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Full Research Article

Productivity and Nitrogen Requirement of Maize (*Zea mays* L.) in *Rabi* as Influenced by *Kharif* Cropping Practices

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Abstract

Devising fertilizer recommendations to a crop considering cropping sequence as a whole rather than an individual crop *per se* is economically sound and environmentally safe. Experiments were conducted on Vertisols of Regional Agriculture Research Station, Lam, Guntur, for two consecutive years, (2008-09 to 2009-10) to study N requirement of maize as influenced by preceding cropping practices. The crop residues/biomass turnout was registered in the order of sunnhemp>greengram with inorganic N>greengram with FYM>soybean with inorganic N>soybean with FYM during both the years of the study. The N turnout through crop residues/biomass across different *kharif* cropping practices, ranged from 17.7 kg ha^{-1} to 95 kg ha^{-1} and 17.3 kg ha^{-1} to 90.4 kg ha^{-1} during the first and the second year of the study, respectively. The growth parameters of *rabi* maize like plant height and dry matter accumulation were significantly increased by different preceding *kharif* cropping practices and N levels given to maize in sequence. During both the years of the study, significantly the highest kernel yield of maize was recorded with the application of 225 kg N ha^{-1} following sunnhemp *in situ* green manuring. Further, *rabi* maize following green gram and soybean in *kharif* with fertilizer N or FYM were significantly inferior to that following sunnhemp *in situ* greenmanuring but superior to that of following *kharif* fallow at all the levels of fertilizer N application. Fertilizer N replacement values estimated for different *kharif* cropping practices on succeeding maize ranged from 15 to 52 kg ha^{-1}.

1. Introduction

Growing weird weather patterns and inadequate supply of water for cultivation of rice are shifting growers' interest towards maize thanto other crops in early *rabi* season on Vertisols of Andhra Pradesh state in India. Maize has a strong exhaustive effect on the soil and the addition of nutrients through fertilizers is, however, far below the crop removal (Tandon, 1995). Exploring different agronomic practices to cut short N requirement of maize may reduce cost of cultivation and increase profitability. Retention of legume residues improves the N economy of the cropping system and enhances the crop productivity through many other potential benefits such as lower pest and disease incidence (Kirkegaard et al., 2008). The inclusion of legumes and stover incorporation improves the productivity of soil and the grain yield of subsequent non-legume crop owing to release of nitrogen and other growth promoting factors (Shivaran and Ahlawat, 2000). Incorporation of plant residues is a useful means of sustaining organic matter content and thereby enhance the biological activity, improve physical properties and nutrient availability (Palm et al., 2001). Dual purpose legumes such as greengram, cowpea and soybean may provide direct economic yield and rich residues with nodules which can mimic the effect of green manuring (Ojiem et al., 2006; Timsina et al., 2006). Information on the effect of such practices on maize in rotation is not available. Therefore, the present study is aimed at to explore the influence of a few possible cropping practices taken up in *kharif* season on productivity and N requirement of maize in succeeding *rabi* season.

2. Materials and Methods

A field experiment was conducted at Regional Agriculture Research Station, Lam, Guntur during 2008-09 and 2009-10. The experimental site is situated at an altitude of 31.5 m above mean sea level, 16°10′ N latitude, 80°29′ E longitude and about 8 km away from the Gunturtown in the Krishna Agro-climatic

Zone of Andhra Pradesh, India. The results of the soil analysis indicated that the experimental site is clay soil, slightly alkaline in reaction, low in available organic carbon (0.35%) (Walklley and Black, 1934) and nitrogen 188 kg ha^{-1}, (Subbiah and Asija, 1956) medium in available phosphorus 28 kg ha^{-1} (Olsen et al., 1954) and high in available potassium 852 kg ha^{-1} (Jackson, 1973). The treatments consisted of six *kharif* cropping practices as main plots fallow, Greengram with 20 kg N ha^{-1}, Greengram with 5 t FYM ha^{-1}, Soybean with 50 kg N ha^{-1}, Soybean with 5 t FYM ha^{-1} and Sunnhemp *in situ* green manuring and succeeded by maize in *rabi* with four fertilizer N levels (0, 75, 150, and 225 kg ha^{-1}) in sub plots arranged in a split plot design and were replicated three times. The cultivars used in the study for greengram, soybean, sunnhemp and maize were LGG 460, LSB 3, Local, and Pioneer 30 V 92, respectively. The sunnhemp crop at pre flowering stage (40 days after sowing) was incorporated in the treatments concerned. The *kharif* crops, greengram and soybean, were cut at ground level at maturity, dried and threshed plot wise. Grain yields were recorded plot-wise and the crop residues were incorporated after spreading in the respective plot on the same dates of incorporation of green manure. Observations were recorded on yield of greengram and soybean, biomass of sunnhemp and crop residues incorporated into the soil. Grain and stover yields of maize were recorded and analysed statistically following the analysis of variance technique for the split plot design as suggested by Gomez and Gomez (1984).

3. Results and Discussion

3.1. Performance of kharif crops

The *kharif* crops performance was assessed by taking mean yield and N turnout data over three replications. During both the years of the study, greengram and soybean with the receipt of inorganic N recorded higher grain yield than that with FYM (Table 1). Irrespective of N source, soybean recorded more grain yield than that of greengram during both the years. The crop residue/biomass turnout was registered in the order of sunnhemp>greengram with inorganic N>greengram with FYM>soybean with inorganic N>soybean with FYM during both the years of the study. The N turnout through crop residue/ biomass across different *kharif* cropping practices, which became main plot treatments for the subsequent *rabi* maize, ranged from 17.7 kg ha^{-1} to 95.0 kg ha^{-1} and 17.3 kg ha^{-1} to 90.4 kg ha^{-1} during the first and the second year of the study, respectively. The N turnout through soybean residue (17.7 kg ha^{-1} and 17.3 kg ha^{-1} during the first and the second year, respectively) was the least of all and the sunnhemp biomass turnout was the highest of all (95.0 kg ha^{-1} and 90.4 kg ha^{-1} during the first and the second year, respectively). Greengram was superior to soybean in N carry over to the subsequent crop through residue. Overall, the *kharif* cropping practices had caused a lot of variation in N carryover to subsequent *rabi* maize through residue/biomass turnout of N.

3.1.1. Effect of kharif cropping practices and fertilizer N on succeeding maize

During both the years of the study, plant height increased significantly with increasing level of N application to maize following different *kharif* cropping practices. Irrespective of N level, sunnhemp *in situ* green manuring favoured the succeeding maize to grow taller (Table 2). Similarly, all the *kharif* cropping practices which preceded the *rabi* maize also increased the succeeding maize plant height compared to that preceded by *kharif* fallow duly indicating the advantage of residue/biomass incorporation. The superior performance of maize following sunnhemp *in situ* green manuring might be due to three fold increase in biomass N turnout (90 kg ha^{-1} to 95 kg ha^{-1}) compared to that of greengram (33 kg ha^{-1} to 38 kg ha^{-1}) or soybean (17 kg ha^{-1} to 19 kg ha^{-1}) and also because of narrower C:N ratio of sunnhemp biomass (Table 1), which might have favored faster decomposition and release of nutrients.The data on the yield components of maize such as number of cobs plant^{-1}, number of kernels cob^{-1}, kernel weight cob^{-1} were significantly influenced by the *kharif* cropping practices together with the application of fertilizer N

Table 1: Grain yield, residues biomass yield and nitrogen turnout in *kharif* cropping practices

Cropping practice	2008				2009			
	Grain yield (kg ha^{-1})	Crops residue/biomass turnout (kg ha^{-1})	Nitrogen turnout (kg ha^{-1})		Grain yield (kg ha^{-1})	Crops residue/biomass turnout (kg ha^{-1})	Nitrogen turnout (kg ha^{-1})	
			Grain	Crops residue/biomass			Grain	Crops residue/biomass
Fallow	-	-	-	-	-	-	-	-
Greengram with 20 kg N ha^{-1}	1064	3045	34.7	34.7	987	2956	32.7	34.9
Greengram with 5 t FYM ha^{-1}	997	2933	32.9	38.2	854	2828	28.6	33.7
Soybean with 50 kg N ha^{-1}	1474	1553	58.2	18.9	1368	1497	56.4	18.7
Soybean with 5 t FYM ha^{-1}	1337	1439	53.2	17.7	1242	1364	51.5	17.3
Sunnhemp *in situ* green manuring	-	4220	-	95.0	-	3896	-	90.4

during both the years of the study. Of all the *kharif* cropping practices, sunnhemp *in situ* green manuring with fertilizer N @ 225 kg ha^{-1} increased the yield components significantly. Sunnhemp *in situ* green manuring preceding maize might have helped in maintaining the buildup of soil organic matter, which in turn helped in improving the soil structure, pore size and water-holding capacityand translated intosuperior growth performance as discussed earlier. Similar superior performance was also reported by Sujatha et al. (2008); Lelei et al. (2009). As seen with the plant height, the yield components of maize were also increased with increasing level of fertilizer N application showing higher N responsiveness of maize irrespective of the crop it preceded in the sequence (Table 2). Such increased response of maize to fertilizer N application irrespective of the preceding crops to maize in sequence was reported by others (Franke et al., 2008; Adiku et al., 2009, Sharma and Behera, 2009). Higher kernel yield was recorded in maize following sunnhemp *in situ* green manuring with the application of 225 kg N ha^{-1}. Sunnhemp *in situ* green manuring along with fertilizer N might have maintained adequate supply of N to enhance maize crop productivity through the increased growth and yield attributes. Similar increase in yield due to incorporation of green manures/residues which facilitate the growth of the succeeding crops through improvement in soil properties and release of nutrients was also reported by Adiku et al. (2009); Sharma and Behera (2009).

Incorporation of the crop residues after harvesting the grain of greengram and soybean, irrespective of the nutrition that they received (fertilizer N or with FYM) gave significantly higher yield of succeeding maize than that following without i.e., fallow (Table 2). But both of these crops were inferior to sunnhemp *in situ* green manuring in their effect on succeeding maize. These crops, however, have given grain yield to aid profitability of the sequence. The yield of greengram and soybean ranged from 997 kg ha^{-1} to 1474 kg ha^{-1} and 854 kg ha^{-1} to 1242 kg ha^{-1} during the first and second year of the study, respectively, showed the scope to compensate for reduction in maize productivity following this practice (Table 1). The incorporation of greengram and soybean residuesinteracted positively with added fertilizer N, and the release of nutrients might have coincided with the early growth stages of succeeding maize crop. These results are in accordance with the findings of Franke et al. (2004); Franke et al. (2008); Sharma and Behera (2009); Yusuf et al. (2009).

Kernel yield of maize with every *kharif* cropping practice increased progressively with each increment in N application to maize. The highest kernel yield was obtained following sunnhemp *in situ* green manuring followed by greengram and soybean, all of which were significantly superior to fallow. A similar result was observed by Singh et al. (2003); Sharma and Behera (2009). These observations showed that sunnhemp *in situ* green manuring could account for substantial

Table 2: Growth, yield attributes and yield as influenced by *kharif* cropping practices and fertilizer N on succeeding *rabi* maize

Treatments	Plant height (cm)		Cob length (cm)		No. of kernels cob^{-1}		Kernel weight cob^{-1}		Kernel yield (kg ha^{-1})		Stover yield (kg ha^{-1})	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Kharif cropping practices (KCP)												
Fallow	201.0	188.5	17.7	17.2	262	260	78.8	74.5	5561	5450	6503	6407
Greengram with 20 kg N ha^{-1}	234.9	216.8	19.4	18.9	293	280	91.5	85.0	6079	6032	7125	7062
Greengram with 5 t FYM ha^{-1}	234.4	217.2	19.8	19.3	296	288	91.6	87.2	6100	6010	7198	7127
Soybean with 50 kg N ha^{-1}	228.8	210.5	19.0	18.5	291	279	89.7	83.1	5947	5931	7029	6983
Soybean with 5 t FYM ha^{-1}	232.3	215.4	19.6	19.1	294	281	91.1	85.1	6027	5898	7105	7029
Sunnhemp *in situ* green manuring	255.9	233.4	20.9	20.5	319	306	108.9	101.7	6594	6652	7655	7651
SEm±	6.8	4.8	0.43	0.48	6.0	4.9	2.6	2.5	155	157	161	166
CD (p=0.05)	21.4	15.2	1.36	1.33	18.9	15.6	8.2	8.2	428	438	508	518
N levels (kg ha^{-1})												
0	182.4	160.0	16.6	16.1	164	155	54.3	51.7	3961	3933	4917	4821
75	220.7	201.3	19.1	18.2	255	243	78.0	75.9	5499	5500	6564	6468
150	246.2	232.4	20.4	19.6	341	330	103.6	94.9	7137	7019	8045	8057
225	275.7	260.9	21.5	21.0	411	401	131.8	121.8	7611	7531	8885	8828
SEm±	4.2	4.5	0.45	0.44	5.2	3.5	1.6	1.6	149	129	149	139
CD (p=0.05)	11.6	12.4	1.25	1.29	14.5	9.8	4.4	4.4	413	357	414	387
KCP X N levels	20.1	21.4	NS	NS	22.0	17.0	7.6	NS	NS	NS	NS	NS

amount of nitrogen thus explaining higher maize grain yields. A similar result was observed by Bhandari et al. (1989) who reported that the green manured plots receiving 60 kg N ha^{-1} produced as high grain yield as that obtained with 120 kg N ha^{-1} which indicated that the green manures like *Sesbania* could supplement 60 kg N ha^{-1} to succeeding maize. While, Sharma and Behera (2009) reported that response of maize to N fertilizer rates following summer legumes was quadratic and there was a saving of N to the extent of 57-67 kg ha^{-1} with *Sesbania* green manuring, but there was a linear increase in yield with increasing N rates after fallow. Similar findings were also reported earlier by Tripathi and Hazra (2002); Tiwari et al. (2004); Balkcom and Reeves (2005).

Stover yield of *rabi* maize was significantly influenced by *kharif* cropping practices and level of N application during both the years of the study, but their interaction was found to be non-significant (Table 2). Maximum stover yield was recorded in maize preceded by sunnhemp *in situ* green manuring in *kharif* and it was on a par with that preceded by greengram with FYM during the first year of the study (2008-09) only. The stover yield of maize following greengram or soybean with organic or inorganic N were on a par but both were significantly superior to that following *kharif* fallow during both the years of the study. Irrespective of the *kharif* cropping practices, there was a progressive increase in the stover yield with increase in level of N application from 0 to 225 kg ha^{-1} during both the years of the study.

The fertilizer N credits for different *kharif* cropping practices were calculated in terms of fertilizer N replacement values worked out by substituting the maize kernel yield obtained after these practices with zero applied N into best fit quadratic N response equation for maize kernel yield following *kharif* fallow where:

$Y=3389+26.38\ N-0.040\ N^2$ with R^2 0.99 for 2008-09 and

$Y=3365+22.65\ N-0.023\ N^2$ with R^2 0.99 for 2009-10.

The fertilizer N replacement values calculated for sunnhemp *in situ* green manuring were 49 and 52 kg ha^{-1} during the first and the second year of the study, respectively (Table 3). While those for greengram with inorganic N were 30 kg ha^{-1} and 29 kg ha^{-1}, greengram with FYM were 24 kg ha^{-1} and 23 kg ha^{-1}, soybean with inorganic N were 15 and 16 kg ha^{-1}, soybean with FYM were 23 kg ha^{-1} and 23 kg ha^{-1} during the first and the second year of the study, respectively.

Table 3: Fertilizer N replacement values (kg ha^{-1}) of *kharif* cropping practices

Kharif cropping practices (KCP)	Fertilizer N replacement values (kg ha^{-1})	
	2008-09	2009-10
Greengram with 20 kg N ha^{-1}	30	29
Greengram with 5 t FYM ha^{-1}	24	23
Soybean with 50 kg N ha^{-1}	15	16
Soybean with 5 t FYM ha^{-1}	23	23
Sunnhemp *in situ* green manuring	49	52

4. Conclusion

Overall, the field studies conducted for two consecutive years, involving different *kharif* cropping practices followed by maize in sequence in every year, clearly indicated the importance of sunnhemp *in situ* green manuring, greengram or soybean crops grown either with inorganic or organic N for grain and the incorporation of crop residues for enhancing the fertilizer N usage and for increasing succeeding maize productivity.

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