



Effect of Integrated Nutrient Management on Crop productivity and Soil Fertility Status under Maize (*Zea mays*) - Wheat (*Triticum aestivum*) Cropping Sequence

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ABSTRACT

A field experiment was conducted to investigate the effect of integrated nutrient management in maize (Var. RCM-76) and wheat (Var. DBW-14) during the *Kharif* and *Rabi* season of 2015-16 and 2016-17 at three villages *i.e.* Louding, Shakti and Changprong in Tawang district of Arunachal Pradesh. Continuous application of farmyard manure (FYM) and cut paddy straw along with chemical fertilizers improved grain yield and fertility status. Substitution of 50 percent N through FYM and 50 percent recommended dose of fertilizer (RDF) in maize and 100% RDF through inorganic fertilizer in wheat recorded the highest grain yield of maize (3.5 t/ha) and wheat (4.0 t/ha), net return of maize (Rs. 26,250/ha) and wheat (Rs. 36,000/ha) and nutrient uptake (209.2, 30.4 and 196.0 kg N, P and K/ha) in maize – wheat cropping system, respectively. Soil fertility status in terms of pH organic carbon, available N, P and K after two cycles of cropping, fertilizer and manure application were also affected by nutrient management practices. Continuous cropping with combined application of organic manure along with chemical fertilizers was found to be effective not only, for increasing grain yield of crops in maize-wheat cropping system, but also, for higher benefit: cost ratio, nutrient uptake and maintenance of soil fertility status.

Key Words: Economics, Integrated nutrient management, Nutrient uptake, Soil fertility.

INTRODUCTION

Fertilizers played a vital role in agriculture production and productivity in India but continuous and imbalanced use of chemical fertilizer creates problems in the production potential and deterioration of soil health. Use of chemical fertilizers in combination with organic manure is required to improve the soil health (Bajpai *et al*, 2006). In this regards, long-term fertilizers experiments are considered as vital tools to examine sustainability of intensive cropping system and the impact of continuous application of integrated nutrient management practices on crop productivity and soil health. Maize-wheat is the third most important cropping system after rice-wheat and rice-rice in India, and is grown on about 1.80 mil/ ha each year (Jat *et al*, 2012). Maize, a crop with high

yield and market potential, fits well into rice-wheat systems by replacing rice in rain fed conditions in Tawang district of Arunachal Pradesh. In Tawang district the land is a sloppy and slightly acidic, so organic carbon washout due to rainfall and high P-fixation capacity (Singh, 2007). Hence, there is a need to evaluate the effect of combinations chemical fertilizer with organic source of nutrients, *viz.* FYM and paddy straw on crop productivity and changes in soil fertility of an acid soil under maize-wheat cropping system.

MATERIALS AND METHODS

Location of study

A field experiment was conducted during the *Kharif* and *Rabi* seasons of 2015-16 and 2016-17 at three villages *viz.* Louding, Shakti and Changprong

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of Tawang district. The area falls under humid, subtropical climate. The daily temperature of the experimental site during the year varies widely between minimum 18°C and maximum 35°C with an average rainfall of 2,220 mm. The soil was sandy loam with slightly acidic (pH 6.0), organic carbon (0.75%), electrical conductivity (0.25 ds/m), available N (225.0 kg/ha), P (35.5 kg/ha) and K (140 kg/ha).

The different treatment combinations were T₁, 50% recommended dose of fertilizer (RDF) - 50% RDF; T₂, 50% RDF - 100% RDF; T₃, 75% RDF - 75% RDF; T₄, 100% RDF - 100% RDF; T₅, 50% N through FYM + 50% RDF - 100% RDF; T₆, 25% N through FYM + 75% RDF - 75% RDF; T₇, 50% N through cut paddy straw + 50% RDF - 100% RDF; T₈, 25% N through cut paddy straw + 75% RDF - 75% RDF and T₉, 50 kg - 50 kg Urea/ha for maize and wheat for *Kharif* and *Rabi* seasons respectively (Table 1).

Table 1. Different treatments combining different doses of fertilizers during *Kharif* and *Rabi* season.

Treatment	<i>Kharif</i> Season	<i>Rabi</i> Season
T ₁	50% RDF	50% RDF
T ₂	50% RDF	100% RDF
T ₃	75%RDF	75% RDF
T ₄	100%RDF	100% RDF
T ₅	50%N(FYM)+50%RDF	100% RDF
T ₆	25%N(FYM)+75%RDF	75% RDF
T ₇	50%N(CPS)+50%RDF	100% RDF
T ₈	25%N(CPS)+75%RDF	75% RDF
T ₉	Farmer's practices Urea @ 50kg/ha.	Farmer's practices Urea @ 50kg/ha.

Recommended dose of fertilizer (RDF), Farm yard manure (FYM), Cut Paddy Straw (CPS)

The recommended fertilizer dose (100% RDF) of N, P and K was 100.0, 22.0 and 21.0 kg/ha; respectively for both the crops, of which one third of N and full dose of P and K were applied as basal dose. The remaining N was divided into two equal

parts and applied 25 and 45 days after sowing as pre treatments. The source of N, P and K were urea, single superphosphate and muriate of potash respectively. Organic manure *viz.* FYM and cut paddy straw were applied on the basis of N content as per the treatment 15 to 20 days before sowing in the rainy season of every year.

Procedure of handling the cobs

This study was undertaken on the nutrient management experiment with Maize var. RCM 76 and Wheat var. DBW 14 during 2015-16 and 2016-17. Total cobs from net plot area of each plot were harvested, sun dried and shelled. The seeds were cleaned, sun dried and weighed. Stoves from the net plot area were also weighed. Similarly, for wheat harvested bundles from each net plot were threshed, cleaned, sun dried and weighed separately grain and straw yield was recorded and expressed in t/ha.

Estimation of Total P and Total K

Total N content in the plant parts were estimated by modified Kjeldahl digestion and distillation method. Total P and K in plant parts were digested in triadic mixture (HNO₃:HClO₄: H₂SO₄) in 10:4:1 ratio on volume basis). Total P content was determined calorimetrically at 440nm following Vanado-molybdate nitric acid yellow-colour method. Total K of plant sample was determined by flame photometer from the same aliquot obtained for total P as described by Tandon (1999). Nutrient uptake of each nutrient (N, P and K) was calculated separately for grain and straw/stover by multiplying its content with respective grain and straw/stover yield values. In order to get the total uptake of nutrient, the uptake values for grain and straw/stover and stone were added up. Up-take values were expressed in kg/ha.

Estimation of essential nutrient in soil

Post harvest surface soil samples were collected treatment-wise from all replications of ongoing permanent manorial trial after harvest of wheat crop during 2015-16 and 2016-17. Soil pH was determined in soil water suspension of 1:2.5:: Soil:

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water, after stirring for 30 minutes using Systronic pH meter as described by Jackson, (1973). Organic carbon content of soil samples were determined by Walkley and Black rapid titration methods as described by Baruah and Barthakur (1997). Available nitrogen in soil was determined by alkaline potassium permanganate method of Subbiah and Asija (1956). Available soil P content was extracted by Bray P₁ extractant (0.03N NH₄F in 0.025N HCl solution) and estimated calorimetrically at 660nm using Systronics make colorimeter. Available potassium content in soil samples were extracted in 1:5: soil: neutral normal ammonium acetate (pH-7.0) by shaking for 5 minutes and filtered. Potassium was then estimated in the extract with the help of Elico make flame photometer.

Calculation of Economics

Economics of the cropping system was calculated based on the additional expenditure incurred due to different treatments along with the normal cost of cultivation in raising crops. Benefit: cost ratio (B: C) was calculated based on the ratio of net profit to total cost incurred.

RESULTS AND DISCUSSION

Grain yield

The maximum grain yield of maize and wheat was recorded with 50% N through F.Y.M. + 50% N through inorganic fertilizer in maize and 100% RDF in wheat. Pooled mean data for maize varied from 3.5 t/ha to 1.03 t/ha and wheat 4.0 t/ha to 1.24 t/ha respectively and influenced by INM practices (Table 2). The increase in mean grain yield was 0.55 t/ha for maize and 0.14 t/ha for wheat to recommended dose of fertilizers (100% RDF) both in maize and wheat. This was an agreement with the result of long term fertilizers experiments carried out in different agro climatic situations of the country (Singh and Wanjari, 2013). Application of 50% N through F.Y.M. + 50% through chemical fertilizer in maize and 100% RDF in wheat was significantly superior to 100% recommended fertilizer applied to both the crops and remained on a par with 25% N substitution through F.Y.M. and 75% through inorganic source in maize and 75% RDF in wheat. Substitution of N through cut paddy straw significantly reduction in grain yield was up to 0.19 t/ha in maize and 0.12 t/ha in wheat as compared to recommended dose

Table 2. Effect of integrated nutrient management practices on grain yield and economics of maize-wheat cropping system (pooled data of two years).

	Treatment		Yield (t/ha.)		Gross return (Rs./ha)		Net return (Rs. /ha.)		B:C ratio	
	<i>Kharif</i>	<i>Rabi</i>	Maize	Wheat	Maize	Wheat	Maize	Wheat	Maize	Wheat
T1	50%RDF	50%RDF	2.3	2.45	34,500	44,100	3,200	4,100	1.1:1	1.0:1
T2	50%RDF	100%RDF	2.48	3.0	37,200	54,000	12,400	18,000	1.4:1	1.5:1
T3	75%RDF	75%RDF	2.70	3.25	40,500	58,500	9,350	27,350	1.3:1	1.3:1
T4	100%RDF	100%RDF	2.95	3.86	44,250	69,480	18,250	28,680	1.7:1	1.7:1
T5	50%N(FYM)+50%RDF	100%RDF	3.5	4.0	52,500	72,000	26,250	36,000	2.0:1	2.0:1
T6	25%N(FYM)+75%RDF	75%RDF	2.93	3.9	43,950	70,200	19,533	31,200	1.8:1	1.8:1
T7	50%N(CPS)+50%RDF	100%RDF	2.76	3.74	41,400	67,320	11,450	19,234	1.4:1	1.4:1
T8	25%N(CPS)+75%RDF	75%RDF	2.72	3.10	40,800	44,800	6,800	9,300	1.2:1	1.2:1
T9	Farmer's practices Urea @ 50kg/ha.	Farmer's practices Urea @ 50kg/ha.	1.03	1.24	15,450	22,320	-15,850	-18,580	-1:0	-1:0

of fertilizers *i.e.* 100% RDF applied in both maize and wheat. The finding indicated that the combined application of well-decomposed organic nutrient source and inorganic fertilizer application. Pathak *et al*, (2005) and Jat *et al*, (2012) also observed similar findings. However, substitution of a part of N through rice straw did not perform well possibly due to slow mineralization of organic N leading to its deficiency during growing period of maize.

Nutrient uptake- Pooled mean data for total N, P and K uptake (kg/ha) by maize and wheat were presented in Table 3. Total nutrient uptake varied from 54.0 to 103.0, 6.9 to 13.6 and 45.7 to 94.4 kg N, P and K, respectively in maize; 57.9 to 106.2, 8.4 to 16.8 and 53.3 to 101.3 kg N, P and K/ha for N, P and K, respectively in wheat. Higher nutrient uptake for INM practices was due to combined application of organic and inorganic fertilizers. Significantly highest total N, P and K uptake were recorded under treatment receiving 50% N through FYM + 50% N through inorganic fertilizer in maize and 100% RDF in wheat. Higher availability of nutrients due to residual effect of organic sources there by improving physiological and metabolic functions inside the plant might have been responsible for

better expression of growth parameters, yield and nutrient uptake. The findings confirm those of Mahapatra *et al* (2007), Kumar (2008 and Kumar and Dhar (2010).

Soil properties

Pooled mean data for soil pH, organic carbon, available N, P and K after two crops cycling of maize-wheat cropping were affected by nutrient management practices are given in Table 4. Variation in soil pH was from 6.02 to 6.50 as compared to the initial value of 6.0; organic carbon varied from 228.0 to 360.0 as compared to initial value 225.0 kg N/ha; available P varied from 15.5 to 110.0 as compared to initial value 35.5 kg P/ha and available K varied from 109.0 to 135.5 as compared to initial value 140 kg/ha. Under maize – wheat cropping system, combined application of 25-50% N through well-decomposed nutrient sources, *i.e.* F.Y.M. in maize and 75-100% RDF through chemical fertilizers to both the crops, was found beneficial in increasing the productivity of crops and improving soil fertility status as compared to sole application of chemical fertilizer. Applications of well-decomposed organic manures solubilise soil nutrients; while application of fresh crop residue immobilize the available

Table 3. Effect of integrated nutrient management practices on nutrient uptake by maize and wheat in maize-wheat cropping system (pooled data of two years)

	Treatment		Nutrient uptake (kg/ha)					
	<i>Kharif</i>	<i>Rabi</i>	Maize (pooled data of 2 years)			Wheat (pooled data of 2 years)		
			N	P	K	N	P	K
T ₁	50%RDF	50%RDF	54.0	6.9	45.7	57.9	8.4	53.3
T ₂	50%RDF	100%RDF	56.2	7.3	48.9	86.4	12.8	82.3
T ₃	75%RDF	75%RDF	61.8	7.9	54.3	75.4	11.2	71.4
T ₄	100%RDF	100%RDF	89.4	11.9	79.6	90.9	13.8	86.4
T ₅	50%N(FYM)+50%RDF	100%RDF	103.0	13.6	94.4	106.2	16.8	101.3
T ₆	25%N(FYM)+75%RDF	75%RDF	88.4	11.7	76.9	90.3	13.7	84.2
T ₇	50%N(CPS)+50%RDF	100%RDF	81.3	10.6	71.4	89.4	13.4	83.8
T ₈	25%N(CPS)+75%RDF	75%RDF	77.3	9.9	68.0	79.3	11.4	73.0
T ₉	Farmer's practices	Urea @ 50kg/ha.	21.9	2.7	19.2	27.8	3.8	26.5

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Table 4. Effect of integrated nutrient management practices on fertility status of soil after two years of cropping, fertilizer and manure application (pooled data of two years)

	Treatment		pH	(OC%)	Available N (kg N/ha)	Available N (kg N/ha)	Available N (kg N/ha)
	<i>Kharif</i>	<i>Rabi</i>					
T1	50%RDF	50%RDF	6.18	0.59	234.0	39.5	125.0
T2	50%RDF	100%RDF	6.10	0.64	238.5	58.0	122.5
T3	75%RDF	75%RDF	6.14	0.70	236.0	63.5	118.0
T4	100%RDF	100%RDF	6.05	0.74	269.5	97.5	115.5
T5	50%N(FYM)+50%RDF	100%RDF	6.50	0.90	360.5	110.0	135.5
T6	25%N(FYM)+75%RDF	75%RDF	6.32	0.80	330.5	90.0	129.0
T7	50%N(CPS)+50%RDF	100%RDF	6.12	0.78	321.5	84.3	122.5
T8	25%N(CPS)+75%RDF	75%RDF	6.08	0.76	288.5	73.5	118.0
T9	Farmer's practices	Urea @ 50kg/ha.	6.02	0.55	228.4	15.5	109.0

nutrients resulting in reduction in available nutrients during crop growth. Combined application of FYM along with chemical fertilizers thus resulting in a significant improvement in available nutrient status of soil and enhance crop productivity. Similar results were obtained under different cropping sequences in different types of soils of India (Behera and Nand Ram, 2004; Bajpai *et al*, 2006; Laxminarayan, 2006).

CONCLUSION

Based on two years study, it may be concluded that application of 50 percent N through FYM and 50 percent recommended dose of fertilizer (RDF) in maize and 100% RDF through inorganic fertilizer in wheat recorded the highest grain yield of maize (3.5 t/ha) and wheat (4.0 t/ha), net return of maize (Rs. 26,250/ha) and wheat (Rs. 36,000/ha) and nutrient uptake (209.2, 30.4 and 196.0 kg N, P and K/ha) in maize – wheat cropping system.

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