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Feasibility of *Rabi* maize (*Zea mays* L.): Chickpea (*Cicer arietinum* L.) intercropping system under middle Gujarat condition

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Abstract
A field experiment to find out the feasibility of *rabi* maize (*Zea mays* L.) - chickpea (*Cicer arietinum* L.) intercropping system under middle Gujarat condition was carried out at College Agronomy Farm, Anand Agricultural University, Anand (Gujarat) during *rabi* and summer season of 2019-20 and 2020-21 on loamy sand soils found low in organic carbon and available nitrogen, medium in available phosphorus and potassium with slightly alkaline in reaction. The treatment comprised of six different intercropping treatments *viz.*, T_1: Sole maize, T_2: Sole chickpea, T_3: maize + chickpea 1:1 (Additive series), T_4: maize + chickpea 1:1 (Replacement series), T_5: maize + chickpea 2:1 (Paired row) and T_6: maize + chickpea 2:2 (Paired row) set up under randomized block design. Results manifested significant influence of different intercropping systems on growth and yield attributes of maize *viz*., dry matter accumulation at harvest, cob girth, cob length, number of grains/cob, grain yield and stover yield of maize, maize equivalent yield, land equivalent ratio under treatment maize + chickpea intercropping system (1:1 Additive series) and significantly the higher plant height at harvest observed under sole maize plant treatment. Sole chickpea recorded significantly the higher plant height at 60 DAS and at harvest, higher plant dry matter accumulation at 60 DAS and at harvest, highest number of nodules / plant, number of branches/plant, number of pods/plant, seed yield and haulm yield. As far as MEY, LER and economics were concerned, treatment with maize + chickpea 1:1 (Additive series) produced highest MEY, covered highest LER and fetched the highest net realization and BCR value as compared to remaining intercropping treatments.

Keywords: Chickpea, intercropping system, *Rabi* maize

Introduction
Intercropping, the agricultural practice as growing of two or more crops in the same space at the same time in a particular field, is an age old and commonly used cropping practice which aims at to match efficiently crop demands to the available growth resources and labour. In India, the intercropping systems comprising cereals and legumes are very common. The role of cereal + legume intercropping systems for improving the productivity and profitability and sustaining the soil health through improving physical, chemical and biological soil parameters is well established. However, proper identification of location-specific cereals and legumes and their arrangement is necessary to optimally use the available resources. Maize being one of the important staple food crops of the world and largely cultivated in India confining an area of 9.60 million ha with the production of 27.15 million tonnes, having average productivity of about 2.80 tones/ha (Anon, 2020) [2]. In Gujarat state, maize is having an area of 0.44 million ha with a production of 0.68 million tones and productivity of 1659 kg/ha (Anon., 2018) [2]. As maize crop is generally cultivated solely at wider row spacing provides an opportunity to cultivate legumes as an intercrop to utilize inter row space for higher profitably and returns. Among the pulses, chickpea is one of the most important and extensively cultivated pulse crops. However, Kheroar and Patra (2013) [7], reported that interfere of legumes intercrops with normal growth of maize crop. That's why, present investigation was undertaken to determine the feasibility of rabi maize-chickpea intercropping system under different row arrangements like additive series, replacement series and paired row (1:1, 2:1 and 2:2) proportions of planting over the respective sole crop of maize and chickpea.

Materials and Methods
A field experiment was carried out at College Agronomy Farm, Anand Agricultural University, Anand (Gujarat) during *rabi* season of 2019-20 and 2020-21 to find out the feasibility of *rabi* maize (*Zea mays* L.) - chickpea (*Cicer arietinum* L.) intercropping system under middle Gujarat condition on loamy sand soils found low in organic carbon (0.22%) and

available nitrogen (179 kg/ha), medium in available phosphorus (42.65 kg/ha) and potassium (282 kg/ha) with slightly alkaline in reaction (8.23). The treatment was comprised of six different intercropping planting patterns *viz.*, T_1: Sole maize, T_2: Sole chickpea, T_3: maize + chickpea 1:1 (Additive series), T_4: maize + chickpea 1:1 (Replacement series), T_5: maize + chickpea 2:1 (Paired row) and T_6: maize + chickpea 2:2 (Paired row) set up under randomized block design. The maize variety GAYMH 3 (Gujarat Anand Yellow Maize Hybrid - 3) was taken as main crop which was intercropped with chickpea variety GJG 3 (Gujarat Junagadh Gram 3). The sole crop of maize and chickpea were drilled at 60 cm x 20 cm and 30 cm x 10 cm spacing, whereas, for intercropping system different planting patterns were: maize + chickpea in 1:1 ratio with additive and replacement series, maize + chickpea in paired row with 2:1 and 2:2 ratio, manifesting different plant populations. For paired row the spacing was 45-90-45 cm. The recommended doses of fertilizers *i.e.*, 150:60:00 NPK kg/ha was applied to maize crop only under sole and intercropping system, while 20:40:00 NPK kg /ha was applied only to sole chickpea. Maize as a main crop and chickpea as an intercrop were sown simultaneously. Following characters were calculated from the formula given below:

Shelling percentage

Shelling percentage is the ratio of grain weight to the cob weight was calculated by following formula.

$$\textbf{Shelling percentage} = \frac{\text{Weight of grain kg / ha}}{\text{Weight of cob with shells kg / ha}} \times 100$$

Maize equivalent yield (MEY) (kg / ha)

Maize equivalent yield was worked out for all the experimental units by following formula.

$$\boxed{\text{Yield of maize}} \; \boxed{+} \; \boxed{\frac{\text{Yield of chickpea x Price of chickpea}}{\text{Price of maize}}}$$

Land Equivalent Ratio (LER)

The Land Equivalent ratio (LER) of the area under sole cropping to the under intercropping needed to give equal amount of yield at the same management level.

$$\text{Land Equivalent Ratio} = \frac{\text{Sum of the fractions of the intercropped yield}}{\text{Sole crop yield}}$$

Results and Discussion

Periodical Plant Population

Maize

Plant population of maize / plot (Table 1) clearly indicated that the significantly higher plant population was recorded under sole maize (279) and maize + chickpea 1:1 Additive series (281) on pooled basis. Similar trend was followed at harvest and significantly higher plant population was recorded under sole maize (267) and maize + chickpea 1:1 Additive series (271) on pooled basis. Significantly the highest plants/plot for chickpea was recorded under sole chickpea treatment at 15 DAS (1099) and at harvest (1074.50). Plant population is one of the vital indicators determining crop yield and particularly in different intercropping systems with different planting patterns and crop geometry number of plants per unit area plays a key role as it balances the allocation of all the resources and inputs for efficient utilization by the component crops. For maize under sole crops and in additive series number of rows remained the same (9 rows/plot), while under replacement series it came down to five (5) rows, while in paired row system there remained eight (8) rows.

Chickpea

For chickpea the highest number of rows (18) were found under sole chickpea crop, whereas, for other intercropping systems it came down to eight (8) for 1:1 Additive series and 2:2 paired row series and four (4) for 1:1 replacement series and 2:1 paired row series. These results are in agreement with those reported by Ali *et al.* (2017) [1].

Table 1: Periodical Plant population and plant height of maize and chickpea as influenced by different intercropping systems (On pooled basis)

Intercropping system	Plant population / plot at 15 DAS		Plant population / plot at harvest		Plant height (cm) at 30 DAS		Plant height (cm) at 60 DAS		Plant height (cm) at harvest	
	Maize	Chickpea	Maize	Chickpea	Maize	Chickpea	Maize	Chickpea	Maize	Chickpea
T_1: Sole Maize	279	--	267.00	--	73.73	--	148.63	--	184.82	--
T_2: Sole Chickpea	--	1099	--	1074.50	--	18.27	--	37.19	--	51.70
T_3: Maize + chickpea (1:1) Additive series	281	483	271.00	475.00	72.06	17.68	147.88	31.78	183.52	41.77
T_4: Maize + chickpea (1:1) Replacement series	155	242	146.25	239.00	70.58	17.70	140.75	35.89	172.91	47.84
T_5: Maize + chickpea (2:1) Paired row (45-90-45 cm)	242	238	237.50	237.00	68.63	17.60	138.00	31.77	152.46	37.26
T_6: Maize + chickpea (2:2) Paired row (45-90-45 cm)	244	421	236.75	417.00	68.85	17.22	139.38	27.18	160.37	34.73
S.Em. $\pm$	3.67	8.30	2.81	8.36	1.94	0.48	3.96	1.12	5.27	1.44
C.D. at 5%	10.70	24.23	8.20	24.40	NS	NS	NS	3.28	15.38	4.20
C.V.%`	8.33	7.39	7.90	7.68	7.75	7.67	7.84	9.70	8.73	9.53

Growth parameters

Maize

The mean data pertaining to periodical plant height was measured periodically at 30 and 60 DAS as influenced by different intercropping systems were found to be non - significant during individual years and on pooled basis, whereas at harvest different intercropping system affected plant height significantly (Table 2). At harvest significantly the higher plant height of 184.82 cm was recorded under the treatment T_1 (sole maize) on pooled basis, which was found at par with treatments T_3 (maize + chickpea 1:1 Additive series) and T_4 (maize + chickpea 1:1 Replacement series) for plant height of maize at harvest. An increase in plant height might be attributed to the optimum space available in sole maize that reduced the competition for light and nutrients, which probably provided congenial physical environment and turned the plant to grow taller. While maize intercropped with chickpea (2:1 paired row) recorded considerably lower height compared with sole maize, might be due to higher crop competition for resources like water, nutrient, space which suppress the crop growth. Similar results were reported by Manasa *et al*. (2018) [8] and Patel *et al*. (2018) [17].

Periodical dry matter accumulation (Table 3) for maize recorded at 30 and 60 DAS as influenced by different intercropping systems were found to be non - significant, however, at harvest it was found significantly influenced by different intercropping systems, wherein Treatment T_3 (maize + chickpea 1:1 Additive series) being at par with treatment T_1 (Sole maize) and T_6 (maize + chickpea 2:2) recorded significantly higher plant dry matter accumulation (148.71 g/plant) on pooled basis. Dry matter accumulation depends upon net photosynthesis which is governed by several factors including space, nutrient availability *etc*. Therefore, it might be due to higher crop competition for resources which suppress the crop growth and reduced number of leaves/ plant and ultimately decrease the dry matter accumulation of a crop. The present findings are in agreement with the results of Pandey *et al*. (2019) [13] and Patel *et al*. (2018) [17].

Table 2: Periodical Plant dry matter accumulation of maize and chickpea as influenced by different intercropping systems (On pooled basis)

Intercropping system	Plant dry matter accumulation (g/plant) at 30 DAS		Plant dry matter accumulation (g/plant) at 60 DAS		Plant dry matter accumulation (g/plant) at harvest	
	Maize	Chickpea	Maize	Chickpea	Maize	Chickpea
T_1: Sole Maize	42.17	--	79.89	--	141.72	--
T_2: Sole Chickpea	--	3.98	--	10.97	--	15.98
T_3: Maize + chickpea (1:1) Additive series	44.87	3.65	81.92	8.35	148.71	13.13
T_4: Maize + chickpea (1:1) Replacement series	42.95	3.92	77.07	10.27	134.49	14.63
T_5: Maize + chickpea (2:1) Paired row (45-90-45 cm)	41.68	3.65	75.36	8.28	130.52	13.23
T_6: Maize + chickpea (2:2) Paired row (45-90-45 cm)	42.32	3.65	78.75	7.83	138.33	12.27
S.Em. ±	1.25	0.12	2.37	0.31	3.85	0.47
C.D. at 5%	NS	NS	NS	0.92	11.24	1.37
C.V.%`	8.23	8.64	8.54	9.73	7.94	9.60

Table 3: Yield attributes of maize and chickpea as influenced by different intercropping systems (On pooled basis)

Intercropping system	Cob girth (cm)	Cob length (cm)	Number of grains / cob	Number of nodules / plant (35 DAS)	Number of branches / Plant	Number of pods / Plant	Seed Index (g)		Shelling percentage
	Maize	Maize	Maize	Chickpea	Chickpea	Chickpea	Maize	Chickpea	Maize
T_1: Sole Maize	17.07	23.65	293.25	--	--	--	22.10	--	75.81
T_2: Sole Chickpea	--	--	--	18.53	25.14	40.55	--	22.48	--
T_3: Maize + chickpea (1:1) Additive series	18.58	24.33	307.00	10.50	21.35	34.76	22.84	21.53	77.33
T_4: Maize + chickpea (1:1) Replacement series	17.60	20.67	253.50	13.08	22.87	37.00	21.54	20.73	74.84
T_5:Maize + chickpea (2:1) Paired row (45-90-45 cm)	15.16	20.75	249.38	11.53	21.53	35.37	21.25	21.36	74.71
T_6:Maize + chickpea (2:2) Paired row (45-90-45 cm)	15.77	20.02	264.75	10.41	20.52	31.67	21.45	20.95	73.38
S.Em. ±	0.54	0.70	8.90	0.47	0.70	1.25	0.60	0.64	2.27
C.D. at 5%	1.57	2.06	25.96	1.36	2.03	3.64	NS	NS	NS
C.V.%`	9.05	8.94	9.20	10.30	8.82	9.84	7.82	8.40	8.53

Chickpea

Intercropping systems did not exert their significant impact on the plant height of chickpea at 30 DAS, while at 60 DAS and at harvest significant difference in plant height of chickpea was observed. At 60 DAS and at harvest treatment T_2 (chickpea sole) being at par with treatment T_4 (maize + chickpea 1:1 Replacement series) recorded significantly higher plant height of 37.19 cm and 51.70 cm, respectively on pooled basis. In the different intercropping systems maize growth was higher as compared to chickpea throughout the growth period that created smothering and shading effect on chickpea after 30 DAS. Due to this effect, availability of light to chickpea was hindered. On the other hand, intercropping system of maize + chickpea (1:1 Replacement series) plant height of chickpea was found higher because row of maize in chickpea provided better light interception as compared to maize + chickpea (1:1 Additive series). Efficient utilization of solar radiation causes increase in photosynthetic activity, metabolic activity and efficient utilization of applied nutrients. Results were in confirmation of those reported by Prabhakar and Chandranath (2017) [16] and Modi (2016) [10].

It was further observed that though at 30 DAS different intercropping systems could not exert their significant effect on the dry matter accumulation, but at 60 DAS and at harvest significant difference in dry matter accumulation of chickpea was observed due to intercropping systems. At 60 DAS and at harvest treatment T_2 (chickpea sole) being at par with T_4 (maize - chickpea 1:1 replacement series) gave significantly net higher dry matter accumulation (10.97 and 15.98 g/plant, respectively) in pooled analysis. It might be due to the maize with chickpea intercropping combination the competition faced by intercropped chickpea resulted into poor growth due to smothering effect of maize and thus should be less dry matter accumulation as compared to sole chickpea. Similar opinion was mentioned by Pandey *et al*. (2019) [13] and Manasa *et al*. (2018) [8].

Yield attributes
Maize
Data on cob girth, cob length and number of grains/cob (Table 3) revealed that different intercropping systems manifested significant impact on all the three characters. Significantly higher cob girth (18.58 cm) on pooled basis was recorded under treatment T_3 (maize + chickpea 1:1 Additive series), which was found at par with treatment T_1 (maize sole) and T_4 (maize + chickpea 1:1 Replacement series). Though, Treatment T_3 (maize + chickpea 1:1 Additive series) showed significantly higher cob length (24.33 cm) on pooled basis, it was found at par with the treatment T_1. Significantly higher values of number of grains / cob (307.00) were found on pooled basis under T_3 (maize + chickpea 1:1 Additive series) treatment, but it was found statistically identical with the treatment T_1 (sole maize). Seed index and shelling percentage were remained unaffected due to different intercropping systems. This might be due to lower competition for the nutrient uptake and space suitable for proper growth and development. Besides this chickpea as an intercrop fix biological nitrogen in the soil. Symbiotic rhizobium through bacteria survives on root nodule. The fixed nitrogen could be utilized by maize for better cob girth, cob length and number of grains/cob. These results also collaborated by Vaghela *et al*. (2020) [22], Jan *et al.* (2016) [6], Massave *et al*. (2016) [9], Modi (2016) [10] and Reddy and Pulled (2016) [20].

Chickpea
Results pertaining to number of noduled/plant, number of branches/plant and number of pods/plants of chickpea showed significant influence, while seed index was not differed appreciably due to different intercropping systems (Table 3). Treatment T_2 (sole chickpea) had significantly the highest number of nodules/ plant (18.53) in pooled analysis. Treatment T_2 (chickpea sole) being at par with treatment T_4 (maize + chickpea 1:1 Replacement series) showed significantly the higher number of branches / plant (25.14) and number of pods/ plant (40.55) in pooled analysis. The results might be ascribed to efficient utilization of soil moisture, solar radiation and nutrients, accrued to wider inter row space and increased photosynthesis and metabolic activity under treatment T_2 (chickpea sole) and T_4 (maize + chickpea 1:1 Replacement series). An increased photosynthesis might transformed source to sink effectively. Similar results were found by Kheroar and Patra (2013) [7], Panwar *et al*. (2016) [15] and Padhi (2001) [12].

Yield
Maize
The appraisal of mean data presented in Table 4 revealed that grain yield of maize was significantly influenced due to different intercropping systems during the year 2019-20, 2020-21 and in pooled analysis. Treatment T_3 (maize + chickpea 1:1 Additive series) recorded significantly the higher grain yield during the year 2019-20 (5489 kg / ha), 2020-21 (5692 kg / ha) and in pooled analysis (5591 kg / ha). However, it was found statistically at par with treatment T_1 (sole maize). The percent increase in grain yield under the treatment T_3 was higher over the treatment T_4, T_5 and T_6 were 45%, 20% and 17% on pooled basis, respectively. It was further evident from the data that stover yield was also significantly influenced due to different intercropping systems during both the years as well as in pooled analysis. Treatment T_3 (maize + chickpea 1:1 Additive series) registered significantly the higher stover yield (7083, 7267 and 7175 kg/ha) during the years 2019-20, 2020-21 and pooled analysis, respectively, however, it was found at par with treatment T_1 (sole maize) and T_6 (maize + chickpea 2:2 paired row) during first and second year. The percent increase in stover yield under the treatment T_2 was higher over the treatment T_3, T_4, T_5 and T_6 were 5%, 21%, 28% and 8%, respectively on pooled basis. Yield is a resultant effect of cumulative impact of all the growth and yield attributes. The significant impact of treatment T3 (maize + chickpea 1:1 Additive series) on grain yield might be ascribed to its better performance through out to growth period and obtaining higher yield attributes *viz.*, higher cob length, cob girth, number of grains/cob under this treatment. The higher performance in maize - chickpea 1:1 (Additive series) intercropping system might be accrued to sufficient availability of solar radiation, soil moisture and nutrients. The increase in stover yield under treatment T_3 is mainly attributed to growth attributing parameter like plant height. These results are in conformity with findings of Pandey *et al.* (2020) [14], Vaghela *et al.* (2020) [22], Parimaladevi *et al.* (2019) [16], Patel *et al.* (2018) [17] and Prabhakar and Chandranath (2017) [16].

Table 4: Grain/ Seed and Stover/ Haulm yield of maize and chickpea as influenced by different intercropping systems

Intercropping system	Grain yield (kg / ha)			Seed yield (kg / ha)			Stover yield (kg / ha)			Haulm yield (kg / ha)			MEY (kg / ha)	LER
	Maize			Chickpea			Maize			Chickpea				
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	(On pooled basis)	
T_1: Sole Maize	5447	5482	5465	--	--	--	6903	6831	6867	--	--	--	5465	1.00
T_2: Sole Chickpea	--	--	--	1704	1777	1740	--	--	--	2349	2488	2418	4746	1.00
T_3: Maize + chickpea (1:1) Additive series	5489	5692	5591	998	973	985	7083	7267	7175	1783	1882	1833	8277	1.49
T_4: Maize + chickpea (1:1) Replacement series	3738	3986	3862	547	528	537	5837	5975	5906	1232	1132	1182	5327	1.38
T_5: Maize + chickpea (2:1) Paired row (45-90-45 cm)	4554	4755	4655	502	498	500	5772	5468	5620	1080	1043	1061	6018	1.30
T_6: Maize + chickpea (2:2)Paired row (45-90-45 cm)	4792	4805	4799	743	667	705	6329	6613	6471	1591	1448	1520	6721	1.40
S.Em. $\pm$	234	250	171	44	48	32	325	309	224	77	81	56	180	0.02
C.D. at 5%	693	770	500	134	148	95	1002	953	655	239	250	164	519	0.05
C.V.%`	9.76	10.11	9.94	9.69	10.84	10.27	10.18	9.62	9.90	9.64	10.16	9.90	8.34	4.03

Chickpea

Results on seed (Table 4) of chickpea showed that there was a significant impact of different intercropping systems on seed yield of chickpea. Significantly the highest seed yield of chickpea (1704, 1777 and 1740 kg / ha) was obtained under the treatment T_2 (sole chickpea) during the year 2019-20, 2021-21 and on pooled basis, respectively. The per cent increase in seed yield under the treatment T_2 was to the tune of 77%, 224%, 248% and 146% on pooled basis over the treatment T_3, T_4, T_5 and T_6 respectively. As far as haulm yield was concerned, treatment T_2 (sole chickpea) produced significantly the highest haulm yield of 2349, 2488 and 2418 kg/ha during the both the year as well as on pooled basis, respectively. The percent increase in haulm yield under the treatment T_2 was higher over the treatment T_3, T_4, T_5 and T_6 were to the tune of 32%, 105%, 128% and 59%, respectively on pooled basis. The superiority of seed yield in sole chickpea might be due to efficient utilization of available resources under no competition from maize crop. Secondly, plant population of chickpea was lower under all the maize + chickpea intercropping system (1:1 and 2:2). This might be the reason for 50% seed yield reduction in intercropping system. Similar results were reported by Bezabih (2020) [3], Chhetri and Shinha (2018) [4], Modi (2016) [10], Mohapatra *et al*. (2016) [11] Yadav *et al.* (2016), Hamd alla *et al.* (2014) [5] Singh *et al*. (2008) [21] and Popat (2012) [18].

MEY, LER and Economics

Treatment T_3 (maize + chickpea 1:1 Additive series) out yielded all the treatments with significantly the highest maize equivalent yield of 8277 kg/ha in pooled analysis. An increase reported under T_3 over the treatments T_1, T_2, T_4, T_5 and T_6 were to the tune of 51%, 74%, 55%, 37% and 23% on pooled basis, respectively (Table 4). It is evident from the data (Table 4) that all intercropping systems gave land equivalent yield (LER) greater than 1.0. The difference in LER due to different treatments was found significantly the highest under treatment T_3 (maize + chickpea 1:1 Additive series) *i.e.*, 1.49 in in pooled analysis, indicating 49% more area would be required for producing the same quantity of grain yield for solitary cropping system compared to intercropping. Economics of maize + chickpea intercrops as influenced by different intercropping systems (Table 5) indicated that treatment T_3 (maize + chickpea 1:1 Additive series) fetched the highest net realization (₹1,63,311/ ha) with maximum BCR value of 6.51.

Table 5: Economics of maize + chickpea intercropping system (On pooled basis)

Treatments	Maize yield (kg/ha)		Chickpea yield (kg/ha)		Maize income (₹ /ha)		Chickpea income (₹ /ha)		Gross realization (₹ /ha)	Common cost (₹ /ha)	Treat. Cost (₹ /ha)	Total cost (₹ /ha)	Net realization (₹ /ha)	BCR
	Grain	Stover	Seed	Haulm	Grain	Stover	Seed	Haulm						
T_1	5465	6867	--	--	120230	6867	--	--	127097	19752	6880	26632	100465	4.77
T_2	--	--	1740	2418	--	--	104400	4836	109236	19752	8256	28008	81228	3.90
T_3	5591	7175	985	1833	123002	7175	59100	3666	192943	19752	9880	29632	163311	6.51
T_4	3862	5906	537	1182	84964	5906	32220	2364	125454	19752	7130	26882	98572	4.67
T_5	4655	5620	500	1061	102410	5620	30000	2122	140512	19752	8380	28132	112020	4.99
T_6	4799	6471	705	1520	105578	6471	42300	3040	157389	19752	9880	29632	127757	5.31

Selling price: Seed = 1. Maize – ₹ 22 /kg, 2. Chickpea – ₹ 60 /kg, 3. Stover - ₹ 1 /kg & 4. Haulm – ₹ 2 /kg

Conclusion

In the light of above discussion it could be conclude that intercropping system with maize -chickpea with 1:1 (Additive series) produced higher maize equivalent yield, covering highest land equivalent ratio and fetching highest net realization and BCR under middle Gujarat condition.

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