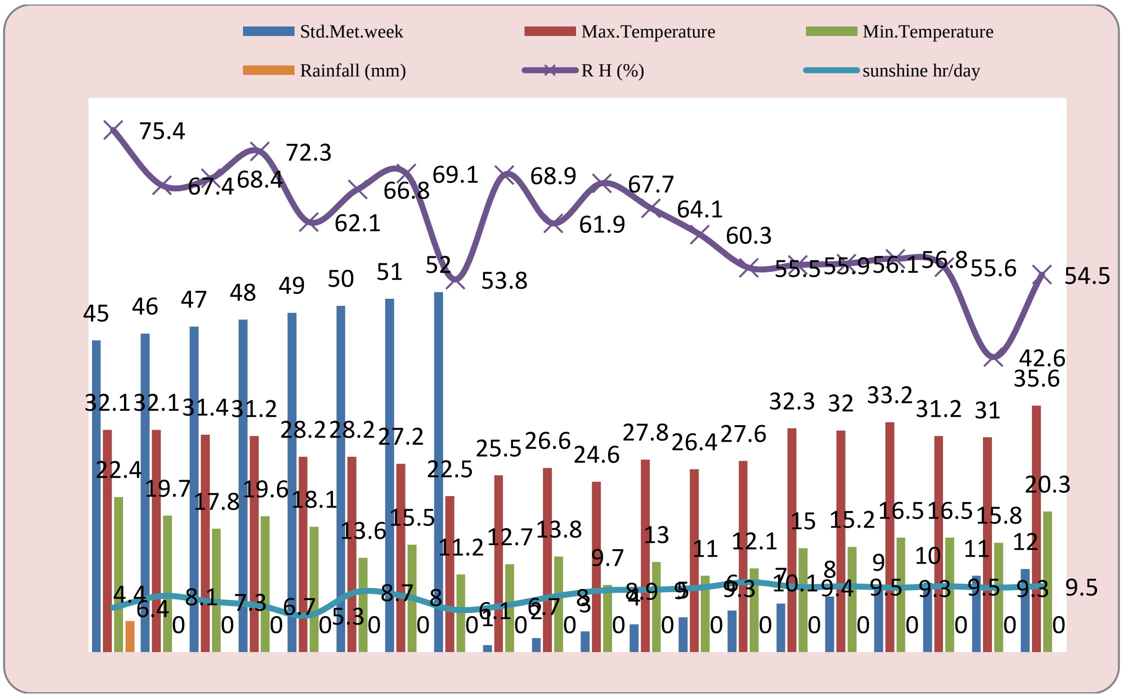

Fig. 2. Mean weekly weather parameters recorded during crop seasons of the year 2019-20

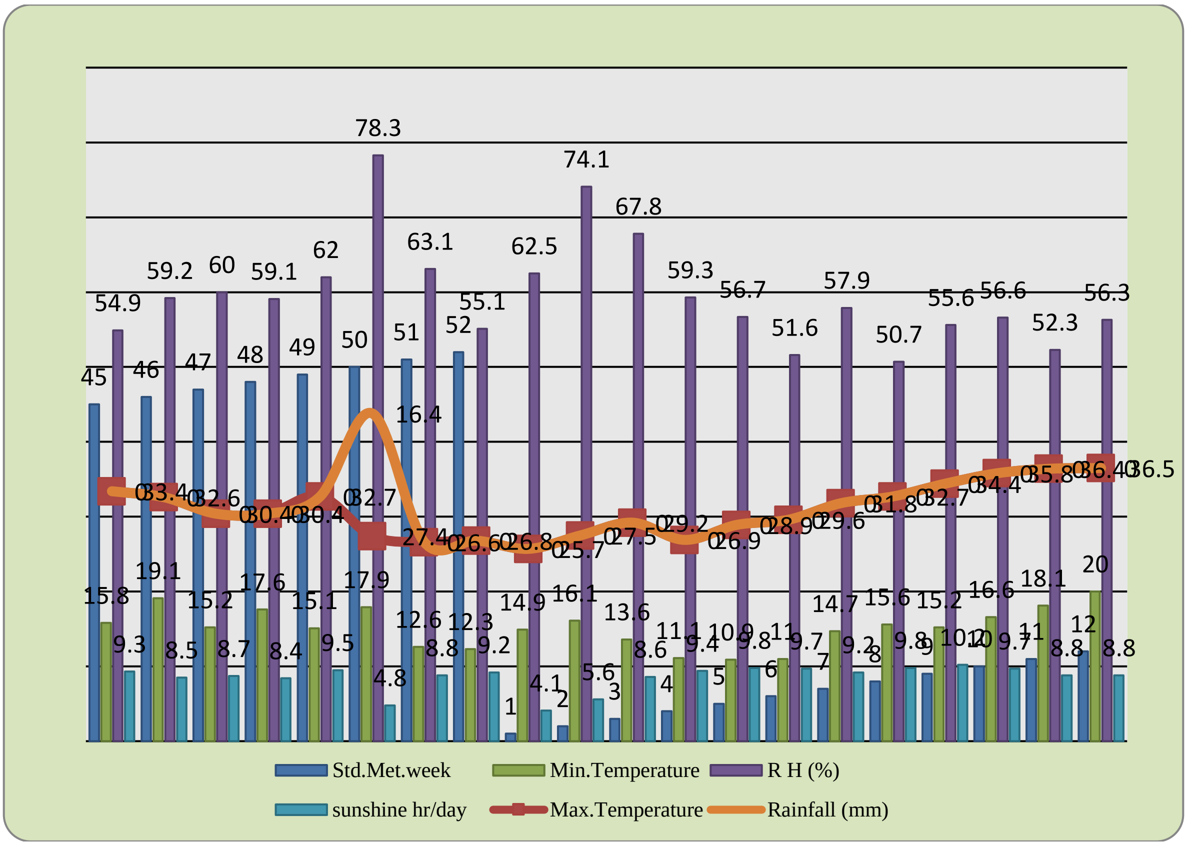

Fig. 3. Mean weekly weather parameters recorded during the crop seasons of the year 2020-21

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. Thinning operation was done at 15 days after sowing during both the years of experimentation. Maintained equal plant population in all the plots by keeping 10 cm distance between plant to plant in each row. Pre-emergence application of pendimethalin 30 % EC 750 g a.i./ha was sprayed one day after sowing to control the weeds. Further, one interculturing followed by hand weeding were done at 30 DAS during both the years to keep the experimental field free from weeds. The total five irrigation at 1st year and four irrigation at 2nd year was given at 15 days interval. The linseed and fenugreek crops were affected by the incidence of leaf spot and sucking pests, respectively. Adequate plant protection measures were taken when incidence of pest and disease reach above ETL by spraying of fungicide (Carbendazim 50% WP, 250 a.i./ha, 500 g/ha) and insecticide (Thiamethoxam 25 % WG, 50 a.i./ha, 200 g/ha) to check the damage. When the plant showed the maturity symptoms, border line area (three rows each from both sides of plot and 0.5 m length on both sides of plot) were harvested first and removed from the experimental plot. Then five randomly selected plants (previously tagged) from each net plot were harvested for recording necessary biometric (growth) observations and produce of these plants were added to respective net plot later on. Finally, net plot area was harvested and left as such in the respective plot for sun drying for about five days. After drying, threshing and cleaning of seed were done. The seed, stover and straw yield were recorded plot wise. Yield were converted into kg/ha before statistical analysis. 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 [6].

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.* [7] under production potential of chickpea based intercropping systems and Borad [3] 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. Higher number of nodules per plant of sole chickpea was due to the root has lesser competition for growth factors in the rhizosphere, which provides conductive ecosystem for better growth and development of roots. These results are in close corroborated with the findings of Kumar and Singh [23].

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.* [19], Ramarao *et al.* [8] and Verma *et al.* [22].

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.* [7], Poddar *et al.* [9], Priya *et al.* [10], Borad [3]. Zafaranieh [24] and Sing *et al.* [21].

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. These results are closely related to the findings of Awasthi *et al.* [17], Alam [15], Tanwer *et al.* [19] and Das *et al.* [20].

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.* [7], Poddar *et al.* [9], Meena *et al.* [11], Borad [3] and Gangadhar *et al.* [16].

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.

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

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	--	--	--	--	--	--	--	--	--	--	--	--
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$\pm$	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$\pm$	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$\pm$	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

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.* [7], Yadav [12], Poddar *et al.* [9] and Meena *et al.* [11].

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.* [13], Mahfouz *et al.* [14] and Kaparwan *et al.* [18].

4. CONCLUSION

On the basis of two year field experimentations, leads to following conclusions.

The effect of different intercropping treatments did not show any significant variation on plant height of chickpea measured at 30 and 60 DAS during both the years and in pooled results. While significantly higher plant height of chickpea at harvest was recorded under sole chickpea but it was remained at par with chickpea + linseed (3:1) and chickpea + fenugreek (3:1) during the year 2019-20, 2020-21 and in pooled analysis.
The number of nodules per plant of chickpea workout at 35 DAS exerted significant variation due to different treatment and sole chickpea recoded significantly the highest number of nodules per plant during the individual years and in pooled analysis.

Sole chickpea being at par with chickpea + fenugreek (3:1) and recorded significantly higher number of seeds/pod during the year 2019-20, 2020-21 and on pooled base analysis, respectively. While treatment chickpea + linseed (3:1) was also remained at par during both the year.

The maximum overall yield was observed in the sole chickpea during the year 2019-20, 2020-21 and on pooled basis, respectively. Among the different intercropping systems, chickpea + fenugreek (3:1) row ratio produced significantly higher seed yield of chickpea as compared to rest of the treatment except, chickpea + linseed (3:1) during the individual years as well as in pooled basis.

Sole chickpea recorded significantly the highest stover yield of chickpea during both years as well as pooled results, respectively. Among the different row ratios, chickpea + fenugreek (3:1) recorded higher stover yield and remained at par with chickpea + linseed (3:1) in pooled results.

Effect of different intercropping systems did not influence on of crude protein content in chickpea seed during the year 2019-20, 2020-21 and on pooled basis. These findings highlight the significance of balanced intercropping ratios for optimizing crop growth and productivity.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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