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Growth and yield of summer maize as influenced by intercropping systems

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Abstract
A field experiment was carried out at College Farm, Navsari Agricultural University, Navsari (Gujarat) to study the production potential of summer maize based intercropping systems during summer season of 2016. The experiment was carried out in randomized block design with four replications and ten treatments. Plant stand per net plot as well as days to 50 per cent silking of maize was not influenced significantly by various treatments. Plant height of maize was recorded maximum in sole maize (Paired rows at 45-75 cm) (156.66 and 176.47 cm at 45 and 90 DAS, respectively), whereas number of leaves per plant and dry matter accumulation were recorded maximum in sole maize (Normal sowing) as compared to intercropping treatments. Among intercropping treatments, maize + green gram (1:1) recorded maximum plant height (147.96 and 166.65 cm at 45 and 90 DAS, respectively), number of leaves per plant (6.80, 11.15 and 13.55 at 30, 60 and 90 DAS, respectively) and dry matter accumulation (53.50 and 99.93 g/plant at 45 DAS and harvest, respectively). Sole maize (Normal and paired rows sowing) recorded higher number of cobs per plant, cob length, cob girth, number of seeds per cob and 100 grains weight as compared to intercropping treatments. Grain and straw yield (3325 and 7292 kg/ha, respectively) was recorded significantly higher in T_1 – sole maize (Normal sowing). Both sole maize treatments recorded more grain and straw yield than intercropping treatments. Among the intercropping treatments, maize + green gram (1:1) (T_5) recorded maximum grain as well as straw yield followed by maize + cowpea (1:1) (T_8).

Keywords: cob, grain, straw, dry matter accumulation, harvest index, green gram, cowpea

Introduction
Maize (*Zea mays* L.) is the world's leading cereal grain crop. It is one of the most versatile emerging crops having wider adaptability. Maize is known as queen of cereals because of its highest genetic yield potential. It is the only food cereal crop that can be grown in diverse seasons, ecologies and uses. Besides this, maize has many types like normal yellow/white grain, sweet corn, baby corn, popcorn, waxy corn, high amylase corn, high oil corn, quality protein maize, *etc*. In addition to staple food for human being and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries, *etc*.

Intercropping has been recognized potentially beneficial system to increase crop production per unit time and area, which can provide substantial yield advantages compared to sole cropping. These advantages may be especially important because they are achieved not by means of costly inputs, but by the simple expedient of growing crops together (Willey, 1979) [12]. The system not only serves a purpose of insurance against crop failure, but also reduces soil erosion if the plants of subsidiary crops have trailing habit. Proper intercropping may serve as crop rotation also.

The recent concept of intercropping is to maintain optimum plant population of both component crops by adjusting crop geometry. The space in the field, which is made available to the individual plant, is an important factor affecting the growth and yield of crop. It provides congenial environmental conditions for the optimum growth and development of crop. The modification of crop geometry may help in accommodating the companion crop. By adopting the appropriate planting pattern the productivity can be enhanced.

Cereals are most important intercropped with pulses on a variety of soils because the time of peak nutrient demand of cereal and pulse is not overlap in cereal + pulse intercropping system, e.g., the peak nutrient demand period for green gram is around 35 DAS while it is 50 days for maize. Competition for light is also less among cereal + pulse intercropping. Complementary should exist between cereal + pulse intercropping. The difference in maturity of cereal and pulse is more advantage for easy harvesting.

Material and Methods

A field experiment was carried out during summer season of 2015-16 at College Farm, Navsari Agricultural University, Navsari (Gujarat). The climate of this zone is typically tropical, characterized by humid and warm monsoon with heavy rains, cold winter and fairly hot summer. The summer season commences by the middle of February and the temperature reaches to its maximum in April or May. Thus, April and May are the hottest months of the season/year. The overall meteorological data (Figure 1.) revealed that the weather and climate conditions were normal and favorable for the growth and development of maize and pulse crops.

The experimental field was clayey in texture and showed low, medium and high rating for available nitrogen (214 kg/ha), phosphorus (35.16 kg/ha) and potassium (345.50 kg/ha), respectively. The soil was slightly alkaline (pH 7.8) with normal electric conductivity (0.65 dS/m).

Total ten treatments *viz.*, T_1 - sole maize, T_2 - sole maize (Paired rows at 45-75 cm), T_3 - sole green gram, T_4 - sole cowpea, T_5 - maize + green gram (1:1), T_6 - maize + green gram (Paired 2:1), T_7 - maize + green gram (Paired 2:2), T_8 - maize + cowpea (1:1), T_9 - maize + cowpea (Paired 2:1) and T_{10} - maize + cowpea (Paired 2:2) were evaluated in randomized block design with four replications.

The recommended dose of NPK was 60-40-00 kg/ha for maize while, this value for sole intercrop was 20-40-00 kg/ha. The plot wise quantity of seed was weighted and sown manually at a depth of 2-3 cm in the furrow. At the same time, green gram and cowpea seeds were sown in marked rows. Seed were covered properly with soil and irrigation was applied carefully in each plot immediately after sowing. One intercultural operation was carried out by using mechanical weeder at 24 day after sowing followed by two hand weeding at 25 and 43 days after sowing.

The statistical analysis of data recorded for different characters during the course of investigation was carried out through the procedure appropriate to the Randomized Block Design of the experiment as described by Panse and Sukhatme (1967) [9]. The significance of difference was tested by 'F' test. Five per cent level of significance was used to test the significance of results. The critical differences were calculated when the differences among treatments were found significant in 'F' test. In the remaining cases, only standard error of means was worked out. The co-efficient of variance (C.V. %) was also worked out.

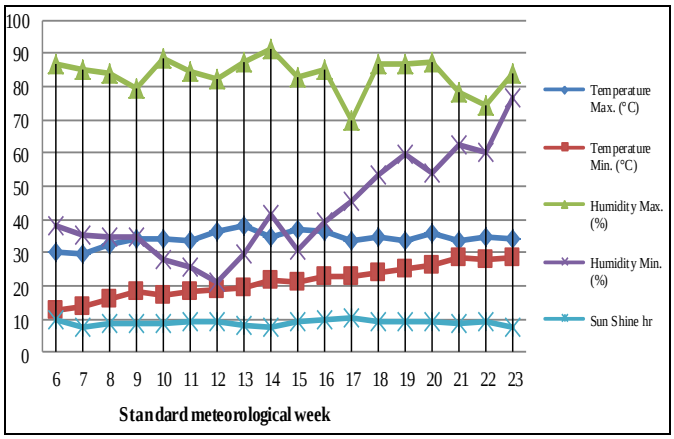

Fig 1: Mean weekly meteorological data during crop season of the year 2016

Results and Discussion

Growth characters

Plant stand

The results (Table 1) showed non-significant influence of different treatments on plant stand of maize at harvest. This was mainly due to the fact that a uniform maize stand in each row was maintained by thinning in all the treatments, therefore, no competition between inter row and intra row crops.

Plant height (cm)

The results (Table 1) showed non-significant effect of various treatments on plant height of maize up to 30 DAS, while the differences were significant at 60 and 90 DAS. The results revealed that both sole maize treatments *viz.*, sole maize and sole maize (Paired rows at 45-75 cm) were statistically at par. Plant height of maize was significantly increased due to the fact that the optimum space available in sole maize reduced the competition of light and nutrients, which probably provided favourable physical environment and helped the plant to grow taller.

Introducing of green gram and cowpea in maize recorded considerably lower height compared with sole maize. It might be due to higher inter crop competition for resources which suppress the crop growth. Considerably higher plant height of maize under sole maize as compared to different intercropping treatments was also reported by Choudhary *et al.* (2012) [3], Mandal *et al.* (2014) [6] and Nyasasi and Kisetu (2014) [8].

Table 1: Growth characters of maize as influenced by sole and intercropping treatments:

Treatments	Final plant stand	Plant height (cm)			Number of leaves per plant			Dry matter accumulation (g/plant)		Days to 50% Silking
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	45 DAS	At harvest	
Sole maize	97.00	42.75	155.09	173.43	6.80	11.15	13.55	53.50	99.93	68.50
Sole maize (Paired rows at 45-75 cm)	97.25	43.00	156.66	176.47	6.55	11.05	13.40	52.09	97.29	68.00
Sole green gram	-	-	-	-	-	-	-	-	-	-
Sole cowpea	-	-	-	-	-	-	-	-	-	-
Maize + green gram (1:1)	101.75	42.16	147.96	166.65	6.35	10.25	13.20	50.08	89.46	68.00
Maize + green gram (paired 2:1)	100.25	40.88	138.87	155.64	5.65	9.15	11.55	46.65	79.02	69.75
Maize + green gram (paired 2:2)	101.00	41.28	142.98	160.66	5.90	9.75	12.15	48.92	82.82	66.00
Maize + cowpea (1:1)	101.25	41.98	146.11	163.93	6.25	10.20	12.55	49.19	87.26	68.75
Maize + cowpea (paired 2:1)	106.50	40.08	136.77	152.44	5.55	9.05	11.45	45.55	73.14	69.00
Maize + cowpea (paired 2:2)	104.00	41.13	140.62	159.18	5.75	9.40	12.05	47.93	79.14	66.75
S.Em. ±	6.29	2.17	4.60	5.21	0.28	0.41	0.45	1.66	3.09	2.59
C.D. at 5%	N.S.	N.S.	13.54	15.33	0.83	1.20	1.33	4.88	9.07	N.S.

Number of leaves per plant

Number of leaves per plant at 30, 60 and 90 DAS was reduced remarkably under intercropping treatments. This might be due to more competition among plants (Maize as well as intercrops) for light, space, water and nutrients.

Dry matter accumulation (g/plant)

The results revealed that all the sole maize treatments *viz.*, T_1 - sole maize (normal sowing) and T_2 - sole maize (Paired rows at 45-75 cm) accumulated higher plant dry matter at 45 DAS and harvest as compared to intercropping treatments. Introducing green gram and cowpea intercrops in maize recorded considerably lower dry matter accumulation per plant of maize as compared to sole maize. It might be due to higher inter crop competition for resources which supress the crop growth as evident from lower plant height and reduced number of leaves per plant. The present findings are in agreement with the results of Sarlak *et al*. (2008) [10], Choudhary *et al*. (2012) [3] and Mandal *et al*. (2014) [6].

Days to 50 per cent Silking

The data on days to 50 per cent siilking of maize were non-significantly influenced by various treatments.

Yield attributes

Number of cobs per plant

The data of number of cobs per plant as influenced by various treatments showed that all the intercropping treatments recorded less number of cobs per plant, but differences were statistically non-significant.

Cob length and cob girth (cm)

Intercropping of green gram and cowpea with maize in different row ratios reduced the cob length and girth as compared to sole maize. Among the intercropping treatments, T_5 – maize + green gram (1:1) recorded the maximum cob length and girth (12.39 and 12.54 cm, respectively).

Number of seeds per cob and 100 grains weight (g)

The results showed that intercropping of green gram and cowpea with maize in different row ratios reduced the number of seeds per cob and 100 grains weight as compared to sole maize. Among the intercropping treatments, T_5 – maize + green gram (1:1) recorded the maximum number of seeds per cob (247.75) and 100 grains weight (16.98 g).

Lower values of yield attributes under intercropping treatments might be due to the suppressing effect of fast growing, vigorous growth of broad leaved canopied intercrop. These findings are in conformity with the results reported by Sheoran *et al.* (2010) [11], Chaoudhary *et al.* (2012) [3] and Kaushal *et al*. (2015) [5] who also observed lower number of seeds per cob and 1000 grain weight of maize under intercropping treatments with different legume intercrops.

Table 2: Yield attributes and yield of maize as influenced by sole and intercropping treatments

Treatments	No. of cobs per plant	Cob length (cm)	Cob girth (cm)	No. of seeds per cob	100-grains weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)	Maize equivalent yield (kg/ha)
Sole maize	1.15	13.42	12.98	254.85	17.33	3325	7292	31.44	3325
Sole maize (Paired rows at 45-75 cm)	1.10	12.81	12.73	252.45	17.11	3176	7067	31.09	3176
Sole green gram	-	-	-	-	-	-	-	-	5160
Sole cowpea	-	-	-	-	-	-	-	-	3596
Maize + green gram (1:1)	1.00	12.39	12.54	247.75	16.98	2962	6646	30.84	5305
Maize + green gram (paired 2:1)	1.10	10.81	10.85	213.70	16.44	2655	5861	31.16	3946
Maize + green gram (paired 2:2)	1.00	11.92	12.03	226.95	16.68	2790	6113	31.33	5236
Maize + cowpea (1:1)	1.10	12.15	12.21	231.05	16.84	2916	6457	31.12	4495
Maize + cowpea (paired 2:1)	1.05	10.26	10.94	209.15	16.37	2618	5750	31.32	3457
Maize + cowpea (paired 2:2)	1.05	11.46	11.48	220.50	16.53	2737	6019	31.35	4373
S.Em. ±	0.07	0.61	0.49	11.22	0.21	146	358	1.20	233
C.D. at 5%	N.S.	1.80	1.45	32.98	0.63	431	1052	N.S.	675

Yield potential

Grain yield (kg/ha)

Sole maize (T_1) recorded the highest grain yield (3325 kg/ha) which was statistically at par with T_2 - sole maize sown at 45-75 cm paired row system (3176 kg/ha), T_5 - maize + green gram (1:1) (2962 kg/ha) and T_8 - maize + cowpea (1:1) (2916 kg/ha) (Table 2). Grain yield of maize was reduced in intercropping treatments to varying extent. Maize + green gram (1:1) (T_5) recorded maximum seed yield among intercropping treatments, whereas lowest seed yield of maize was noted when it was intercropped with cowpea.

The reduction in seed yield of maize under intercropping treatments could be assigned to lower values of almost all yield attributes *viz*., number of cob per plant, cob length, cob girth, number of seeds per cob and 100 grain weight under intercropping treatments resulting from poor plant growth due to competition effect between maize and intercrops for resources like sun light, space, moisture and plant nutrients. Reduction in seed yield of maize owing to legume intercropping was also reported by Chalka and Nepalia (2005) [2], Marer *et al.* (2007) [7], Sheoran *et al.* (2010) [11], Chaudhary *et al.* (2012) [3], Mandal *et al.* (2014) [6], Nyasasi and Kisetu (2014) [8], Kaushal *et al.* (2015) [5].

The maximum reduction in grain yield of maize due to cowpea intercropping can be ascribed to its relatively luxuriant vegetative growth of cowpea as compared to green gram which supressed the growth of maize.

Straw yield (kg/ha)

Sole maize (Normal sown) (T_1) recorded the highest straw yield of maize (7292 kg/ha) closely followed by sole maize sown at 45-75 cm spacing (T_2) (7067 kg/ha) (Table 2). Maize straw yield was decreased significantly due to intercropping of green gram and cowpea in different row ratios. All the intercropping treatments were statistically at par with respect to straw yield of maize.

Harvest Index (%)

The data pertaining to the harvest index of maize as affected by different treatments (Table 2) showed non-significant influence of different treatments on harvest index of maize.

Maize equivalent yield (kg/ha)

The results (Table 2) revealed that maize equivalent yield was influenced significantly due to various intercropping treatments. Higher maize equivalent yield from all intercropping treatments indicated yield advantage from green

gram and cowpea intercropping treatments over sole maize. Maximum maize equivalent yield was recorded in T_5 - maize + green gram (1:1) and it was at par with T_7 - maize + green gram (Paired 2:2) and T_3 - sole green gram. This might be due to higher yield of maize grains and green gram seeds as well as higher price of green gram seeds. Similar result about higher maize equivalent yield in intercropping were also reported by Chalka and Nepalia (2005) [2], Choudhary *et al*. (2012) [3], Behere *et al*. (2013) [1] and Choudhary *et al*. (2014) [4].

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