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Productivity, protein content and economics of quality protein maize (QPM) as influenced by integrated nutrient management practices

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Abstract

In North Eastern Region (NER) of India, an imbalance supply of fertilizers and lack of proper recommendations of fertilizer application for hybrid maize leading to a wide gap in yield. Thus, a field experiment was conducted during *kharif* 2011 on the Experimental Farm of the College of Post Graduate Studies (CAU-Imphal), Umiam, Meghalaya to evaluate the effect of *in-situ* green manuring of intercropped cowpea (*Vigna uniguiculata* L) and combined application of fertilizer with FYM on productivity, protein content and economic returns of quality protein maize (QPM). Higher yield attributes, yield and economic return over sole maize were recorded due to green manuring in maize though the difference for most of the parameters between the treatments was statistically at par. Grain yield obtained from green manured maize plots (5.39 t ha^{-1}) was 22 per cent higher as compared to sole maize (4.42 t ha^{-1}). Among the integrated nutrient management practices, maximum yield (5.64 t ha^{-1}) of maize was recorded in 75% recommended dose of fertilizer (RDF) + FYM 5 t ha^{-1} which was at par with 50% RDF + FYM 7.5 t ha^{-1} (5.50 t ha^{-1}), RDF (5.36 t ha^{-1}) and 75% RDF + FYM 2.5 t ha^{-1} (4.83 t ha^{-1}) but significantly superior over 50% RDF + FYM 7.5 t ha^{-1} (4.53 t ha^{-1}) and control (3.58 t ha^{-1}). The highest economic return was recorded under 75% RDF + FYM 5 t ha^{-1} (Rs. 30,300 ha^{-1}) however; maximum benefit cost ratio (1.99) was obtained from RDF alone. Thus, treatment 75% RDF + FYM 5 t ha^{-1} was proved as the best combination for higher productivity of QPM in hill ecosystems of NER.

Keywords: Integrated nutrient management, Quality Protein Maize, Green manuring

Introduction

Maize (*Zea mays* L.) is the third most important cereal crop of the world and India both in terms of area and production. However, in north eastern states, maize is the second most important food crop after rice. Maize is cultivated over an area of 18,056 hectares with a production of 41,242 tonnes and a productivity of 2,284 kg ha^{-1} in Meghalaya (Anonymous, 2015-16). The productivity of maize in north eastern region (NER) is comparatively lesser as compared to the national productivity (2,150 kg ha^{-1}) due to improper nutrient management. Maize, being an exhaustive crop, requires appropriate nutrient supplementation to sustain soil health. Hence, judicious application of organic and inorganic fertilizers is very important for optimum yield of maize crop. More than 85 per cent of maize produced is directly utilized for food and fodder. Therefore, improvement in its quality has a greater role for food and nutritional security in the country. QPM has the specific features of having amino acids with high content of lysine and tryptophan which leads to higher biological value and net protein utilization. QPM looks and tastes like normal maize with same or high yield potential, but it contains twice the quantity of essential amino acids which makes it rich in quality protein and low in amount of leusine which makes QPM a special and distinctive status among cereals. Adoption of QPM in tribal dominated belts of NER hills of India could be a strong support for ensuring food and nutritional security where maize is the second major crop after rice (Prasanna *et al.*, 2001) [8]. Thus, the present study was conducted to evaluate the effect of *in-situ* green manuring of intercropped cowpea and integrated nutrient management (INM) on productivity, protein content and economic returns of QPM and their residual effects on soil fertility.

Materials and Methods

A field experiment was conducted during *Kharif* 2011 at the Experimental Farm of the College of Post Graduate Studies (CAU), Umiam, Meghalaya in split plot design (SPD) with 12 treatment combinations replicated thrice.

Geographically, Umiam is located in North-east Hill Region of India at 25°41'N latitude, 91°54'E longitude and at an elevation of 950 m above mean sea level. The average annual rainfall received was 2,617.10 mm. The mean maximum and minimum temperature during the cropping season ranged from 31.4 °C and 16.4 °C, respectively. The mean relative humidity ranged from 89.28% in the morning and 76.19% in the evening hours. Mean bright sunshine hours and mean evaporation rate ranges from 2.84 to 4.10 h d^{-1} and 2.10 to 2.35 mm d^{-1}, respectively while wind speed varied from 1.47 to 2.57 km h^{-1} during the crop growing period. The two main plots treatments consisted of sole maize and maize with cowpea green manuring; and sub-plot consist of six integrated nutrient management combinations, *viz*., Control, RDF, 50% RDF + FYM 5.0 t ha^{-1}, 50% RDF + FYM 7.5 t ha^{-1}, 75% RDF + FYM 2.5 t ha^{-1} and 75% RDF + FYM 5 t ha^{-1}. The RDF of maize is 80-60-40 N, P_2O_5 and K_2O ha^{-1}. The fertilizer sources used were urea (46% N), single super phosphate (16% P_2O_5) and murate of potash (60% K_2O). The soil fertility under various treatments was estimated by soil analysis of composite soil sample collected before sowing and from different plots after harvesting of crop. The soil of the experimental site was sandy clay loam with bulk density of 1.36 g cc^{-1}, low in available N (250.85 kg ha^{-1}), available P_2O_5 (20.62 kg ha^{-1}), available K_2O (106.43 kg ha^{-1}) with acidic reaction (pH 5.1) and high organic carbon content (0.99%). The observation for yield attributes such as cob length, grain rows per cob, grains per row, grain yield, test weight, benefit: cost (B:C) ratio were recorded, calculated and statistically analyzed at harvest. The cost of cultivation, net return and benefit:cost ratio were calculated on the basis of prevailing market prices of different inputs and outputs.

For statistical analysis of experimental data, analysis of variance (ANOVA) was done in split plot design for various observations. Significance of treatment differences was tested by F (Variance ratio) test. Critical difference (CD) at 5 per cent level of significance (P=0.05) was worked out for comparison and statistical interpretation of treatments as per Gomez and Gomez (1988) [3].

Results and Discussions

Significant variation was recorded in the yield and yield attributing characters of maize due to different Integrated Nutrient Management (INM) practices (Table 1 and 2). The yield attributes such as cobs per plant, number of grain rows and per cob and test weight and grain weight per plant were *at par* due to *in-situ* incorporation of cowpea as a green manure crop even though higher values were observed for these characters in green manured treatments as compared to sole maize. However, these yield attributes differed significantly due to different nutrient combinations between organic and inorganic sources. This was due to the capability of a plant to produce economic yield which depends not only on the size of photosynthetic system but also upon the efficiency and length of time for which it is active, and the amount of dry matter translocated to economic sink. Maximum cobs $plant^{-1}$ was recorded under RDF which was at par with 50% RDF + FYM 5 t ha^{-1} and 75% RDF + FYM 2.5 t ha^{-1} but significantly more over the other treatments. Green manured maize produced relatively more grain rows (13.98) over the sole maize (13.41) even though the difference was not significant. The INM combinations also brought a significant difference in number of grain rows cob^{-1}. Minimum and maximum number of grain rows per cob was recorded under control (12.79) and 75% RDF + FYM 5 t ha^{-1} (14.52), respectively. Application of 75% RDF + FYM 5 t ha^{-1} being at par with RDF, 50% RDF + FYM 7.5 t ha^{-1}, and 75% RDF + FYM 2.5 t ha^{-1}, recorded significantly more grain row over 50% RDF + FYM 5 t ha^{-1}. Minimum and maximum grains per row were observed under control (19.8) and 75% RDF + FYM 5 t ha^{-1} (25.2), respectively. Application of 75% RDF + FYM 5 t ha^{-1} being at par with RDF and 50% RDF + FYM 7.5 t ha^{-1}, recorded significantly higher grains per cob over other treatments. Different combinations of fertilizer with FYM brought a marked difference in test weight of maize grains. Maximum test weight was observed under 75% RDF + FYM 5 t ha^{-1} (253.51 g) while the lowest was under control (200.97 g) treatments, respectively. All the treatments receiving fertilizer and FYM produced significantly higher grain weight $plant^{-1}$ over the control. Maximum grain weight $plant^{-1}$ was obtained under 75% RDF + FYM 5 t ha^{-1} (82.73 g) which being at par with RDF and 50% RDF + FYM 7.5 t ha^{-1}, recorded significantly higher grain weight $plant^{-1}$ over the remaining combinations of fertilizers with FYM. Between intercropped green manure and sole maize treatments, grain weight $plant^{-1}$ of green manured maize was 23.7% more over sole maize but did not differ significantly.

Between green manured and sole maize, green manured maize produced higher biological, grain and stover yield and HI over sole maize however, the difference for grain yield and HI was *at par*. These findings are in close conformity with the findings of Sharma *et al* (2010) [9], Jat *et al*. (2010) [4] and Jat *et al*. (2011) [5] who also reported higher yields of maize due to incorporation of intercropped cowpea for green manuring purpose in comparison to no green manuring due to better soil properties and more availability of plant nutrients in soil. All the plots receiving nutrients either as fertilizer or combination of fertilizer with FYM produced significantly more grain, stover and biological yield over the control. Maximum grain yield was obtained under 75% RDF + FYM 5 t ha^{-1} (5.64 t ha^{-1}) which was at par with 50% RDF + FYM 7.5 t ha^{-1}(5.50 ha^{-1}), RDF(5.36 t ha^{-1}) and 75% RDF + FYM 2.5 t ha^{-1}(4.83 t ha^{-1}) but significantly higher grain yield over 50% RDF + FYM 5 t ha^{-1}(4.53 t ha^{-1}) and control (3.58 t ha^{-1}). The highest stover yield was recorded under the treatment 75% RDF + FYM 5 t ha^{-1} (11.06 t ha^{-1}) which was at par with RDF and 50% RDF + FYM 7.5 t ha^{-1} but significantly high over remaining combinations of fertilizers and FYM. Biological yield also differed significantly due to application of different levels of combinations of RDF with various doses of FYM. Maximum biological yield (16.70 t ha^{-1}) was recorded from the treatment 75% RDF + FYM 5 t ha^{-1} which was at par with RDF (16.26 t ha^{-1}) and 50% RDF + FYM 7.5 t ha^{-1}(15.70 ha^{-1}) and these three treatments produced significantly high biological yield over remaining three treatments. Harvest index (HI) did not differ significantly due to green manuring but slightly high HI was observed with cowpea green manured maize. However, various combinations of fertilizer and FYM brought significant differences in HI where all the nutrients treated plots gave significantly lower HI as compared to control. This was because of proportionally greater partitioning of photosynthate in controlled plots as compare to application of various combinations of RDF with FYM. Kumar *et al*., (2005) [6], Singh and Nepalia (2009) [10], Tetarwal *et al.*, (2011) [11] and Balai *et al*. (2011) [2] also reported significantly high grain, stover and biological yield of maize due to integration of FYM with various levels of recommended fertilizer doses. This was because of significantly more values of yield attributes at higher levels of

RDF with various doses of FYM and more number of plants at the time of maize harvest.

Protein content in grain and stover did not vary significantly either due to green manuring or various combinations of RDF with FYM. However, green manured maize had slightly more protein both in grain and stover over sole maize. Among various combinations of RDF with FYM, treated plots observed comparatively more protein both in grains and stover as compare to control deprived of external sources of nutrients and solely depend on inherent supply power. Maximum (10.75 and 4.49 per cent, in grain and stover, respectively) and minimum (9.8 and 3.85 per cent in grain and stover, respectively) protein content was associated with the treatments 75% RDF + FYM 5 t ha^{-1} and control treatments, respectively. No significant difference for this very important quality trait of maize was because of at par nitrogen content in grain and stover of maize both due to green manuring as well as combination of FYM with inorganic fertilizers.

Economic returns from a crop depend on the market value of its economic output and the quantity of output produced. High grain and stover yields per hectare in green manure maize due to greater nutrients availability throughout crop growth and favourable physical and biological environment might have the reason for this economic gain over sole maize. Gross return, Net return and B:C ratio in this QPM did not vary significantly due to green manuring however, green manure treated plots yielded relatively high values of all these three indicators of economic sustainability. As evidenced from the table, green manured 21.5%, 41.5% and 12.7% high gross return, net return and B:C ratio, respectively over non manured sole maize. Only marginal increase in cost of cultivation and much more gross return as evidenced by relatively more grain and stover yield in green manured plots was the reason for this trend. Combinations of various levels of RDF with different doses of FYM however, brought significant difference in gross return, net return and B:C ratio of QPM. All the nutrient applied treatments observed significantly more values of this economic indicators over no external nutrient supplied treatment (control) as given in Table 3. Maximum gross return was obtained from the treatment 75% RDF + FYM 5 t ha^{-1} which were at par with RDF and 50%RDF + FYM 7.5 t ha^{-1} treatments. Return from these treatments was significantly more over remaining three treatments. Maximum net return was also observed from 75% RDF + FYM 5 t ha^{-1} treatment which was close at par with the net return reported from RDF treatment. Net return from these two treatments was significantly high over the remaining four treatments of fertilizers and FYM combinations. As net return is the product of gross return-cost of cultivation, much more decline in gross return in controlled plots as evidenced by significantly low grain and stover yield was the reason why all treated plot had recorded significantly more net return over control. The same justification may be extended to difference in net return among other combinations of fertilizers and FYM as higher the net return was invariably associated with high grain and stover yield from the respected treatments. In contrary to gross and net return maximum B:C ratio was observed from RDF treatment than 75% RDF + FYM 5 t ha^{-1} treatment. This was because of relatively less cost of cultivation in RDF treatment (Rs. 29.64 thousand ha^{-1}) than 75% RDF + FYM 5 t ha^{-1} (Rs. 31.60 thousand ha^{-1}) this treatment as this indicator is the product of gross return/cost of cultivation. Despite lowest cost of cultivation in control plots, significantly lower gross return was responsible for lowest B:C ratio in this treatment. Similar trend in economic returns from maize was also observed by Kumar and Thakur (2009) [7], Jat *et al*., (2010) [4] Kumar *et al*., (2005) [6], Singh and Nepalia (2009) [10], Tetarwal *et al*., (2011) [11] and Balai *et al*. (2011) [2] due to various integration of green manuring, FYM and fertilizers.

Thus, the study reveals that an integrated application of green manure, FYM and fertilizers would be a better alternative for sustainable production of QPM over the fertilizer as sole source for nutrient application.

Table 1: Yield attributes of quality protein maize as influenced by green manuring and various combinations of RDF with FYM

Treatments	Cobs $plant^{-1}$	Cob length (cm)	Cob diameter (cm)	No. of grain rows cob^{-1}	No. of grains row^{-1}	No. of grains cob^{-1}	Test weight (g)	Grain yield $plant^{-1}$ (g)
Green Manuring								
Sole Maize	1.00	13.10	12.20	13.41	21.23	286.30	217.69	61.97
Maize + Cowpea for green manuring	1.02	14.15	12.66	13.98	23.99	339.51	232.75	76.66
SEm±	0.03	0.38	0.13	0.13	0.66	7.46	6.67	2.84
CD(P=0.05)	N.S	N.S	N.S	N.S	N.S	45.38	NS	N.S
Fertilizer and FYM combination								
Control	0.80	11.78	11.93	12.79	19.80	253.54	200.97	50.49
RDF	1.17	13.91	12.77	14.38	24.18	349.28	250.35	81.28
50% RDF + FYM 5 t	0.93	13.08	12.24	13.22	20.64	273.38	215.87	59.99
50% RDF + FYM 7.5 t	0.97	14.19	12.62	13.67	23.59	324.53	229.41	75.15
75% RDF + FYM 2.5 t	1.07	13.84	12.26	13.58	22.27	309.49	219.23	66.25
75% RDF + FYM 5 t	1.13	14.94	12.78	14.52	25.20	367.22	235.51	82.73
SEm±	0.05	0.47	0.26	0.35	0.91	16.40	9.31	3.49
CD(P=0.05)	0.16	N.S	N.S	1.02	2.68	48.38	27.47	10.29

Table 2: Grain yield, stover yield, biological yield and harvest index of quality protein maize as influenced by green manuring and integration of RDF with FYM

Treatments	Protein content (%) grain	Protein content (%) stover	Grain yield (t ha^{-1})	Stover Yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index
Green manuring						
Sole Maize	10.20	4.05	4.42	8.41	12.83	0.35
Maize + Cowpea green manuring	10.64	4.19	5.39	9.81	15.21	0.36
SEm±	0.11	0.14	1.82	1.36	3.11	0.4
CD(P=0.05)	NS	NS	NS	8.28	18.94	N.S

Fertilizer and FYM combination						
Control	9.81	3.85	3.58	54.83	9.07	0.4
RDF	10.51	3.92	5.36	10.90	16.26	0.33
50% RDF + FYM 5 t	10.00	4.07	4.53	8.47	13.00	0.35
50% RDF + FYM 7.5 t	10.64	4.09	5.50	10.21	15.71	0.35
75% RDF + FYM 2.5 t	10.81	4.29	4.83	8.54	13.36	0.36
75% RDF + FYM 5 t	10.75	4.49	5.64	11.06	16.70	0.34
SEm±	0.26	0.16	3.41	7.05	10.04	0.01
CD(P=0.05)	NS	NS	10.07	20.78	29.63	0.03

Table 3: Economics of quality protein maize as influenced by green manuring and integration of RDF with FYM

Treatments	Cost of cultivation (₹ '000, ha^{-1})	Gross return (₹'000, ha^{-1})	Net return (₹ '000 ha^{-1})	B:C ratio
Green manuring				
Sole Maize	29.02	48.41	19.40	1.66
Maize + Cowpea green manuring	31.37	58.83	27.46	1.87
SEm±	-	3.11	1.88	0.06
CD(P=0.05)	-	NS	NS	NS
Fertilizer and FYM combination				
Control	26.62	38.57	11.95	1.45
RDF	29.64	59.07	29.43	1.99
50% RDF + FYM 5 t	30.85	49.57	18.72	1.60
50% RDF + FYM 7.5 t	32.21	60.09	27.89	1.86
75% RDF + FYM 2.5 t	30.24	52.52	22.28	1.73
75% RDF + FYM 5 t	31.60	61.91	30.30	1.96
SEm±	-	3.71	3.71	0.12
CD(P=0.05)	-	10.94	10.94	0.35

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