Himachal Journal of Agricultural Research 35 (1):17-20, 2009

Integrated nutrient management in maize (*Zea mays*)-wheat (*Triticum aestivum*) cropping system in mid hills of Himachal Pradesh

B.S. Mankotia, R.C. Thakur, Sanjay Kumar and J. Shekhar
CSK Himachal Pradesh Krishi Vishvavidyalaya
Rice and Wheat Research Centre, Malan, Nagrota Bagwan-176 047, India.

Abstract

A field experiment was conducted on maize (*Zea mays* L.) – wheat (*Triticum aestivum* L. emend. Fiori & Poal) cropping system during *kharif* 2002 to *kharif* 2004 at Research Farm of CSK HPKV, Palampur, to evaluate six treatments viz., M_1: Sole maize (no manure), M_2: Sole maize + FYM @ 5 t/ha on dry weight basis, M_3: Maize + cowpea for green manure (*Vigna unguiculata* (L) Walp), M_4: Maize + cowpea for grain purpose, M_5: Maize + soybean (*Glycine max* L.) for grain purpose and M_6: Maize + Sunhemp (*Crotalaria juncea*) for green manure in rainy season and three fertility levels *viz.* 50%, 100% (80 kg N, 40 kg P_2O_5 and 40 kg K_2O/ha) & 150% of recommended NPK to wheat were tested in *rabi* season. Maize received recommended fertility level of 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha. A row of legume (green manure/grain crop) was grown between every two lines of maize ($_{M3-6}$) spaced 60 cm apart. Green manure crops were uprooted and cut at 60-65 days of sowing for *in-situ* green manuring in standing maize. Significant increase in the grain yield of maize was brought over M_1 by the application of FYM @ 5 t/ha (M_2) and by growing of cowpea for green manure (M_3) or grain (M_4) purpose as well as by growing of soybean for grain purpose(M_6); FYM application registered significantly highest maize grain yield (53.6 q/ha). Grain yield of succeeding wheat in second year was more in farmyard manured (M_2) and legume grown plots (M_{3-6}). Economic analysis of maize-wheat cropping system revealed that net returns from M_2 (FYM application) was Rs 40,662/ha and Rs 38,989/ha from M_3 (cowpea green manure); though latter recorded higher benefit: cost ratio (Rs 1.65) than M_2. Thus, *in-situ* green-manuring of cowpea appears to be an economically viable alternative of FYM when it is not available. Intercropping of soybean in maize in 1:1 ratio (additive series) followed by wheat was the most remunerative crop sequence.

Key words: Integrated nutrient management, green manure, nutrient uptake, productivity, profitability, maize - wheat system.

Introduction

Maize-wheat is the major cropping system in rainfed areas of the Himachal Pradesh and contributes substantially to the food grain production in the state. Farmyard manure is the proven source of nutrition to agricultural crops but its availability is inadequate. It is preferred to be applied in vegetable crops *vis-a-vis* farmers use dung for fuel purpose also in the state. Inclusion of legume green manure in cropping is beneficial (Shende and Sen, 1958). Owing to comparatively low temperature in hills, wheat in general matures in the end of May, thus, leaving insufficient time to raise green manure crop before sowing of maize. Hence present investigation was undertaken to explore the possibility of growing legumes for *in-situ* green manuring in standing maize in maize-wheat cropping system.

Material and Methods

A field experiment was conducted on maize–wheat cropping system during *kharif* 2002 to *kharif* 2004 at Research Farm of CSK HPKV, Palampur, to explore the possibility of *in-situ* green manuring in standing maize. The experimental soil was silty clay loam in texture, acidic (pH 5.6) in reaction having 369.2 kg N/ha, 18.4 kg P_2O_5/ha, 286 kg K_2O/ha. In *kharif* (maize), six treatments were evaluated *viz.* M_1: Sole maize (no manure), M_2: Sole maize + FYM @ 5 t/ha, M_3: Maize+cowpea for green manure (*Vigna unguiculata* (L) Walp), M_4: Maize + cowpea for grain purpose, M_5: Maize + soybean (*Glycine max* L.) for grain purpose and M_6: Maize + Sunhemp (*Crotalaria juncea*) for green manure, in randomized block design. Each plot was divided into three sub-plots and three fertility levels *viz.* 50%, 100% (80 kg N, 40 kg P_2O_5 and 40 kg K_2O/ha), & 150% of recommended NPK to wheat were tested in *rabi* season and data were analyzed using split plot design. A row of legume (green manure/grain crop) was grown between every two lines of maize (M_{3-6}) spaced 60 cm apart. Seed rate for soybean was 50 kg/ha and for cowpea and sunhemp 15 kg/ha. Maize received recommended fertility level of120 kg N, 60 kg P_2O_5 & 40 kg K_2O/ha and intercropped legumes were given 20 kg each of N & P_2O_5/ha as additional starter dose.

Green manure crops were uprooted and cut at 60-65 days of sowing for *in-situ* green manuring in standing maize. Half kilogram biomass of green manure crops was kept for the estimation of nitrogen content and N additions to the cropping system. Well decomposed farmyard manure having 0.65 to 0.77 percent N was applied to maize in M_2 which supplied 32.5 to 38.5 kg N/ha. Returns and maize grain equivalent yield were computed on the basis of prevailing market prices of the produce.

Results and Discussion

Effect on maize

Maize being an exhaustive crop responded well to the application of farmyard manure and to *in-situ* green manuring. Perusal of the data revealed that application of FYM @ 5 t/ha (M_2) and growing of cowpea for green manure (M_3) or grain (M_4) purpose as well as growing of soybean for grains (M_5) significantly increased the maize yield compared to M_1 (sole maize without FYM & legumes) (Table 1). The grain yield of latter ($M_{1,}$) was at par with that in sunhemp green-manure (M_6). Green manure cowpea (on an average 44.5 q/ha) produced more biomass as compared to sunhemp (30.1 q/ha) (Table 2) owing to its quick early growing habit. High biomass production from cowpea resulted in higher addition of nitrogen (41.7 to 46.3 kg/ha) from this as compared to sunhemp (26.3 to 34.0 kg/ha) green manure crop. These findings corroborate with those of Willey (1979) and Singh *et al.* (1986). Enrichment of soil nitrogen due to nitrogen fixation by legumes (Willey, 1979) and non competitive nature of legumes (Shrivastava *et al.*, 1983) are the possible reasons ascribed for higher grain yield of maize intercropped with legume (M_{3-6}). Gangwar and Kalra (1988) opined that legumes supply part of N requirement of maize crop by excretion mechanism operative in legumes. The beneficial effect of farm yard manure and legumes were also reflected in growth (plant height) and yield parameters (viz. number of grains/cob and 1000-grain weight (Table 1). On an average, maize plants were taller by 23 cm in farmyard manured plots and by 17 cm in cowpea manured plots. Similarly, the grains per cob were higher on an average by 138 and 61 grains/cob in farmyard manure and cowpea manure plots, respectively. Significant improvements in the test weight were also observed in all three years. Thus, average of three years revealed that FYM application (M_2, 53.6 q/ha) and green manuring of cowpea (M_3, 44.9 q/ha) increased the maize grain yield by 56.7 & 31.3 percent, respectively, over M_1 (34.2 q/ha). The corresponding increase from sunhemp (M_6) was 8.5 per cent probably due to lower biomass and nitrogen addition. The effect of farmyard manure on maize crop was more pronounced probably as manure was well decomposed and that might have supplied nutrition to maize crop right from the seedling stage, whereas legumes take time to establish, nodule formation and further benefit to the associated crop.

Soybean provided additional grains to the tune of 7.9 to 9.2 q/ha (M_6), whereas cowpea produced only 1.03 to 1.5 q/ha additional grains due to sparse flowering and poor seed setting. Thus, intercropping of soybean with maize in 1:1 ratio (additive series) resulted in on average 67.0 q/ha maize equivalent grain yield, whereas it was 48.5 q/ha with cowpea. Therefore, intercropping of soybean in maize for grains is a suitable cropping system in mid-hills of Himachal Pradesh.

Table 1. Effect of treatments on productivity of maize/legumes (q/ha), plant height, grains/cob and test weight of maize in maize-wheat cropping system

Treatment	Maize/legume grain yield				Plant height(cm)			Grains (No./cob)			1000 grain weight (g)		
	2002	2003	2004	Mean	2002	2003	2004	2002	2003	2004	2002	2003	2004
M_1	33.7	34.2	34.8	34.2	280.2	273.3	282.0	387	378	387	260	261	263
M_2	53.3	53.8	53.8	53.6	300.5	301.3	302.7	523	512	530	318	317	335
M_3	43.8	43.8	47.1	44.9	295.1	293.3	298.0	448	437	450	288	285	283
M_4	45.5	45.1	44.0	44.3	291.6	291.2	289.7	447	423	449	267	264	267
	(1.0)	(1.5)	(1.1)	(1.2)									
	48.5*	49.6*	47.3*	48.5*									
M_5	41.1	41.3	37.2	38.6	287.0	285.9	286.7	418	419	415	266	267	267
	(9.2)	(8.6)	(7.9)	(8.6)									
	68.0*	69.8*	63.4*	67.0*									
M_6	37.2	38.0	36.0	37.1	287.5	286.4	288.3	400	408	410	261	263	260
CD(P=0.05)	4.4	4.2	1.7		8.5	11.5	2.9	103	49	12	35	16	16

Values in parenthesis indicate grain yield of legume; *maize equivalent yield

Table 2. Biomass and nitrogen addition through green manures

Green manure	Biomass (q/ha)			N added (kg/ha)			
	2002	2003	2004	2002	2003	2004	Mean
Cowpea	118.3	126.8	132.2	41.7	45.5	46.3	44.5
Sunhemp	67.7	71.6	57.1	30.1	34.0	26.3	30.1

Effect on wheat

Residual effect of legumes and farmyard manure significantly affected the grain and straw yield of succeeding wheat in second year (Table 3) when wheat grain and straw yields after sole maize (M_1) were significantly less compared to farmyard manured (M_2) or legume plots (M_{3-6}), owing to improved growth (plant height) and yield parameters under these treatments (Table 3). Plants in farmyard manure plots (M_2) and cowpea manure (M_3) plots were taller by 6.0 and 5.8 cm, respectively. M_2 and M_3 recorded significantly higher number of grains/spike and 1000-grain weight during both the years compared to M_1. More nitrogen addition by cowpea green manure (M_3, Table 1) appears to have resulted in statistically similar wheat grain and straw yields as in FYM (M_2) plots. Residual effects of manures on succeeding crops have also been reported by Velayudham and Jagdish Seth (1986) and Shah *et al.* (2000), Esther Skekinah (2004) and Tiwari *et al.* (2004)

Application of different fertility levels to wheat revealed that plant height and number of ears/meter row length increased consistently and significantly with increasing fertility level during both the years. Application of 150% NPK produced on average taller plants by 3.9 cm whereas 50% NPK resulted in lesser plant height by 3.1 cm compared to 100% NPK. Likewise, an improvement in spike length, number of grains per spike and 1000-grain weight was also observed. Application of 100% NPK resulted in significant increase in number of grains/spike in 2003-04 as well as in 1000-grain weight during both the years compared to lower fertility level. Thus, grain and straw yield of wheat increased significantly with increasing fertility level. On an average, application of 150% NPK increased grain yield by 44.7 & 26.6 percent over 50% NPK and 100% NPK, respectively (Table 3). Results are in close agreement with those of Sharma and Sharma (1993) and Kumar *et al.* (2005).

Table 3. Performance of wheat as affected by the IPNS treatments in maize-wheat cropping system

Treatment	Plant height (cm)		Ears (No./m row length)		Ear length (cm)		Grain /spike		1000 grain (g)		Straw (q/ha)		Grain (q/ha)		Mean
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	
Residual effect on wheat															
M_1	87.4	86.4	39.7	38.4	7.8	7.6	40	33	35.9	33.8	43.4	35.8	25.0	19.5	22.25
M_2	93.1	92.8	49.7	48.5	8.8	8.3	43	42	37.9	36.6	49.4	50.6	28.4	27.3	27.85
M_3	92.8	92.5	48.3	47.1	8.2	8.2	41	41	37.9	37.8	49.1	48.7	27.7	28.2	27.95
M_4	90.7	90.3	46.7	45.9	8.2	8.1	41	40	37.5	37.5	47.7	46.8	26.2	27.0	26.60
M_5	88.7	88.6	42.4	41.5	8.0	7.9	40	41	37.2	37.0	46.4	41.8	25.8	25.1	25.45
M_6	88.2	88.4	40.4	40.0	8.0	7.8	40	40	37.3	37.0	45.2	40.6	25.5	24.5	25.00
CD (P=0.05)	NS	0.84	NS	1.2	0.1	NS	1	0.9	0.6	0.4	NS	2.9	NS	2.1	
Direct effect of fertility levels on wheat															
50 % NPK	86.6	86.4	37.6	37.2	7.9	7.8	39	38	35.8	35.0	39.2	33.9	21.5	20.3	20.90
100 %NPK	89.7	89.5	44.2	43.0	8.3	8.1	42	40	37.6	37.1	47.6	45.5	26.8	26.0	26.45
150 %NPK	93.7	93.3	51.7	50.7	8.3	8.1	41	40	38.5	37.9	53.4	52.1	30.8	29.7	30.25
CD (P=0.05)	1.1	NS	2.2	0.9	0.1	NS	NS	1.5	0.5	0.3	4.5	3.7	1.4	0.8	

I:2002-03, II: 2003-04; treatment details are given under material and methods

Economics of maize-wheat system

FYM application (M_2) increased the net returns by 57.5% and benefit: cost ratio compared to check (M_1, Rs 25,832/ha) (Table 4). Similar increases were observed due to different green manure intercrops. Cowpea green manure (M_3) with 51.0% higher net returns over control (M_1) exhibited greater advantage as compared to sunhemp (M_6, Rs 29,855/ha). The net returns from M_2 (FYM application) was Rs 40,662/ha and Rs 38,989/ha from M_3 (cowpea green manure); latter

Table 4. Mean net returns and benefit: cost ratio from maize-wheat cropping system

Treatment	Net return (Rs/ha)	Net return [% increase over check (M_1)]	Benefit:cost ratio
M_1	25,821	-	1.20
M_2	40,662	57.5	1.43
M_3	38,989	51.0	1.65
M_4	38,965	50.9	1.60
M_5	45,634	76.7	1.72
M_6	29,855	15.6	1.27

recorded higher benefit: cost ratio (Rs 1.65) than M_2. Kumar *et al.* (2005) have also reported that higher cost of FYM affects profit and benefit:cost appreciably. Thus *in-situ* green manuring of cowpea appears as an economically viable alternative of FYM when it is not available in mid-hill of Himachal Pradesh. Sunhemp green-manuring proved to be relatively less economical than cowpea green-manuring but better than cultivation of sole maize (no manures) – wheat (M_1, Rs 25,821/ha net returns & 1.20 B:C ratio). Among the different treatments, soybean grown for grain purpose in maize registered highest net returns (M_5, Rs 45,634/ha) and benefit:cost ratio (1.72). Thus, intercropping of soybean in maize in 1:1 ratio (additive series) followed by wheat was the most remunerative crop sequence.

References

Esther Skekinah D 2004. Performance of fodder maize (*Zea mays*) – based cropping system in a farming systems approach in western zone of Tamil Nadu. Indian J. Agron. **49** (1): 22-25.

Gangwar B and Kalra GS 1998. Influence of maize legume associations and nitrogen levels on maturity, grain quality and protein productivity. Legume Res. **11** (1): 6-10.

Kumar A, Thakur KS and Sharma S 2005. Integrated nutrient management in maize (*Zea mays*)–gobhi sarson (*Brassica napus* sp *oleifera* var. *annua*) cropping system under rainfed condition. Indian J. Agron. **50** (4): 274-77.

Shah RR, Rai RK and Mukherjee PK 2000. Effect of green manure *dhaincha* (*Sesbania aculeata*) and phosphorus on growth, yield and phosphorous uptake by wheat (*Triticum aestivum*). Indian J. Agron. **45** (4): 707-10.

Sharma GD and Sharma HL 1993. Fertilizer management for yield maximization of rice – wheat cropping system. Fert. News **3** (11):19-23.

Shende NK and Sen G 1958. Phosphate manuring of legumes. Indian J. Agron. **3** (2): 89-98.

Shrivastva UK, Yadav RP, Rastogi VK, Namdeo KN and Agrawal SK 1983. Intercropping system of maize with legumes under various nitrogen levels. Indian J. Agron. **28**: 156-58.

Singh NB Singh PP and Nair KPP 1986. Intercropping of legumes in maize under varying nitrogen levels and maize populations. Ann. Agric. Res. **7** (1): 37-43.

Tiwari RC, Sharma PK and Khandelwal SK 2004. Effect of green-manuring through *Sesbania cannabina* and *Sesbania rostrata* and Nitrogen application through urea to maize (*Zea mays*) in maize – wheat (*Triticum aestivum*) cropping system. Indian J. Agron. **49** (1): 15-17.

Velayudham K and Jagdish Seth 1986. Effect of preceding crops of cowpeas and maize on yield of wheat. Indian J. Agric. Sci. **56** (4): 263-66.

Willey RW 1979. Intercropping-its importance and research needs. 1. Competition and yield advantages. Field Crops Abst. **62** (1): 1-10.

VIR SOFTECH