

Original Research Article

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## Quality Characters of Maize and NPK Status of Soil as Influenced by Various Sole and Intercropping Treatments

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### ABSTRACT

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A field experiment was carried out at College Farm, Navsari Agricultural University, Navsari (Gujarat) to study the quality characters and yield potential of summer maize based intercropping systems during summer season of 2016. The experiment was laid out in randomized block design with four replications and ten treatments. Protein, oil and carbohydrates content of maize were not affected significantly by various treatments. Both sole maize treatments ( $T_1$  and  $T_2$ ) were statistically at par with respect to protein, oil and total carbohydrate yield. Intercropping treatments significantly declined protein, oil and total carbohydrate yield of maize except  $T_5$  - maize + green gram (1:1). The effect of different treatments was significant on available N and  $P_2O_5$  status of soil after crop harvest, but non-significant on available  $K_2O$ . Available N and  $P_2O_5$  content after crop harvest in soil were recorded remarkably higher in sole green gram ( $T_3$ ) and sole cowpea ( $T_4$ ) closely followed by maize + green gram/cowpea intercropping treatments and least in sole maize. Among the intercropping treatments, maize + green gram (Paired 2:2) ( $T_7$ ) recorded maximum available N and  $P_2O_5$  content after crop harvest in soil followed by maize + green gram (1:1) ( $T_5$ ).

### Introduction

Maize is one of the most important cereal crops of the world and contributes to food security in most of the developing countries. United States is the largest maize producer and also has a large surplus, which also makes it the largest maize exporter. Brazil, Ukraine and Argentina are the other key maize producing countries behind USA. The four countries together account for 80 - 85% of the total exports in maize. In India, maize is emerging as third most important crop after rice and wheat. Its importance lies in the fact that it is not only used for human food and animal feed but at the same time it is also

widely used for corn starch industry, corn oil production, baby corns etc.

Some of the established and speculated advantages of cereal-legume intercropping systems are higher yields, greater land use efficiency and improvement of soil fertility through nitrogen fixation by component legume (Willey, 1979). In addition, legume intercrops are included in cropping systems because they reduce soil erosion and suppress weeds. Cereal like maize, pearl millet and sorghum are traditionally intercropped with legumes like green gram, cowpea, black gram

and groundnut. Such cereal/legume mixtures probably reduce competition for nitrogen, since the legume depends mainly on its own N fixation while the cereal uses mineral N (Banik and Sharma, 2009).

## Materials and Methods

An experiment was conducted during summer season of 2016 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 average annual rainfall of the tract is about 1500 mm. 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 (Table 1) revealed that the weather and climate conditions were normal and favorable for the growth and development of maize and pulse crops.

The experimental soil was clayey in texture, slightly alkaline (pH 7.8) in reaction with normal electric conductivity (0.65 dS/m), low in available nitrogen (214 kg/ha), medium in phosphorous (35.16 kg/ha) and rich in potassium (345.50 kg/ha).

Total ten treatments *viz.*, T<sub>1</sub>- sole maize, T<sub>2</sub> - sole maize (Paired rows at 45-75 cm), T<sub>3</sub> - sole green gram, T<sub>4</sub> -sole cowpea, T<sub>5</sub>- maize + green gram (1:1), T<sub>6</sub> -maize + green gram (Paired 2:1), T<sub>7</sub> -maize + green gram (Paired 2:2), T<sub>8</sub> - maize + cowpea (1:1), T<sub>9</sub> - maize +

cowpea (Paired 2:1), T<sub>10</sub> - maize + cowpea (Paired 2:2) were tried in randomized block design with four replications.

Representative samples of seed were taken from each treatment and dried in oven at 65°C temperature for 24 hours and powdered by mechanical grinder. Then the nitrogen content of seed was determined by micro Kjeldahl's method (Jackson, 1967). The protein content in seed was calculated by multiplying nitrogen content of seed (%) with the conversion factor of 6.25 (Bhuiya and Chowdhary, 1974). The protein yield in seed was calculated by using the following formula.

$$\text{Protein yield (kg/ha)} = \frac{\text{Protein content in seed (\%)} \times \text{Seed yield (kg/ha)}}{100}$$

Representative seed samples were taken from each treatment and grind by mortar and pestle. Then oil content of seed was determined by Automatic Soxhlet Extractor. The oil content in seeds is expressed as percentage. The oil yield was computed for each treatment by using the following formula.

$$\text{Oil yield (kg/ha)} = \frac{\text{Oil content in seed (\%)} \times \text{Seed yield (kg/ha)}}{100}$$

The total carbohydrate content (%) was estimated from the grinded grain of maize representative samples using phenol sulphuric acid method (Krishnaveni *et al.*, 1984). The total carbohydrate content yield was computed for each treatment by using the following formula.

$$\text{Total carbohydrate yield (kg/ha)} = \frac{\text{Total carbohydrate content in seed (\%)} \times \text{Seed yield (kg/ha)}}{100}$$

For estimation of available N, P and K in soil after harvest of crop, respective soil samples were drawn from each plot at 30 cm soil depth and analyzed for determination of content of respective nutrient using the following methods.

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). 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.

## **Results and Discussion**

### **Yield and quality**

#### **Grain yield (kg/ha)**

The results (Table 2) indicated significant influence of different treatments on grain yield of maize. Sole maize *viz.*, normal sowing (T<sub>1</sub>) and paired rows at 45-75 cm (T<sub>2</sub>) with 3325 and 3176 kg/ha grain yield were statistically at par and recorded higher grain yield as compared to all maize + green gram and maize + cowpea intercropping treatments. 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 suppress the growth of maize. Similar results of reduction in grain yield of maize under intercropping systems are also in agreement with the findings of Sheoran *et al.*, (2010), Chaudhary *et al.*, (2014), Mandal *et al.*, (2014).

In comparison of intercropping treatments, treatment T<sub>5</sub> – maize + green gram (1:1) recorded the maximum grain yield of maize followed by T<sub>8</sub>– maize + cowpea (1:1), T<sub>7</sub> – maize + green gram (Paired 2:2) and T<sub>9</sub>– maize + cowpea (Paired 2:2).

#### **Protein content (%)**

Results (Table 2) revealed that there was no significant effect of different treatments on protein content of maize. However, protein content was recorded numerically higher in sole maize (T<sub>1</sub>) closely followed by sole maize (Paired rows at 45-75 cm). The higher protein content of maize in sole maize was observed by Mandal *et al.*, (2014).

#### **Protein yield (kg/ha)**

The effect of different treatments was found to be significant on protein yield of maize (Table 2). The maximum protein yield (343.96 kg/ha) was recorded in T<sub>1</sub> – sole maize which was statistically at par with T<sub>2</sub> – sole maize (Paired rows at 45-75 cm) (326.66 kg/ha) and T<sub>5</sub> – maize + green gram (1:1) (302.39 kg/ha).

#### **Oil content (%)**

The data (Table 2) indicated that there was reduction in oil content of maize under various intercropping treatments, but the differences could not reach to the significant level when compared with sole maize except maize + green gram (1:1).

This might be owing to the fact that oil content is a varietal character and less influenced by environment.

The non-significant effect of legume intercrops on oil content of maize was also reported by Sultana *et al.*, (2013).

**Oil yield (kg/ha)**

The results (Table 2) showed significant influence of different treatments on oil yield of maize. The results revealed that both sole maize treatments *viz.*, T<sub>1</sub> – sole maize and T<sub>2</sub> – sole maize (Paired rows at 45-75 cm) recorded oil yield of 220.17 and 208.21 kg/ha, respectively and were statistically at par.

Intercropping green gram and cowpea with maize in various row ratios reduced the oil yield of maize as compared to sole maize. Among the intercropping treatments, T<sub>5</sub> – maize + green gram (1:1) recorded higher oil

yield of maize (191.46 kg/ha).

This significant difference in oil yield might be due to large variation in grain yield of maize under different treatments.

**Total carbohydrate content (%)**

Results (Table 2) revealed that there was no significant effect of different treatments on total carbohydrate content of maize. However, total carbohydrate content was recorded numerically higher in sole maize (T<sub>1</sub>) closely followed by sole maize (Paired rows at 45-75 cm).

**Estimation of available N, P and K in soil after harvest of crop, respective soil samples were drawn from each plot at 30 cm soil depth and analyzed for determination of content of respective nutrient using the following methods**

Sr. No.	Particulars	Procedure used	Reference
1.	Available Nitrogen	Alkaline potassium permanganate method	Jackson (1967)
2.	Available Phosphorus	Spectrophotometric method (Olsen's method)	Jackson (1967)
3.	Available Potassium	Flame photometric method	Jackson (1967)

**Table.1** Mean weekly meteorological data during crop season of the year 2016

Month & Year	Std. Week	Date	Temperature (°C)		Relative humidity (%)		Sun shine hrs. day <sup>-1</sup>
			Max.	Min.	Max.	Min.	
Feb. 2016	6	01-06	30.3	12.9	86.7	38.0	9.9
	7	07-13	29.5	13.8	85.1	35.1	7.7
	8	14-20	32.6	15.9	84.3	34.7	8.6
	9	21-27	34.3	18.6	79.5	34.9	8.6
Mar. 2016	10	28-05	33.9	17.4	88.3	27.7	8.6
	11	06-12	33.5	18.4	84.7	25.9	9.0
	12	13-19	36.3	19.0	82.5	21.1	9.1
	13	20-26	38.0	19.6	87.5	29.7	8.2
	14	27-02	34.8	21.5	91.4	41.7	7.5
April 2016	15	03-09	36.9	21.0	83.0	30.6	9.4
	16	10-16	36.5	22.9	84.9	39.4	9.8
	17	17-23	33.8	22.8	69.6	45.5	10.5
	18	24-30	34.9	24.1	86.7	53.2	9.3
May 2016	19	01-07	33.8	25.2	86.8	59.6	9.3
	20	08-14	36.0	26.4	87.5	54.2	9.2
	21	15-21	33.5	28.4	78.5	62.7	8.6
	22	22-28	34.7	28.1	74.2	60.0	9.4
	23	29-31	34.2	28.3	83.9	76.9	7.5

**Table.2** Protein content (%), protein yield (kg/ha), oil content, oil yield, total carbohydrate content (%) and total carbohydrate yield of Maize as influenced by sole and intercropping treatments

<b>Treatment</b>	<b>Seed yield (kg/ha)</b>	<b>Protein content (%)</b>	<b>Protein yield (kg/ha)</b>	<b>Oil content (%)</b>	<b>Oil yield (kg/ha)</b>	<b>Total carbohydrate content (%)</b>	<b>Total carbohydrate yield (kg/ha)</b>
Sole maize	3325	10.34	343.96	6.63	220.17	74.21	2467.24
Sole maize (Paired rows at 45-75 cm)	3176	10.28	326.66	6.55	208.21	74.14	2349.28
Sole green gram	-	-	-	-	-	-	-
Sole cowpea	-	-	-	-	-	-	-
Maize + green gram (1:1)	2962	10.21	302.39	6.46	191.46	74.01	2189.65
Maize + green gram (paired 2:1)	2655	9.94	263.51	6.06	160.64	73.58	1956.64
Maize + green gram (paired 2:2)	2790	10.06	280.36	6.28	174.52	73.80	2058.64
Maize + cowpea (1:1)	2916	10.17	296.58	6.40	186.55	73.91	2153.70
Maize + cowpea (paired 2:1)	2618	9.87	258.74	5.98	156.31	73.47	1921.37
Maize + cowpea (paired 2:2)	2737	10.01	273.84	6.20	169.93	73.71	2020.64
S.Em. ±	146	0.15	15.67	0.16	10.26	1.31	105.54
C.D. at 5%	431	N.S.	46.09	N.S.	30.18	N.S.	310.41

**Table.3** Available N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O status of soil after harvest as influenced by sole and intercropping treatments

Treatment	Available N (kg/ha)	Available P <sub>2</sub> O <sub>5</sub> (kg/ha)	Available K <sub>2</sub> O (kg/ha)
Sole maize	189.82	30.34	319.45
Sole maize (Paired rows at 45-75 cm)	194.54	31.15	320.44
Sole green gram	269.42	41.11	343.56
Sole cowpea	261.47	39.93	342.23
Maize + green gram (1:1)	238.58	37.05	336.87
Maize + green gram (paired 2:1)	220.85	36.04	325.14
Maize + green gram (paired 2:2)	242.76	37.21	339.21
Maize + cowpea (1:1)	230.79	36.25	327.15
Maize + cowpea (paired 2:1)	215.84	34.50	322.51
Maize + cowpea (paired 2:2)	236.88	36.75	329.47
S.Em. ±	7.07	0.90	10.04

**Total carbohydrate yield (kg/ha)**

The effect of different treatments was found to be significant on total carbohydrate yield of maize grains (Table 2). The maximum total carbohydrate yield (2467.24 kg/ha) was recorded in T<sub>1</sub> – sole maize which was statistically at par with T<sub>2</sub> – sole maize (Paired rows at 45-75 cm) (2349.28 kg/ha) and T<sub>5</sub> – maize + green gram (1:1) (2189.65 kg/ha).

**NPK status of soil (After crop harvest)**

**Available N in soil (kg/ha)**

The results pertaining to the available N status of soil after crop harvest (Table 3) showed significant differences on available N in soil due to different treatments.

The maximum available N status of soil after crop harvest was observed in T<sub>3</sub> – sole green gram (269.42 kg/ha) followed by T<sub>4</sub> – sole cowpea (261.47 kg/ha). Both sole maize treatments (T<sub>1</sub> and T<sub>2</sub>) were statistically at par and recorded lower N status as compared to rest of the treatments. Among the intercropping treatments, T<sub>7</sub> - maize + green

gram (Paired 2:2) recorded the highest available N content in soil which was statistically at par with T<sub>5</sub> - maize + green gram (1:1), T<sub>10</sub> - maize + cowpea (Paired 2:2) and T<sub>8</sub> – maize + cowpea (1:1).

Maximum available N content in soil after crops harvest in both sole pulses (T<sub>3</sub> and T<sub>4</sub>) as well as intercropping treatments might be due to fixation of atmospheric nitrogen by rhizobium bacteria in nodules on their roots and mineralization of N from organic residues. This could also be ascribed to the residual effect of applied chemical fertilizer to respective crops based on recommendation dose. Same results were also reported by Padhi and Panigrahi (2006), Dahmardeh *et al.*, (2010), Sheoran *et al.*, (2010), Girijesh *et al.*, (2015) and Kaushal *et al.*, (2015).

**Available P<sub>2</sub>O<sub>5</sub> in soil (kg/ha)**

The effect of various treatments on available P<sub>2</sub>O<sub>5</sub> in soil after crop harvest was found to be significant (Table 3). The differences in available P<sub>2</sub>O<sub>5</sub> content of soil after crop harvest were non-significant in case of sole maize treatments (T<sub>1</sub> and T<sub>2</sub>). The status was improved to some extent under sole green



gram and sole cowpea followed by maize + green gram/cowpea intercropping treatments.

Increase in available P<sub>2</sub>O<sub>5</sub> status in soil due to pulse crops secrete greater amount of acid phosphatases in soil from roots than maize. To increase plant stand of pulses in intercropping, amount of phosphorus was increased. Dahmardeh *et al.*, (2010) and Girijesh *et al.*, (2015) also found maximum available P<sub>2</sub>O<sub>5</sub> status in soil after crop harvest in sole intercrops (legumes) followed by intercropping treatments compared to sole maize.

### Available K<sub>2</sub>O in soil (kg/ha)

The results indicated non-significant effect of different treatments on available K<sub>2</sub>O content in soil after crop harvest (Table 3). However, available K<sub>2</sub>O content in soil recorded numerically higher in sole green gram (T<sub>3</sub>) closely followed by sole cowpea (T<sub>4</sub>). Intercropping as well as sole maize treatments showed lower available K<sub>2</sub>O content in soil.

Higher available K<sub>2</sub>O content in soil under sole pulses might be due to deep root system of pulses, they could absorb K<sub>2</sub>O from the deep soil level and increased biological and chemical activity in rhizosphere might have resulted in higher available potassium content in soil. Similar results were also reported by Dahmardeh *et al.*, (2010) and Girijesh *et al.*, (2015).

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