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Performance of Maize as Influenced by Cropping Systems and Nutrient Management Practices in Maize Based Cropping System under Bhadra Command Area

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A B S T R A C T

Field experiment was conducted to know the performance of maize in maize based cropping system as influenced by cropping systems and nutrient management practices at the Agricultural Research Station, Kathalagere, Channagiri Taluk, Davanagere district, Karnataka during both *kharif* and *rabi* season. Higher grain and stover yields of maize were recorded with maize + cowpea – groundnut system (57.61 and 84.70 kg ha^{-1}, respectively) as compared to maize + Frenchbean – groundnut system. Application of 100% recommended NPK + poultry manure (Recommended FYM equivalent on N basis) recorded significantly higher grain and stover yields (64.52 and 91.94 q ha^{-1}, respectively) followed by 100% recommended NPK + pressmud @ recommended FYM equivalent on N basis (62.00 and 88.53 q ha^{-1}, respectively). Uptake of nitrogen, phosphorus and potassium by maize (148.8, 37.58 and 134.66 kg ha^{-1}, respectively) was significantly higher with the application of 100% recommended NPK + poultry manure (recommended FYM equivalent on N basis) as compared to other treatments except with the application of 100% recommended NPK + pressmud (recommended FYM equivalent on N basis).

Key words: Maize, Groundnut, Cropping systems, Nutrient management, Organic manure

Maize (*Zea mays* L) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. It is cultivated on nearly 150 m ha in about 160 countries having wider diversity of soil, climate, biodiversity and management practices that contributes 36% (782 m t) in the global grain production. In India, maize is the third most important food crops after rice and wheat. According to advance estimate its production is likely to be 22.23 Metric Tonnes (2012-13) mainly during *Kharif* season which covers 80% area (Anonymous 2010). Maize in India, contributes nearly 9% in the national food basket. 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.

Long term application of organic manures with inorganic fertilizers have clearly shown that high productivity and sustained yields can be achieved through integrated nutrient management. Hence, upward trend in productivity through balanced fertilization is a better option in the current scenario of our country. In the present investigation in order to increase the production potential of maize based intercropping systems, combinations of organic sources of nutrients viz. farm yard manure, pressmud and poultry manure were applied along with inorganic fertilizers.

MATERIALS AND METHODS

A field experiment was conducted in both *kharif* and

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rabi season at Agricultural Research Station, Kathalagere, Davanagere district, Karnataka. The soil was red clay loam soil with nearly n6eutral in soil reaction (6.8), high organic carbon (0.65%), low available P (17.2 kg ha^{-1}) and high available K (233.9 kg ha^{-1}). The experiment was laid out in a factorial randomized complete block design involving two factors comprising fourteen treatment combinations with three replications. Land was ploughed with a bullock pair after the harvest of previous crop and harrowed twice to crush the clods and smoothened to get fine tilth. The plough or the cultivator was lifted at each plot bunds so as to avoid intermixing of the soil. After harvest of first crop, again land was ploughed and harrowed to crush the clods and smoothened to get fine tilth.

For maize, shallow furrows were opened at 60 cm apart with the help of pick axe. The seeds were hand dibbled in the furrows by giving 30 cm spacing and covered with soil. French bean and cowpea seeds were sown as an intercrops in respective treatments on the same day in between two maize rows with spacing of 30 × 15 cm. Groundnut kernels treated with *rhizobium* were sown at 30 cm × 15 cm spacing as a second sole crop. In the treatment containing phosphorous solubilizing bacteria (PSB), seeds of maize, cowpea, Frenchbean and groundnut were treated with PSB at the time of sowing as per specification.

The fertilizer was applied as per the treatments in the form of urea, SSP and muriate of potash and $ZnSO_4$ was applied 5 cm away from the seed line and 5 cm deep into the soil according to treatment details. Recommended FYM was applied to the respective treatment plots for all the crops on area basis three weeks before sowing. Poultry manure, pressmud, green leaf manure and maize stalk compost were applied and were incorporated into the soil three weeks before sowing on nitrogen equivalent basis as that of recommended FYM as per the treatments to all the component crops on area basis in respective season. These organic manures were analyzed for NPK contents.

RESULTS AND DISCUSSION

Among the cropping systems, maximum grain and stover yields were recorded with maize + cowpea – groundnut system (57.61 and 84.70 kg ha^{-1}, respectively) to an extent of 32.14 and 57.59 per cent as compared to maize + Frenchbean – groundnut system (Table 1). This can be attributed to significantly higher values of yield components namely cob length (18.41 cm), cob weight (188.69 g), number of rows per cob (16.90), hundred grain weight (34.11 g), grain weight per cob (154.87 g) in maize + cowpea – groundnut system as compared to maize + Frenchbean – groundnut system (18.21 cm, 185.35 g, 6.90, 33.65 g and 152.61 g, respectively) (Table 2). These results are in conformity with the findings of Kavamahanga *et al*. (1995), Gollar and Patil (1997), Shivay *et al*. (1999), Rana *et al*. (2001).

Table 1 Total dry matter production (g $plant^{-1}$) of maize (*kharif*) at all growth stages as influenced by cropping systems and nutrient management practices in maize based cropping system

Treatment details	30 DAS			60 DAS			90 DAS			At harvest		
	2007-08	2008-09	Pooled	2007-08	2008-09	Pooled	2007-08	2008-09	Pooled	2007-08	2008-09	Pooled
Cropping Systems (C)												
C_1: Maize + Frenchbean - groundnut	8.08	9.12	8.60	79.91	83.61	81.76	256.60	263.47	260.04	303.22	309.12	306.17
C_2: Maize + cowpea - groundnut	10.25	12.09	11.17	84.50	88.13	86.32	264.66	271.02	267.84	311.62	320.12	315.87
S.Em±	0.72	0.96	0.85	1.48	1.59	1.57	2.73	2.66	2.71	2.83	3.76	3.16
C.D. at 5%	2.08	2.68	2.48	4.28	4.45	4.39	7.64	7.42	7.58	7.92	10.53	9.46
Nutrient management practices (N)												
N_1: 100% Rec. NPK	8.23	9.88	9.06	68.58	70.46	69.52	236.03	242.75	239.39	274.49	283.30	278.90
N_2: 75% Rec. NPK + rec.FYM	8.74	10.39	9.57	72.04	75.91	73.98	242.92	249.61	246.27	281.35	292.46	286.91
N_3: 100% Rec. NPK + rec. FYM	10.39	12.94	11.67	79.87	85.56	82.72	258.14	265.26	261.70	300.00	310.08	305.04
N_4: 75% Rec. NPK + poultry manure*	10.10	12.47	11.29	77.59	82.58	80.09	253.69	260.30	257.00	293.25	304.98	299.12
N_5: 100% Rec. NPK + poultry manure*	12.00	14.46	13.23	88.82	94.14	91.48	272.37	279.12	275.75	319.12	328.54	323.83
N_6: 75% Rec. NPK + pressmud*	9.22	10.96	10.09	73.99	78.04	76.02	246.45	252.78	249.62	284.76	297.59	291.18
N_7: 100% Rec. NPK + pressmud*	11.41	13.64	12.53	62.44	88.26	75.35	265.88	270.68	268.28	307.73	315.28	311.51
S.Em±	0.54	0.53	0.52	3.06	2.83	2.88	4.20	4.60	4.82	5.44	6.09	6.64
C.D. at 5%	1.53	1.48	1.50	8.56	8.46	8.63	12.56	13.25	13.89	15.18	17.56	18.54
Interaction (C × N)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*N equivalent basis of recommended FYM; NS: Non Significant; DAS: days after sowing

Significant differences in grain and stover yields with maize + cowpea – groundnut system over maize + Frenchbean – groundnut system may also be attributed to higher values of growth parameters like plant height at harvest (180.62 cm), leaf area at 60 DAS (45.76 dm^2 $plant^{-1}$) and total dry matter production at harvest (315.87 g $plant^{-1}$) as compared to maize + Frenchbean – groundnut system (176.68 cm, 39.82 dm^2 $plant^{-1}$ and 306.17 g $plant^{-1}$,

respectively) (Table 1). The better growth parameters might have influenced the crop positively in terms of absorption of nutrients, use of solar radiation and natural resources more efficiently.

Table 2 Cob length, cob weight, number of rows cob^{-1} and hundred kernel weight of maize (*kharif*) as influenced by cropping systems and nutrient management practices in maize based cropping system

Treatment details	Cob length (cm)			Cob weight plant^{-1} (g)			Number of rows cob^{-1}			Hundred kernel weight (g)		
	2007-08	2008-09	Pooled	2007-08	2008-09	Pooled	2007-08	2008-09	Pooled	2007-08	2008-09	Pooled
Cropping Systems (C)												
C_1: Maize + Frenchbean - groundnut	18.00	18.42	18.21	184.26	186.44	185.35	15.56	16.18	15.87	33.48	33.82	33.65
C_2: Maize + cowpea - groundnut	18.22	18.60	18.41	187.96	189.42	188.69	16.18	17.62	16.90	33.86	34.35	34.11
S.Em±	0.06	0.05	0.06	1.04	0.90	1.16	0.20	0.48	0.34	0.12	0.16	0.15
C.D. at 5%	0.18	0.16	0.19	2.92	2.52	3.24	0.58	1.35	0.98	0.34	0.48	0.42
Nutrient management practices (N)												
N_1: 100% Rec. NPK	17.24	17.82	17.53	182.14	184.25	183.20	14.80	15.45	15.13	33.02	33.44	33.23
N_2: 75% Rec. NPK + rec.FYM	17.76	18.06	17.91	183.96	185.90	184.93	15.20	16.42	15.81	33.18	33.85	33.52
N_3: 100% Rec. NPK + rec. FYM	18.25	18.64	18.45	186.89	188.74	187.82	16.08	17.26	16.67	33.96	34.59	34.28
N_4: 75% Rec. NPK + poultry manure*	18.12	18.48	18.30	185.76	187.70	186.73	15.97	17.10	16.54	33.80	34.28	34.04
N_5: 100% Rec. NPK + poultry manure*	18.64	18.96	18.80	189.56	191.25	190.41	16.96	18.40	17.68	34.95	35.86	35.41
N_6: 75% Rec. NPK + pressmud*	18.00	18.24	18.12	185.12	187.10	186.11	15.50	16.86	16.18	33.50	34.00	33.75
N_7: 100% Rec. NPK + pressmud*	18.48	18.85	18.67	188.14	189.52	188.83	16.24	17.85	17.05	34.50	35.10	34.80
S.Em±	0.12	0.09	0.11	0.93	0.86	0.86	0.27	0.36	0.32	0.26	0.37	0.36
C.D. at 5%	0.34	0.28	0.32	2.62	2.48	2.52	0.78	1.10	0.96	0.79	1.12	1.08
Interaction (C × N)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*N equivalent basis of recommended FYM; NS: Non Significant

Table 3 Grain weight cob^{-1}, grain yield and stover yield of maize (*kharif*) as influenced by cropping systems and nutrient management practices in maize based cropping system

Treatment details	Grain weight cob^{-1} (g)			Grain yield (q ha^{-1})			Stover yield (t ha^{-1})		
	2007-08	2008-09	Pooled	2007-08	2008-09	Pooled	2007-08	2008-09	Pooled
Cropping Systems (C)									
C_1: Maize + Frenchbean - groundnut	151.26	153.96	152.61	53.90	57.29	55.60	79.50	84.50	82.00
C_2: Maize + cowpea - groundnut	154.13	155.60	154.87	55.11	60.11	57.61	81.01	88.36	84.69
S.Em±	0.91	0.54	0.78	0.41	0.85	0.69	0.51	0.94	0.79
C.D. at 5%	2.54	1.58	2.18	1.15	2.55	1.95	1.52	2.93	2.32
Nutrient management practices (N)									
N_1: 100% Rec. NPK	151.15	153.25	152.20	47.78	50.59	49.19	70.14	74.27	72.20
N_2: 75% Rec. NPK + rec.FYM	153.50	155.84	154.67	50.84	54.45	52.65	74.12	79.39	76.76
N_3: 100% Rec. NPK + rec. FYM	158.24	160.76	159.50	55.78	59.45	57.62	80.04	85.31	82.68
N_4: 75% Rec. NPK + poultry manure*	156.75	158.90	157.83	53.70	57.39	55.55	77.65	82.99	80.32
N_5: 100% Rec. NPK + poultry manure*	160.84	162.98	161.91	61.06	67.98	64.52	87.01	96.87	91.94
N_6: 75% Rec. NPK + pressmud*	155.68	156.65	156.17	52.91	56.32	54.62	76.83	81.78	79.30
N_7: 100% Rec. NPK + pressmud*	159.35	161.50	160.43	59.38	64.61	62.00	84.79	92.26	88.53
S.Em±	0.86	0.78	0.78	1.67	2.34	2.24	2.12	3.49	3.04
C.D. at 5%	2.58	2.18	2.25	4.68	6.54	6.25	5.92	9.74	8.71
Interaction (C × N)	NS	NS	NS	NS	NS	NS	NS	NS	NS

*N equivalent basis of recommended FYM; NS: Non Significant

In the present investigation, the growth and yield parameters of maize were positively related with the final yield of maize. The increased growth and yield attributes in maize + cowpea – groundnut system were attributed to higher uptake of nutrients (140.47, 33.98 and 128.05 kg NPK ha^{-1}, respectively) as compared to maize + cowpea – groundnut system (132.30, 32.10 and 122.54 kg NPK ha^{-1}, respectively). This was evidenced by Kavamahanga *et al*. (1995), Sunil-Kumar (2005).

Application of 100% recommended NPK + poultry manure (rec. FYM equivalent on N basis) recorded significantly higher grain and stover yields (64.52 and 91.94

q ha^{-1}, respectively) of maize followed by 100% recommended NPK + pressmud @ recommended FYM equivalent on N basis (62.00 and 88.53 q ha^{-1}, respectively) (Table 3). Application of 100% recommended NPK + recommended FYM had also significantly increased the grain and stover yield (57.62 and 82.68 q ha^{-1}, respectively) as compared to 100% recommended NPK (49.19 and 72.20 q ha^{-1}, respectively). These results corroborate the findings of Obi and Ebo (1995), Chandrashekara *et al*. (2000), Ananda *et al*. (2006), Rajeshwari *et al*. (2007).

Table 4 Total N, P and K uptake by maize plant (*kharif*) as influenced by cropping systems and nutrient management practices in maize based cropping system

Treatment details	Total N (kg ha^{-1})			Total P (kg ha^{-1})			Total K (kg ha^{-1})		
	2007-08	2008-09	Pooled	2007-08	2008-09	Pooled	2007-08	2008-09	Pooled
Cropping Systems (C)									
C_1: Maize + Frenchbean - groundnut	130.96	133.64	132.30	30.65	33.55	32.10	120.36	124.72	122.54
C_2: Maize + cowpea - groundnut	138.63	142.50	140.57	32.15	35.80	33.98	125.24	130.85	128.05
S.Em±	2.42	3.05	2.86	0.51	0.73	0.65	1.70	2.10	1.95
C.D. at 5%	7.25	8.52	7.98	1.42	2.12	1.82	4.76	5.86	5.46
Nutrient management practices (N)									
N_1: 100% Rec. NPK	130.74	132.86	131.80	25.24	27.58	26.41	120.15	123.25	121.70
N_2: 75% Rec. NPK + rec.FYM	133.42	135.62	134.52	28.63	29.84	29.24	123.75	125.76	124.76
N_3: 100% Rec. NPK + rec. FYM	140.18	143.56	141.87	33.44	35.10	34.27	128.52	132.16	130.34
N_4: 75% Rec. NPK + poultry manure*	137.76	140.84	139.30	32.25	36.14	34.20	126.74	131.45	129.10
N_5: 100% Rec. NPK + poultry manure*	146.60	150.36	148.48	36.25	38.90	37.58	133.42	135.90	134.66
N_6: 75% Rec. NPK + pressmud*	135.16	138.24	136.70	30.78	32.65	31.72	125.63	130.50	128.07
N_7: 100% Rec. NPK + pressmud*	142.56	144.75	143.66	34.11	35.96	35.04	130.56	134.53	132.55
S.Em±	2.27	2.23	2.31	0.91	1.29	1.12	1.55	1.26	1.49
C.D. at 5%	6.34	6.68	6.46	2.56	3.62	3.14	4.65	3.54	4.18
Interaction (C × N)	NS	NS	NS	NS	NS	NS	NS	NS	NS

*N equivalent basis of recommended FYM; NS: Non Significant

Similarly, significantly higher grain and stover yield (17.13% and 14.51%, respectively) with 100% recommended NPK + recommended FYM could be attributed to improved values of yield components of maize viz. cob length (18.45 cm), cob weight (187.82 g), number of rows per cob (16.67), hundred grain weight (34.28 g) and grain weight per cob (159.50 g) as compared to 100% recommended NPK. Similar observations with application of poultry manure and farm yard manure due to increased the yield components as reported by Hanumantha Rao *et al*. (2006), Chandrashekara *et al*. (2000), respectively. Difference in yield and yield parameters can be related to improved growth parameters. Total dry matter at harvest was significantly higher with 100% recommended NPK + poultry manure (rec. FYM equivalent on N basis) that accounts to an extent of 5.98% and 16.10% higher over 100% recommended NPK + recommended FYM and 100% recommended NPK, respectively. The higher values of growth parameters with increase in the nutrient supply resulted in higher performance of individual plant to reflect in higher total dry matter (TDM) accumulation. There might have been efficient translocation of photosynthates from source to sink. The results are in conformity with the findings of Singh *et al*. (2006).

Increase in dry matter production in 100% recommended NPK + poultry manure (rec. FYM equivalent on N basis) may be attributed to higher nutrient uptake (148.48, 37.58 and 134.66 kg NPK ha^{-1}, respectively) followed by 100% recommended NPK + pressmud (rec. FYM equivalent on N basis). Nutrient uptake due to the addition of poultry manure and farm yard manure is further evidenced by Keelara (2001), Tolessa Debele *et al*. (2003). The lowest leaf area recorded due to 100% recommended NPK was due to lower nutrient uptake.

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