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Research Paper

Winter maize as affected by preceding rainy-season crops, farmyard manure and nitrogen levels

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ABSTRACT

A field experiment was carried out during 2005–06 and 2006–07 at the Punjab Agricultural University, Ludhiana, to study the effect of preceding rainy-season (*kharif*) crops, viz. soybean [*Glycine max* (L.) Merr.], maize (*Zea mays* L.) and rice (*Oryza sativa* L.), farmyard manure 0 and 20 t/ha and nitrogen 0, 100, 140, 180 and 220 kg/ha on winter maize**.** Winter maize grown after soybean recorded significantly higher growth parameters, yield attributes and yield than after maize and rice. Application of farmyard manure (FYM) significantly increased the yield. The increase in grain yield with 20 t/ha FYM application was 7.8% over no FYM application. Maximum grain yield was obtained with 220 kg N/ha, being 60% higher than the control. Higher benefit: cost ratio was obtained with maize–winter maize followed by soybean–winter maize and the lowest with rice–winter maize cropping system. The benefit: cost ratio increased with increasing level of nitrogen and the minimum benefit: cost was obtained with the control (no nitrogen) and maximum with 180 and 220 kg N/ha.

Key words : Crop production, Cropping system, Nitrogen, FYM, Rice, Soybean, Winter maize

In Northern India, farmers generally follow the rice–wheat cropping system, which is posing a serious threat to natural resources like water and soil. This cropping system requires more water and nutrients, which ultimately deteriorate soil health and resulting-lowering of watertable. So, there is need to diversify the existing cropping system. During the winter (*rabi*) season, winter maize is one of the best alternatives to diversify this cropping system. Winter-sown maize is coming out to be better option than the rainy (*kharif*) season, maize owing to its higher yield and lesser insect pest infestation. A higher levels of NPK failed to sustain the crop yields due to increasing secondary and micronutrient deficiencies particularly with the use of high-analysis fertilizers. Thus, balanced use of fertilizers along with organic manure like farmyard manure (FYM) is considered a promising agro-technique to sustain, increase fertilizer-use efficiency and restore soil fertility (Singh and Aggarwal, 2000; Verma, 2011). Inclusion of a legume crop in the crop rotation may have ameliorating effect on soil as well as on the yield of the succeeding crop. Keeping in view the above points, the present investigation was carried out to find out the effect of preceding *kharif* crops on yield and economics of winter maize at different FYM and nitrogen levels.

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MATERIALS AND METHODS

The Experiment was conducted during 2005–06 and 2006–07 at the research farm, Department of Agronomy, Punjab Agricultural University, Ludhiana (30°56’N and 75°52’ and 247 m above mean sea-level) under irrigated conditions on a well-drained loamy sand soil. The soil was low in available N (172.3 kg/ha), high in available P (28.3 kg/ha), medium in available K (171.6 kg/ha), low in organic carbon (0.38%) and having pH 7.6. The experiment was conducted in split-plot design, with 3 preceding *kharif* crops (soybean cv. ‘SL 295’, maize cv ‘Paras’, rice cv. ‘PR 115’) and 2 FYM (0.75:1.35:0.75) levels (0 and 20 t/ha) in main plots and 5 nitrogen levels (0, 100, 140, 180 and 220 kg/ha) applied to winter maize in sub-plots with 3 replications. The preceding *kharif* crops, viz. soybean, maize and rice, were harvested on 30 October, 27 September and 25 October respectively during both the years. After a pre-sowing irrigation winter maize cv. ‘Bulland’ was sown 19 and 15 November during 2005 and 2006 with spacing of 60 cm × 20 cm. As per treatments one-third dose of nitrogen and whole of phosphorus (60 kg P_2O_5/ha) and potassium (30 kg K_2O/ha) along with zinc sulphate @ 25 kg/ha was applied to winter maize as basal dose at the time of sowing. The remaining 2 equal doses of nitrogen were applied to winter maize in mid-January and at pre-tasseling stage. Winter maize crop was harvested on 23 and 27 May during 2005 and 2006, respectively. and the grain yield was computed at 15% moisture. Available N, P and K kg/ha were analysed by alkaline potassium permangante method (Subbiah and Asija, 1956). 0.1 N sodium bicarbonate method (Olsen *et al.,* 1954) and ammonium acetate method of flame photometer (Jackson, 1967).

RESULTS AND DISCUSSION

Growth parameters

Maximum plant height, dry matter and leaf-area index (LAI) of winter maize were recorded with soybean as compared to preceding maize and rice crops (Table 1). Maximum plant height, dry matter and leaf-area index of winter maize was recorded with preceding *kharif* soybean crop owing to its favourable effect on soil characteristics compared to preceding crops of cereals (rice and maize). Application of 20 t/ha FYM increased significantly plant height, dry matter and leaf-area index of winter maize compared to no FYM application. Bheemaiah and Subramanyam (2003), Barik and Chaudhari (2005) and Verma (2011) also reported increase in plant height, dry matter and leaf-area index of winter maize with the application of FYM. Significant increase in plant height, dry matter and leaf-area index were recorded with the increased dose of nitrogen from 0 to 220 kg/ha. Maximum plant height, dry matter and leaf-area index were recorded with 220 kg N/ha, which were statistically at par with that obtained with 180 kg N/ha, while significantly higher than 140, 100 and 0 kg N/ha Verma (2011) also observed significant increase in plant height, dry matter and leaf-area index of winter maize with 180 kg N/ha.

Days taken to tasseling, silking and physiological maturity

Winter maize took significantly more days to 50% tasseling, 50% silking and maturity in rice–winter maize compared to maize–winter maize and soybean–winter maize cropping system (Table 1). Application of FYM @ 20 t/ha significantly reduced days taken to 50% tasseling, 50% silking and maturity. Increased levels of nitrogen from 0 to 220 kg/ha decreased days taken to 50% tasseling and 50% silking. The minimum days were recorded for silking with 220 kg N/ha and at par with 180 kg N/ha. Paradkar and Sharma (1992) also showed significant decrease in days to silking with increased nitrogen levels in winter maize. The nitrogen levels have significantly influenced the days taken to physiological maturity. More time for physiological maturity was recorded in the control compared with different levels of nitrogen. The minimum time for physiological maturity was recorded with 220 kg N/ha, which was at par up 140 kg N/ha.

Yield attributes

Winter maize grown after soybean recorded significantly higher number of grains/cob, cob length and 1,000-

Table 1. Effect of nitrogen and farmyard manure (FYM) on growth and yield attributes of winter maize after different rainy (*kharif*) season crops (pooled data of 2 years)

Treatment	Plant height (cm)	Dry matter accumulation (t/ha)	Leaf-area index	Number of days		
				Tasseling (50%)	Silking (50%)	Maturity
Kharif crops						
Rice	157.2	17.2	2.1	138	143	176
Maize	164.9	18.7	2.3	136	141	174
Soybean	179.1	22.4	2.7	134	140	173
SEm±	3.95	0.40	0.06	0.55	0.6	0.45
CD (P=0.05)	9.45	1.03	0.34	1.7	1.6	1.4
FYM (t/ha)						
0	163.1	17.8	2.23	137	142	175
20	170.8	20.8	2.50	135	140	173
SEm±	3.25	3.45	0.25	0.35	0.35	0.4
CD (P=0.05)	8.00	8.38	0.14	1.3	1.3	1.2
N (kg/ha)						
0	150.1	14.6	1.88	138	145	176
100	163.7	18.1	2.25	136	142	175
140	169.3	20.1	2.42	135	140	173
180	172.5	21.3	2.62	134	140	173
220	178.9	22.4	2.65	133	138	172
SEm±	4.4	0.51	0.06	0.65	0.5	0.45
CD (P=0.05)	13.75	1.60	0.20	1.9	1.7	1.5

grain weight than after maize and rice (Table 2). Application of 20 t/ha FYM increased significantly number of grain/cob, cob length and 1,000-grain weight of winter–maize compared to 0 t/ha FYM (Table 2). Significant increase in grains/cob, cob length and 1,000-grain weight were recorded with the increased dose of nitrogen from 0 to 220 kg/ha. Maximum grains/cob, cob length and 1,000-grain, weight were recorded with application of 220 kg N/ha, which were statistically at par with that obtained with 180 kg N/ha, while significantly higher than 140, 100 and 0 kg N/ha.

Yield

Grain and stover yields of winter maize was significantly influenced by different preceding *kharif* crops (Table 2). Winter maize grown after soybean recorded significantly higher grain and stover yield than after maize and rice. The improvement in grain and stover yield of winter maize succeeding soybean might be attributed to significantly higher plant height and dry matter as well as improved yield attributes, viz. grains/cob and 1,000-grain weight. Our results were in accordance with Suwanarit *et al.* (1986) and Weil and Samaranayake (1991). The significantly increase in grain and stover yield with 20 t/ha FYM application over no FYM application. Improvement in grain yield of winter maize with the application of FYM was reflected through improvement in growth characters, viz. plant height and dry matter. Vadivel *et al.,* (2001), Bheemaiah and Subrahmanyam (2003) and Verma (2011) also reported similar increase in grain and stover yield of winter maize with the application of FYM. Maximum grain and stover yield was obtained with application of highest dose of 220 kg N/ha. Significant increase in plant height, dry matter and yield-attributing characters, viz. grains/cob and 1,000-grains weight, were mainly responsible for improvement in grain yield with 220 kg N/ha. Singh *et al.* (2003) and Verma (2011) also observed significant increase in grain and stover yield with 180 kg N/ha.

Nutrient uptake

Maximum nitrogen, phosphorus and potassium uptake in winter maize grain were recorded in soybean–winter maize, followed by maize–winter maize and rice–winter maize cropping system. Application of FYM resulted significantly increase uptake of nitrogen, phosphorus and potassium compared to no-FYM application in maize. Nitrogen, phosphorus and potassium uptake by winter maize continued to increase with successive increase in nitrogen levels. Kumar *et al.* (2001) and Verma (2011) also obtained that increase in nitrogen level resulted increase in nitrogen, phosphorus and potassium uptake in winter maize.

Economics

Maximum variable cost was observed in rice–winter maize followed by maize–winter maize and lowest in soybean–winter maize. Cultivation cost increased with in-

Table 2. Effect of nitrogen and farmyard manure (FYM) on yield attributes, grain and stover yield and nutrient uptake by winter maize after different rainy (*kharif*) season crops (pooled data of 2 years)

Treatment	Grains/cob	Cob length (cm)	1,000-grains weight (g)	Grain yield (t/ha)	Stover yield (q/ha)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)
Kharif crops								
Rice	383.4	11.7	229.5	6.0	9.5	96.1	25.6	33.5
Maize	396.1	12.0	232.7	6.6	10.5	145.2	30.8	44.9
Soybean	432.5	12.8	244.3	7.2	11.0	222.4	35.4	59.7
SEm±	6.95	0.15	3.10	1.10	0.17	12.0	3.21	5.02
CD(P=0.05)	19.00	0.40	8.85	0.30	0.50	39.2	8.32	14.23
FYM (t/ha)								
0	392.5	11.9	231.0	6.4	9.9	141.1	26.0	37.6
20	415.7	12.4	240.0	6.9	10.8	163.9	35.4	54.2
SEm±	4.85	0.09	2.40	1.05	1.7	6.02	3.23	5.2
CD(P=0.05)	15.5	0.30	7.20	0.21	0.40	18.65	10.00	
N (kg/ha)								
0	321.8	10.3	209.1	4.7	8.0	102.8	21.8	27.4
100	365.9	11.9	230.8	6.4	9.9	141.8	28.3	40.4
140	419.4	12.3	242.7	6.9	10.7	160.6	31.4	47.7
180	450.1	12.7	246.8	7.4	11.4	176.8	34.8	54.6
220	462.6	13.0	248.2	7.6	11.8	187.7	37.4	62.4
SEm±	10.15	0.2	4.80	0.10	0.20	6.03	4.23	6.03
CD (P=0.05)	31.20	0.40	14.00	0.41	0.60	16.99	11.02	21.21

Table 3. Return over variable cost analysis of different cropping systems

Treatment	Cultivation cost (×10³ ₹/ha)	Gross income (×10³ ₹/ha)	Net returns (×10³ ₹/ha)	Benefit: cost ratio
Cropping systems				
Rice–winter maize	33.9	88.9	55.0	1.62
Maize–winter maize	32.1	90.2	58.1	1.81
Soybean–winter maize	28.1	78.6	50.5	1.79
SEm±	-	0.9	0.84	0.029
CD (P=0.05)	-	2.8	2.79	0.100
FYM (t/ha)				
0	30.5	83.8	53.4	1.75
20	32.3	88.0	55.7	1.73
SEm±	-	0.7	0.55	0.025
CD (P=0.05)	-	2.3	3.02	NS
N (kg/ha)				
0	30.1	71.9	41.6	1.38
100	31.1	84.2	53.1	1.71
140	31.5	88.5	56.9	1.81
180	31.9	91.9	60.0	1.88
220	32.3	93.4	61.0	1.88
SEm±	-	1.05	1.05	0.033
CD (P=0.05)	-	3.45	3.45	0.099

creased level of FYM and nitrogen. Higher gross return was obtained in rice–winter maize cropping system, which was at par with maize–winter maize cropping system and significantly higher than soybean–winter maize cropping system. Application of 20 t/ha FYM increased gross return. Gross income continued to increase significantly with increasing level of nitrogen from 0 to 220 kg N/ha. The maximum net-return and benefit: cost ratio was observed in maize–winter maize cropping system followed by soybean–winter maize and rice–winter maize cropping system. The application of FYM resulted non-significant effect on benefit: cost ratio. The increased levels of nitrogen from 0 to 220 kg/ha increased the net return and benefit: cost ratio.

It was concluded that winter maize grown after soybean recorded the maximum grain yield, while maximum net return and benefit: cost ratio was observed in winter maize grown after *kharif* maize. The yield increased with increased level of FYM and nitrogen. The net return and benefit: cost ratio also increased with increased level of nitrogen.

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