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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT FOR SUSTAINING PRODUCTIVITY OF MAIZE-WHEAT CROPPING SYSTEM IN RAINFED AREAS OF JAMMU

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A field experiment was conducted during 2005 - 2006 and 2006 - 2007 at Dhiansar to study the effect of integrated nutrient management in Maize *Zea mays* L., Wheat *Triticum aestivum* L. cropping system to different sources of nutrient supply, namely, organics and inorganics, in maize and the subsequent effect on succeeding wheat crop. The experiments during both the years consisted of 10 treatments, *viz*. T_1, control; T_2, 10 tonnes FYM+20 kg/ha; T_3, 10 tonnes FYM+30 kg N/ha; T_4, 10 tonnes FYM+40 kg N/ha; T_5, green manuring with sunnhemp (*Cotalaria juncea* L.) + 20 kg n/ha; T_6, green manuring with sunnhemp + 30 kg N/ha; T_7, green manuring with sunnhemp + 40 kg N/ha; T_8, 5 tonnes subabul (*Leucaena leucocephala*) leaves + 20 kg N/ha; T_9, 5 tonnes subabul leaves + 30 kg N/ha; and T_{10}, 5 tonnes subabul leaves + 40 kg N/ha. Incorporation of 10 tonnes/ha farmyard manure in maize increased grain yield of both maize and wheat, net return and water use efficiency over the recommended dose of fertilizer to both crops. Production efficiency in terms of rate of production per day as well as the benefit: cost ratio was also superior with this treatment. Application of organic manures also improved the nutrient statues of the soil.

Keywords: Management, Maize, Nutrient, Wheat

INTRODUCTION

The continuous use of chemical fertilizers after given revolution in late 1960's increased crop productivity but had adverse effect on soil health and environment (Dwivedi and Dwivedi, 2007). In recent years, the productivity level has stagnated and in some situations declined even with the application of recommended dose of fertilizers. Now the thoughts among pioneers, scientists and farmers is how to increase the stagnant or declined yield to higher and sustained level. It seems that one of the practical ways to boost crop yield is to encourage the use of organics in field crops. Because agriculture is a soil-based production system, that extracts nutrients from the soil, effective and efficient approaches to slowing that removal and returning nutrients to the soil will be required in order to maintain and increase crop productivity and sustain agriculture for the long term. Since organics alone cannot meet the nutrient requirement of various cropping systems due to limited availability, the use of integrated nutrient management holds great promise in increasing crop productivity and maintaining good soil health and also discourage emergence of multiple nutrient deficiency.

Maintenance and enhancement of soil productivity in maize-wheat cropping system in rainfed areas of Jammu is a major issue. Cultivation of both the cereals in a year on the same piece of land has led to imbalance in soil fertility resulting in decline in yield of both crops. Farmers have to use more and more fertilizers year after year to obtain the same yield level as obtained with lesser quantity of fertilizer in the previous years due to decline in soil fertility which is not economically desirable due to increase cost of fertilizers. With the availability of high-yielding, photo-insensitive and short-duration hybrids and composites of maize and high-yielding varieties of wheat, this cropping system has become more remunerative as the sowing of wheat in the rainfed/Kandi areas can be done. Under normal conditions, maize – wheat cropping system is the most productive and economically viable system. However, under a wide range of input use and management, yield trends of maize-wheat sequence are different parts of this region. The work on this aspect has been made so far to evaluate the effect of integrated nutrient management on such cropping system. Hence a field experiment was conducted to investigate the effect of integrated nutrient management in a maize-wheat sequence under rainfed conditions.

METHODOLOGY

A field experiment was conducted in two consecutive seasons of 2005-06 and 2006- 07 at Dryland Research Sub Station, SKUAST-J, Dhiansar, Jammu located t latitude 32° 17t to 37° 05t N, longitude 72° 40t to 80° 30t E and altitude ranges between 215 to 7012 meters above MSL. The soil was sandy-loam having pH 6.9 along with electrical conductivity of 0.05m mhos/cm at 25°C and organic carbon 0.34%, respectively. The weather data prevailed during two years the experimentation are given in Table 1. The experimental site soil having available nitrogen, phosphorous and potassium 159, 18 and 124 kgha^{-1}, respectively and total seasonal rainfall received during (rainy) season of 2005-06 and 2006-07 was 554.1 and 707.5 mm in 45 and 23 rainy days respectively. Maize and wheat crops were grown in rotation during Kharif and Rabi season on the experimental plot. The experiments during both the years consisted of 10 treatments, viz. T_1, control; T_2, 10 tonnes FYM+20 kg/ha; T_3, 10 tonnes FYM+30 kg N/ha; T_4, 10 tonnes FYM+40 kg N/ha; T_5, green manuring with sunnhemp *(Cotalaria juncea L.)* + 20 kg n/ha; T_6, green manuring with sunnhemp + 30 kg N/ha; T_7, green manuring with sunnhemp + 40 kg N/ha; T_8, 5 tonnes subabul *(Leucaena leucocephala)* leaves + 20 kg N/ha; T_9, 5 tonnes subabul leaves + 30 kg N/ha; and T_{10}, 5 tonnes subabul leaves + 40 kg N/ha.

The recommended dose of phosphorus and potash (40 P_2O_5 and K_2O kg/ha respectively) to maize and wheat crop were applied uniformly in all the treatments. Standard agronomic operations and plant protection measures followed local recommendations. The experimentation was laid out in randomized block design with three replications. Spacing of 60 cm x 30 cm was maintained in maize by thinning and gap filling and wheat rows were spaced 22.5 cm apart. The farmyard manure was incorporated thoroughly 4 weeks before maize sowing. The residual effects of these treatments were studied on wheat. Maize hybrid 'GS 2' and wheat variety 'PBW 299' were used. Maize yield was converted to wheat-equivalent yield using their prevailing market prices.

RESULT AND DISCUSSION

Crop productivity

The incorporation of 10 tonnes of farmyard manure alongwith 40 kg N/ha had significant effect on maize and wheat yield. Maize and wheat grain yield increased significantly and the response was almost similar during both the years (Table 2). The incorporation of 10 tonnes of farmyard manure alongwith 40 kg N/ha (T4) increased maize yield over the control (T1) by 2.56 and 2.37 times in 2005-06 and 2006-07 respectively and wheat by 1.46 times in 2005-06 and 1.39 times in 2006-07. The incorporation of farmyard manure alongwith 40 kg dose of nitrogen increase soil N, concentrates of P and K. enriches the physio-chemical condition, promotes root growth an thereby increase crop yield. These results agree with those of Srivastava *et al.* (2003), Kumar *et al*. (2007) and Prasad (2007). The yield of maize and wheat was higher with 10 tonnes FYM + 40 kg N/ha during both the years, but it was at a par with the yield obtained with the application of 10 tonnes FYM + 30 kg N/ha, 10 tonnes FYM + 20 kg N/ha, green manuring with sunnhemp + 40 kg N/ha and 5 tonnes subabul leaves + 40 kg N/ha during both the years, which indicates the positive residual effect of these treatments. The results supported with the findings of Jamwal (2005) reported similar results in maize-wheat cropping system.

The total productivity in terms of wheat-equivalent yield of maize-wheat sequence was significantly superior with the application of 10 tonnes FYM 40kg N/ha in maize, but it was on at par with the application of 10 tonnes FYM + 30 kg N/ha, green manuring with sunnhemp + 40 kg N/ ha and 5 tonnes subabul leaves + 40 kg N/ha. The mean total productivity of the system also followed the similar trends, thereby showing positive residual effect of FYM and green manuring. The result corroborate with the similar findings of Bajpai *et al*. (2002) in rice-wheat cropping system and Jamwal (2005) in maize-wheat cropping system.

Production efficiency and cropping system economics

The highest production rate of 5.60 kg/ha/ day in terms of wheat equivalent yield under the maize-wheat intercropping system was observed with the application of 10 tonnes FYM + 40 kg N/ha, followed by application of 10 tonnes FYM + 30 kg N/ha, green manuring with sunnhemp + 40 kg N/ha and 5 tonnes subabul leaves + 40 kg N/ha, indicating sustainability of production with the use of organics. In general the net income was higher in 2006-07 than 2005-06 due to probably to realization of higher prices (Table 3). The highest mean net return of Rs. 15,820/ha was obtained with the application of 10 tonnes FYM + 40 kg N/ha followed by green manuring with sunnhemp + 40 kg N/ha, 10 tonnes FYM + 30 kg N/ ha and 5 tonnes subabul leaves + 40 kg N/ha with net return of Rs. 15,374, 14,988 and 12,894/ha respectively. The highest benefit: cost ratio of 2.46 was observed sowing to green manuring with sunnhemp + 40 kg N/ha, followed by10 tonnes FYM + 40 kg N/ha and 10 tonnes FYM + 30 kg N/ha with benefit: cost ratio of 2.40 and 2.33, respectively, indicating saving of a considerable amount of nitrogen with the incorporation of green manures and farmyard manure. Similar findings were reported by Bajpai *et al.* (2002) (Fig. 1).

Soil-nutrient status

In general, the soil nutrient status was higher in 2006-07 than 2005-06 after the harvest of both maize and wheat in maize-wheat cropping system. The applications of farmyard manure and incorporation of sunnhemp green manure as well as subabul leaves with inorganic nitrogen resulted in a significant increase in available N and P status of soil compared with the control plots (Table 4). The most effective contribution of application of organics to available nitrogen and phosphorus status of soil was observed when 40 kg N/ha was applied through inorganic source along with the organic source. Kumar et al. (2007) reported that, incorporation of farmyard manure in pearmillet with recommended dose of fertilizers significantly increased grain yield of both pearlmillet and wheat and get higher net returns. Bellaki and Badanur (1997) also reported that sunnhemp green manuring alone or in combination with inorganic fertilizer significantly increased the available N and P status of soil which could be attributed to the residual effect of inorganic fertilizers and mineralization of organic sources. The available K status of the soil did not show any substantial change in all the treatments.

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Table 1: Monthly weather - data pertaining to the experimental period

Month	Rainfall		Rainy Days		Temperature			
	2005-06	2006-07	2005-06	2006-07	2005-06		2006-07	
					Maxi.	Min.	Maxi.	Min.
May	8.00	47.60	01	04	36.7	21.2	38.9	25.6
June	19.00	88.60	02	06	41.0	25.7	39.4	24.9
July	347.50	230.90	12	11	34.0	24.4	33.4	25.3
August	160.00	219.20	08	06	33.9	23.7	33.0	25.0
September	27.60	168.80	04	05	33.5	28.4	32.6	22.7
October	1.80	45.40	00	02	32.6	17.6	31.4	19.0
November	0.00	9.40	00	01	27.7	10.9	26.2	13.8
December	0.00	39.30	00	02	22.7	5.3	20.3	7.9
January	72.00	0.00	05	00	19.3	6.6	19.9	5.0
February	8.80	83.40	01	06	27.0	11.7	21.2	9.7
March	43.20	131.10	01	06	27.2	13.1	35.3	11.7
April	15.40	3.20	01	00	33.8	18.4	35.9	19.5

Table 2: Effect of different treatments on grain yield of maize and wheat as influenced by various treatments

Treatments	Grain yield q/ha								
	2005-06			2006-07			Mean of two year		
	Maize	Wheat	Total (wheat equivalent)	Maize	Wheat	Total (wheat equivalent)	Maize	Wheat	Total (wheat equivalent)
Control	6.94	3.05	8.47	11.73	17.50	28.00	6.21	10.50	8.35
10 tones FYM+20kg N/ha	13.61	4.02	14.65	22.47	21.38	41.49	12.18	20.10	16.14
10 tones FYM+30kg N/ha	15.69	4.23	16.49	25.41	23.61	46.35	14.04	22.74	18.39
10 tones FYM+40kg N/ha	17.77	4.44	18.32	27.91	24.30	49.27	15.90	24.97	20.44
GM+20 kg N/ha	11.94	3.61	12.94	17.36	19.61	34.69	10.68	15.53	13.11
GM+30 kg N/ha	13.33	3.68	14.09	18.75	20.41	37.19	11.93	16.78	14.35
GM+40 kg N/ha	14.30	3.88	15.05	19.86	21.04	38.81	12.79	17.77	15.28
5 tones SB +20 kg N/h	13.88	3.61	14.45	20.41	19.44	37.70	12.42	18.26	15.34
5 tones SB +30 kg N/ha	15.06	3.75	15.51	22.63	20.83	41.08	13.47	20.25	16.86
5 tones SB +40 kg N/ha	15.55	3.81	15.96	23.88	21.66	43.03	13.91	21.37	17.64
CD (P=0.05)	1.55	NS	-	3.24	2.91	-	-	-	-
CV (%)	20.90	9.96	-	21.61	19.96	-	-	-	-

GM: Green manuring, SB: Subabul

Table 3: **Gross and net returns in maize-wheat cropping system**

Treatments	CLUI (Kg/ha/day)	Gross returns (Rs. / ha)	Net returns (Rs. /ha)	B: C ratio
Control	2.29	16878	5870	0.71
10 tones FYM+20kg N/ha	4.42	25897	12836	1.09
10 tones FYM+30kg N/ha	5.05	28983	15863	1.31
10 tones FYM+40kg N/ha	5.60	31143	17963	1.39
GM+20 kg N/ha	3.59	21945	9634	0.87
GM+30 kg N/ha	3.93	23618	11248	1.00
GM+40 kg N/ha	4.19	24793	12363	1.06
5 tones SB +20 kg N/h	4.20	24012	11201	0.90
5 tones SB +30 kg N/ha	4.62	26066	13196	1.04
5 tones SB +40 kg N/ha	4.83	27182	14252	1.12

GM: Green manuring, SB: Subabul

Table 4: Nutrient status (kg/ha^{-1}) of soil after harvest of maize and wheat crop

Treatments	After maize harvest						After wheat harvest					
	N		P		K		N		P		K	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Control	130.4	131.7	12.6	13.9	126.0	127.1	128.9	128.3	11.6	11.4	123.9	122.9
10 tones FYM+20 kg N/ha	162.2	164.2	17.1	17.0	131.3	130.2	160.1	162.0	15.9	14.6	130.2	128.1
10 tones FYM+30 kg N/ha	169.6	171.7	18.9	18.8	132.3	131.3	167.5	169.6	17.8	16.7	129.2	129.2
10 tones FYM+40 kg N/ha	170.7	172.8	20.9	21.0	136.5	134.3	167.5	169.6	18.9	18.9	134.4	132.3
GM+20 kg N/ha	164.3	165.2	17.1	17.2	132.3	131.3	163.2	167.4	15.8	14.7	131.3	130.2
GM+30 kg N/ha	167.5	168.5	19.1	19.0	135.5	133.4	166.4	168.5	18.0	17.0	133.4	132.3
GM+40 kg N/ha	170.7	171.7	21.0	20.9	136.5	133.4	167.7	168.5	18.8	18.9	134.4	132.3
5 tones SB +20 kg N/h	163.2	164.2	16.7	16.6	133.4	132.3	162.2	164.2	16.6	16.4	132.3	131.3
5 tones SB +30 kg N/h	165.4	166.3	17.9	17.7	134.4	133.4	163.2	165.2	16.8	16.7	131.3	130.2
5 tones SB +40 kg N/h	168.5	167.4	19.0	18.8	135.5	134.4	164.3	166.3	18.0	17.5	134.4	132.3
CD (P=0.05)	3.59	5.76	1.88	2.17	NS	NS	3.48	3.69	1.97	1.91	NS	NS

GM: Green manuring, SB: Subabul

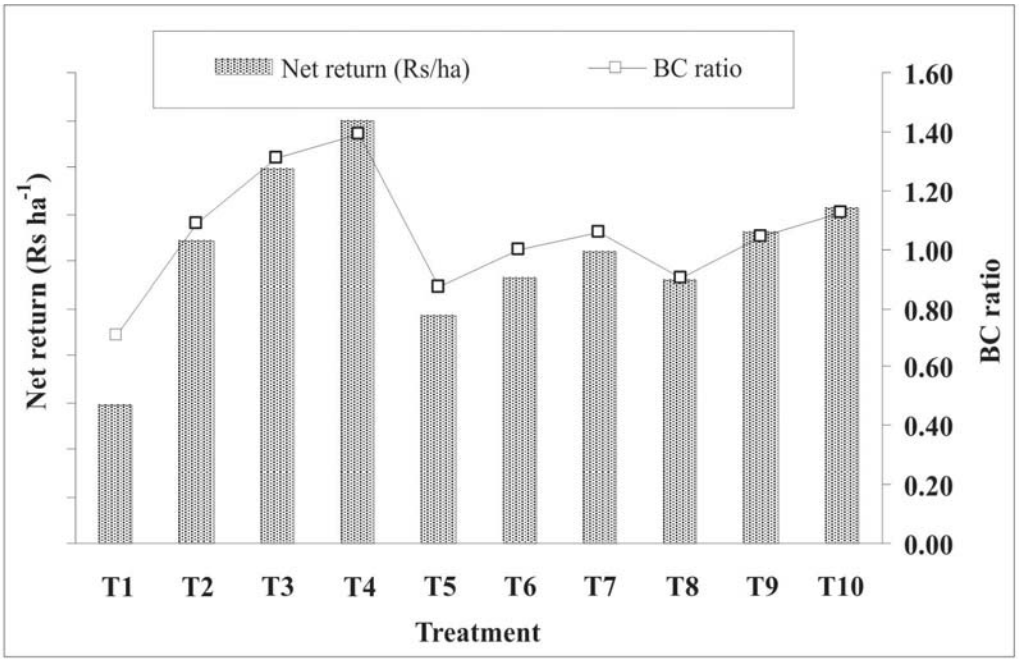

Fig. 1: Benefit cost ratio and net returns as influenced by various sources of nutrient application