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Effect of different intercropping system on growth, yield attributes and yield of chickpea (*Cicer arietinum* L.)

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Abstract
A field experiment was conducted during *Rabi* season 2020-21 and 2021-22 at Instructional-cum-Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The experiment field was laid out in Randomized Block Design, having four replications, each containing 9 treatments *i.e.* sole chickpea, sole linseed, sole safflower, sole wheat, sole mustard, chickpea + linseed (6:2), chickpea + safflower (6:2), chickpea + wheat (6:2) and chickpea + mustard. Result revealed that the different chickpea based intercropping system maximum growth parameter like (plant height, dry matter accumulation, number of primary and secondary branches plant^{-1}, number of functional leaves), yield attributes like (number of pods plant^{-1}, number of seeds pod^{-1} and 100 seed weight) and seed, stover yield and harvest index were recorded under sole chickpea as compared to others during both the years and on mean basis. As regards to different intercropping treatments, they were found at par to each other during both the years and on mean basis. However, among intercropping, the maximum values were noted under chickpea + linseed (6:2) intercropping system during both the years and on mean basis.

Keywords: Chickpea, intercropping, wheat, mustard, safflower, linseed, yield attributes, seed yield

Introduction
Chickpea (*Cicer arietinum* L.) is the most important winter season pulse crop. It is a source of protein and it plays an important role in human nutrition for large population in the developing world. Chickpea valued for its nutritive seeds with high protein content 18-22%, carbohydrate 52-70%, fat 4-10%, minerals like (calcium, phosphorus and iron) and vitamins. Chickpea is the second most important pulse crop after pigeon pea in the world for human diet and other use. It is cultivated in area of 149.66 lakh ha with a total production of 162.25 lakh tonnes and average productivity of 1252 kg ha^{-1} (FAO, 2020) [5]. Chickpea is an important pulse crop in India grown as a dry pulse crop or as a green vegetable with the farmer use being most common. In India it is grown over an area of 99.96 lakh hactare during 2021 with production of 119.11 lakh tonnes and average productivity of 1092 kg ha^{-1} (Anonymous, 2021) [2]. Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, Gujarat, Andhra Pradesh and Karnataka are the major chickpea producing states sharing over 95% area. Chhattisgarh state has good agro-ecological situation for chickpea production. In state it is grown over an area of 3.01 lakh hectares with an annual production of 2.67 lakh tonnes and an average productivity of 887 kg ha^{-1} (Anonymous, 2021) [2]. Chickpea additionally performs a major function in improving soil fertility because of its nitrogen fixing ability. Chickpea can restore as much as a 140 kg N ha^{-1} in a crop growing period (Poonia and Pithia, 2013) [17]. Chickpea is historically grown as a mixed crop with numerous plants like wheat, mustard, linseed, barley, spices etc. In Chhattisgarh, chickpea is main crop growing after rice. Major chickpea growing districts in Chhattisgarh are Rajnandgaon, Bemetara, Mungeli, Balod, Janjgir-champa Raipur, Durg, Kawardha, Korba, Bilaspur, Balod, Dhamtari, Baloda Bazar and Raigarh. Intercropping has gained interest because of potential advantages it offers over yielding, i.e. improved utilization of growth resources by the crops and improved reliability from season to season (Lithourgidis *et al.*, 2011) [13]. The principal gain of intercropping is the greater green usage of the to be had sources and the accelerated productiveness as compared with every sole crop of the mixture (Jannasch and Martin, 1999, Willey, 1979; Li *et al.*, 1999; Mucheru *et al.*, 2010 and Hauggaard and Jensen, 2001) [7, 25, 16, 6]. An possibility to yield for assessing the benefits of intercropping is to use units together with monetary units or nutritional values which may be in addition applied to component crops (Willey, 1985) [24].

Yield benefit happens due to the fact growth sources together with light, water, and vitamins are greater absolutely absorbed and transformed to crop biomass via way of means of the intercrop over the time and space because of variations in aggressive capacity for growth sources among the component crops, which make the most the variantion of the mixed crop in characteristics together with rates of canopy development, very final canopy size (width and height), photosynthetic adaptation of canopies to irradiance conditions, and rooting depth depth (Midmore, 1993; Morris and Garrity, 1993;) [14, 15].

Material and Methods

A field experiment was conducted during *Rabi* season 2020-21 and 2021-22 at Instructional-cum-Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). Raipur comes under the Chhattisgarh plains agro climatic sub zone and having dry moist to sub humid climatic condition. It gets an annual rainfall of 1326 mm (Based on 80 years mean). About 85% of that is obtained at some stage in middle of June to end of September and little amount in October to May. May and December are the most hot and coolest months, respectively. The soil of the experimental field was clay *(Vertisols)* in texture. The soil was neutral (7.1 and 7.1 pH) reaction during 2020-21 and 2021-22. It had low in nitrogen (213.34 and 213.89 kg ha^{-1}) medium in phosphorus (13.78 and 13.96 kg ha^{-1}) and high potassium (315.45 and 316.20 kg ha^{-1}) contents during both years of experiment. The test consist of nine treatment. the test variety used in experiment Indira Chana -1 of chickpea, RLC-153 of linseed, CG Kusum-1 of safflower, GW366 of wheat and Pusa bold of mustard. The crop was sown during last week of November and harvesting is done in second week of March.

Result and Discussion

Growth parameter

Plant height

Plant height is one of the important growth parameters of any crop plants as it determines or modifies the yield contributing characters and finally shapes the grain yield. The data presented in Table- 1 revealed that different chickpea based intercropping system significantly affected the plant height at different time interval of observations except at 30 DAS during both the years and on mean basis.

Among the different intercropping system at 60, 90 DAS and at harvest, significantly tallest plant was registered under sole chickpea as compared to other intercropping systems. As regards to different intercropping treatments, they were found at par to each other at 60, 90 DAS and at harvest during both the years and on mean basis. However, among intercropping, the maximum plant height was noted under chickpea + linseed (6:2) intercropping system during both the years and on mean basis. The lowest plant height was noted in chickpea + mustard (6:2) intercropping system at 60 DAS and at harvest during 2020-21 and on mean basis and at 90 DAS during 2020-21 as well as chickpea + wheat (6:2) intercropping system at 60, 90 DAS and at harvest during 2021-22 and at 90 DAS on mean basis. This might be due to its crowding population where each plant competed for light and space ultimately attained more height. Similar results was also reported that Lal *et al.* (2014) [14] and Singh *et al.* (2019) [18]

Table 1: Plant height of chickpea as influenced by different chickpea based intercropping system

Treatment	Plant height (cm)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean
Sole chickpea	20.10	22.23	21.16	39.94	42.07	41.00	48.06	50.73	49.39	47.66	49.19	48.42
Chickpea + linseed (6:2)	19.92	21.75	20.84	37.12	40.10	38.61	46.39	47.78	47.09	45.17	47.06	46.11
Chickpea + safflower (6:2)	19.85	21.15	20.50	36.70	38.89	37.79	45.74	46.91	46.33	43.55	46.63	45.09
Chickpea + wheat (6:2)	19.87	21.10	20.49	36.98	38.31	37.65	45.81	46.41	46.11	44.76	46.57	45.66
Chickpea + mustard (6:2)	19.82	21.62	20.72	35.78	39.49	37.63	45.13	47.16	46.15	43.21	46.79	45.00
SEm ±	0.50	0.56	0.40	0.73	062	0.54	0.56	0.48	0.51	0.80	0.69	059
CD (P=0.05)	NS	NS	NS	2.14	1.83	1.58	1.63	1.40	1.49	2.35	1.72	1.74

Table 2: Dry matter accumulation of chickpea as influenced by different chickpea based intercropping system

Treatment	Dry matter accumulation (g $plant^{-1}$)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean
Sole chickpea	1.79	1.93	1.86	10.91	11.15	11.03	21.77	23.87	22.82	24.50	26.24	25.37
Chickpea + linseed (6:2)	1.73	1.92	1.82	10.13	10.55	10.34	20.82	22.33	21.57	23.06	24.33	23.70
Chickpea + safflower (6:2)	1.72	1.89	1.80	9.98	10.25	10.11	20.14	21.95	21.05	22.73	23.95	23.34
Chickpea + wheat (6:2)	1.70	1.87	1.78	10.02	10.02	10.02	20.47	21.73	21.10	22.84	23.56	23.20
Chickpea + mustard (6:2)	1.69	1.89	1.81	9.95	11.15	10.20	20.06	22.10	21.08	22.52	24.07	23.29
SEm ±	0.06	0.07	0.06	0.26	0.19	0.20	0.39	0.44	0.28	0.37	0.51	0.40
CD (P=0.05)	NS	NS	NS	0.76	0.57	0.60	1.13	1.30	0.82	1.07	1.50	1.18

Dry matter accumulation

Data with respect to dry matter accumulation (g $plant^{-1}$) of chickpea as influenced by different chickpea based intercropping system during both the years and on mean basis are presented in the Table 2. The findings revealed that dry matter accumulation increased with the advancement of crop age up to harvest. The dry matter accumulation (g $plant^{-1}$) at 30 DAS remained unaffected due to different chickpea based intercropping system during both the years and on mean basis. At 60, 90 DAS and at harvest, significantly highest dry matter accumulation (g $plant^{-1}$) was recorded under sole chickpea as compared to others. As regards to different intercropping treatments, they were found at par to each other at 60, 90 DAS and at harvest during both the years and on mean basis.

However, among intercropping, the maximum dry matter accumulation (g plant^{-1}) was noted under chickpea + linseed (6:2) intercropping system during both the years and on mean basis. The minimum dry matter accumulation (g plant^{-1}) was registered in chickpea + mustard (6:2) intercropping system at 60, 90 DAS and at harvest during 2020-21 and 90 DAS during mean basis as well as chickpea + wheat (6:2) intercropping system at 60 DAS and at harvest during 2021-22 and on mean basis and at 90 DAS during 2021-22. The higher value of total dry matter plant^{-1} was found under sole chickpea this increase in dry matter accumulation under sole chickpea was possibly due to higher interception of solar radiation resulted in more accumulation of photosynthates and consequently the production of higher quantum of total dry matter accumulation. Similar results confirm the findings of Davoodian and Hamzei (2019) [3].

Number of primary branches

The data on number of primary branches plant^{-1} recorded at 30, 60 and 90 DAS as influenced by different chickpea based intercropping system during both the years and on mean basis are presented in Table 3. Number of primary branches plant^{-1} increased with the advancement of crop age up to 60 DAS. At the initial stage, all the intercropping system failed to show their significant impact on number of primary branches plant^{-1} of chickpea during both the years and on mean basis. Whereas, at 60 and 90 DAS, significantly highest number of primary branches plant^{-1} was registered under sole chickpea as compared to other. As regard to intercropping treatments, they were found at par to each other at 60 and 90 DAS during both the years and on mean basis. However, among intercropping, the maximum number of primary branches plant^{-1} was noted under chickpea + linseed (6:2) intercropping system during both the years and on mean basis. The lowest number of primary branches plant^{-1} was registered in chickpea + mustard (6:2) intercropping system at 60 and 90 DAS during 2020-21 and at 60 DAS on mean basis as well as chickpea + wheat (6:2) intercropping system at 60 and 90 DAS during 2021-22 and 90 DAS on mean basis. This might be due to less competition for available resources *viz*., water, nutrients, space and light (Dharmendra *et al*., 2018) [4].

Number of secondary branches

The data on number of secondary branches plant^{-1} was recorded at 30, 60, 90 DAS and at harvest as influenced by different chickpea based intercropping system during both the years and on mean basis are presented in Table 4. As regards to the number of secondary branches plant^{-1}, the highest increment in branches was noted between 60 to 90 days period. At 30 DAS, number of secondary branches plant^{-1} was found non-significant among different intercropping system during both the years and on mean basis. At 60, 90 DAS and at harvest, significantly the highest number of secondary branches plant^{-1} was recorded under sole chickpea as compared to other treatments. As regard to intercropping treatments, they were found at par to each other at all the growth stages during both the years and on mean basis. However among intercropping, the maximum number of secondary branches plant^{-1} was noted under chickpea + linseed (6:2) intercropping system during both the years and on mean basis. The lowest number of secondary branches plant^{-1} was noted under chickpea + mustard (6:2) intercropping system at 60 and 90 DAS during 2020-21 and on mean basis and at at harvest during 2020-21 as well as chickpea + wheat (6:2) intercropping system at 60, 90 DAS and at harvest during 2021-22 and chickpea + wheat (6:2) intercropping system at at harvest during mean basis.

Yield attributes

Number of pods plant^{-1}

The data related to number of pods plant^{-1} of chickpea as influenced by different chickpea based intercropping system during both the years and on mean basis are presented in Table 5. Among different chickpea based intercropping system, sole chickpea registered the significantly maximum number of pods plant^{-1} as compared to other intercropping system. As regard to intercropping treatments, they were found at par to each other during both the years and on mean basis. Maximum number of pods per plant was around 50 in sole crop whereas in intercrops around 5% reduction was observed owing to shading and competitive effect of sole and intercropping. However, among intercropping, the maximum number of pods plant^{-1} of chickpea was noted under chickpea + linseed (6:2) intercropping system during both the years and on mean basis. The lowest number of pods plant^{-1} was noted in chickpea + mustard (6:2) intercropping system during 2020-21 as well as chickpea + wheat (6:2) intercropping system during 2021-22 and on mean basis. This might be due to lesser inter-crop competition, higher photosynthetic active radiation and latent heat available to the crops leading to higher production of photosynthates which together favourably influenced the yield attributing parameters. Similar results were reported by Wien and Smithson (1981) [23].

Number of seeds pod^{-1}

The data on number of seeds pod^{-1} under different treatments have been presented in Table 5. The number of seeds pod^{-1} was not influenced significantly due to different chickpea based intercropping system during both the years and on mean basis. However, the maximum number of seeds pod^{-1} (around 2 seed per pod) was registered under sole chickpea and the lowest number of seeds pod^{-1} was recorded under chickpea + mustard (6:2) intercropping system during 2020-21 as well as chickpea + wheat (6:2) intercropping system during 2021-22 and on mean basis.

100 seeds weight

The 100 seed weight is thus a function of dry matter production and translocation efficiency of the plant. The data on 100 seeds weight (g) of chickpea presented in Table 5. Result reveals that different chickpea based intercropping system did not give significant impact during both the years and on mean basis. However, the maximum 100 seeds weight (24 g) of chickpea was obtained under sole chickpea followed by chickpea + linseed (6:2) and chickpea + safflower (6:2) intercropping system and the lowest 100 seeds weight (23 g) of chickpea was noted under chickpea + mustard (6:2) intercropping system during 2020-21 as well as chickpea + wheat (6:2) intercropping system during 2021-22 and on mean basis.

Seed yield

The data with respect to seed yield of chickpea are presented in Table 6. It is clear from the data that seed yield was significantly affected due to different chickpea based

intercropping system during both the years and on mean basis. Significantly highest seed yield (1638 and 1673 kg ha^{-1}) was registered under the sole chickpea during both the years and on mean basis. As regard to intercropping treatments, they were found at par to each other during both the years and on mean basis. However, among intercropping, the maximum seed yield was noted under chickpea + linseed (6:2) intercropping system during both the years and on mean basis. The lowest seed yield of chickpea was observed under chickpea + mustard (6:2) intercropping system during 2020-21 as well as chickpea + mustard (6:2) intercropping system during 2021-22 and on mean basis. This might be due to lesser inter-crop competition, higher nutrient availability, higher photosynthetic active radiation and latent heat available to the crops leading to higher production of photosynthates which together favourably influenced the yield attributing parameters. Similar results were reported by Ahlawat *et al.* (2005) [1], Kumar and Singh (2006) [8] and Kumar and Sharma (2006). Torkaman *et al.* (2018) [20] also stated that higher seed yield with sole chickpea was mainly due to the higher population per unit area and less disturbance to the microclimate of the chickpea.

Stover yield

The data on stover yield was significantly influenced by different chickpea based intercropping system during both the years and on mean basis (Table 6). Significantly highest stover yield (2570 and 2694 kg ha^{-1}) was registered under the sole chickpea as compared to other treatments during both the years and on mean basis. All intercropping treatments were found at par to each other during both the years and on mean basis. However, among intercropping, the maximum stover yield was noted under chickpea + linseed (6:2) intercropping system during both the years and on mean basis. The lowest seed yield of chickpea was observed under chickpea + safflower (6:2) intercropping system during 2020-21 and on mean basis as well as chickpea + wheat (6:2) intercropping system during 2021-22. This might be due to more number of plant population in sole than intercropping. Similar result was found that Kumar and Nandan (2007) [9]. Wasu *et al.* (2013) [22] reported that the increase in stover yields was possibly due to better growth of crop.

Harvest index (%)

The data on harvest index as influenced by different treatments are presented in Table 6. The perusal of data reveals that the harvest index of chickpea was found non-significant due to different chickpea based intercropping system during both the years but it was found significant during mean basis. The significantly highest harvest index was recorded under sole chickpea as compared to others. As regard to intercropping treatments, they were found at par to each other on mean basis. However, among intercropping, the maximum harvest index was noted under chickpea + safflower (6:2) intercropping system and the lowest harvest index was recorded under chickpea + mustard (6:2) intercropping system. Similar result was found by Thakur *et al.* (2000) [19] and Tripathi *et al.* (2005) [19].

Table 3: Number of primary branches of chickpea as influenced by different chickpea based intercropping system

Treatment	Number of primary branches plant^{-1}								
	30 DAS			60 DAS			90 DAS		
	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean
Sole chickpea	2.04	2.25	2.14	2.76	3.01	2.89	3.09	3.21	3.15
Chickpea + linseed (6:2)	2.02	2.10	2.06	2.39	2.67	2.53	2.70	2.99	2.85
Chickpea + safflower (6:2)	1.94	1.99	1.96	2.26	2.59	2.42	2.62	2.86	2.75
Chickpea + wheat (6:2)	1.97	1.93	1.95	2.33	2.56	2.44	2.68	2.83	2.74
Chickpea + mustard (6:2)	1.93	2.06	2.00	2.19	2.63	2.41	2.59	2.95	2.77
SEm ±	0.11	0.12	0.08	0.12	0.10	0.09	0.06	0.09	0.04
CD (P=0.05)	NS	NS	NS	0.34	0.29	0.26	0.18	0.26	0.13

Table 4: Number of secondary branches of chickpea as influenced by different chickpea based intercropping system

Treatment	Number of secondary branches plant^{-1}											
	30 DAS			60 DAS			90 DAS			At harvest		
	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean
Sole chickpea	3.10	3.63	3.36	8.54	9.75	9.14	12.65	13.19	12.92	13.34	14.28	13.81
Chickpea + linseed (6:2)	2.98	3.57	3.27	7.63	8.57	8.10	11.39	12.28	11.83	12.48	13.38	12.93
Chickpea + safflower (6:2)	2.86	3.49	3.17	7.55	8.47	8.01	10.91	12.05	11.48	11.95	12.94	12.44
Chickpea + wheat (6:2)	2.90	3.43	3.17	7.58	8.40	7.99	11.01	11.96	11.49	12.34	12.83	12.58
Chickpea + mustard (6:2)	2.83	3.52	3.17	7.46	8.53	7.98	10.79	12.14	11.47	11.88	13.19	12.53
SEm ±	0.14	0.18	0.13	0.31	0.36	0.31	0.36	0.27	0.23	0.28	0.27	0.22
CD (P=0.05)	NS	NS	NS	0.90	1.06	0.90	1.05	0.78	0.68	0.83	0.80	0.54

Table 5: Yield attributes of chickpea as influenced by different chickpea based intercropping system

Treatment	Yield attributes of chickpea								
	Number of pods plant^{-1}			Number of seeds pod^{-1}			100 Seed weight (g)		
	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean
Sole chickpea	48.27	51.20	49.73	1.70	1.88	1.79	23.56	23.87	23.72
Chickpea + linseed (6:2)	46.25	48.43	47.34	1.66	1.79	1.72	23.25	23.55	23.40
Chickpea + safflower (6:2)	46.05	47.88	46.96	1.58	1.73	1.66	23.06	23.19	23.12
Chickpea + wheat (6:2)	46.17	47.71	46.94	1.60	1.68	1.64	23.14	23.01	23.07
Chickpea + mustard (6:2)	45.90	48.00	46.95	1.56	1.75	1.66	22.86	23.34	23.10
SEm ±	0.61	0.80	0.43	0.07	0.10	0.07	0.47	0.46	0.34
CD (P=0.05)	1.80	2.36	1.26	NS	NS	NS	NS	NS	NS

Table 6: Seed yield, stover yield and harvest index of chickpea as influenced by different chickpea based intercropping system

Treatment	Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})			Harvest index (%)		
	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean
Sole chickpea	1637.50	1673.00	1655.25	2693.50	2570.00	2631.75	37.82	39.42	38.62
Sole linseed	-	-	-	-	-	-	-	-	-
Sole safflower	-	-	-	-	-	-	-	-	-
Sole wheat	-	-	-	-	-	-	-	-	-
Sole mustard	-	-	-	-	-	-	-	-	-
Chickpea + linseed (6:2)	1389.00	1400.75	1394.88	2335.00	2325.00	2330.00	37.32	37.61	37.47
Chickpea + safflower (6:2)	1331.50	1360.25	1345.88	2220.50	2251.25	2235.88	37.50	37.66	37.58
Chickpea + wheat (6:2)	1333.50	1358.75	1346.13	2259.25	2217.75	2238.50	37.11	38.02	37.57
Chickpea + mustard (6:2)	1325.50	1361.50	1343.50	2243.50	2243.50	2243.50	37.13	37.78	37.46
SEm ±	25.83	26.64	17.76	44.20	42.83	32.31	0.44	0.56	0.26
CD (P=0.05)	75.75	78.13	52.09	129.65	125.63	94.77	NS	NS	0.76

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