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Evaluation of improved nutrient management in yield and economics of hybrid maize in Jhapa, Nepal

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Abstract
As a second most widely planted cereal crop in Nepal, Maize (Zea mays) productivity is highly affected by improper fertilization techniques. Generic but flexible and location-specific fertilizer recommendation method is necessary to improve the yield gaps. Hence, a field experiment was conducted on farmer's field at Garamani, Jhapa using Nutrient Expert® hybrid maize model from March to August 2016 using 3 treatments viz. Nutrient Expert (NE), Farmer Fertilizer practices (FFP) and Government Recommendations (GR) replicated 7 times in RCBD design. The result revealed significant difference in terms of plant number ha-1, cob numberha-1, number of row per cob, length per cob, number of kernel per kernel row, test weight, yield at 15.5% moisture, partial and total factor productivity and benefit cost ratio. The highest yield (7.61tonha-1), revenue, benefit cost ratioand profitwas obtained from NE followed by GR yield (6.55tonha-1) and FFP (6.43tonha-1).

Keywords: Fertilization, Nutrient Expert, Government Recommendation, Productivity

Introduction
Agriculture supports around 60% of the total gross product (GDP) of the nation which is dominated by the cereal crop production in Nepal. Maize is regarded as the 'Queen of cereals and ranks as the second most important cereal crop in Nepal after rice in terms of its area, production and productivity. The demand for maize is increasing due to the upsurge in human population growth rate 1.16% and the changing healthy diet habits of consumer from starch to protein rich food. (Tripathi & Gurung, D.B., 2016). The inflated animal and poultry feed industry, particularly in the Terai and Inner Terai regions of Nepal (Upadhyay, 2004), poultry feed industry growth by 11% (FAO. 2014, Poultry Sector Nepal.) has made maize an important source of cash especially for small holders either directly through its sale to millers or indirectly through the sale of animals that are fed with maize grain (Serchan, 2004).

Yet, the productivity of the country is very low (2.45 t/ha) due to wide gap between crop actual yield potential and farmers' yields (Dhami, 2004). There are many factor behind it, of them, imbalance use of fertilizer, is the major limiting factor for the yield reduction. The imbalance and improper fertilizers management contribute loss of yield causing the wider gap. Farmers apply fertilizer as per wish and availability resulting imbalanced use of fertilizer which causes over-supply or deficit of nutrients resulting low productivity and low economic return. Government of Nepal provides ecological region based blanket fertilizer recommendation which is impractical to meet the demand of specific crop at specific sites as nutrient status of the soil varies from field to field. So, the Government recommendation of the fertilizer is not able to address the soil of farmer's field and becomes impractical to use due to insufficient dissemination of the developed approach. The nutrient needs of a crop directly affects the yield (Janssen *et al*., 1990) so, site specific nutrient management (SSNM) is essential. SSNM improves the Nutrient Use Efficiency by the approach of "Feeding" crops with nutrients as and when needed by the optimal use of existing indigenous nutrient sources and timely application of fertilizers at optimal rates (Dobermann *et al*., 2003). A new tool has been invented to maximize efficient nutrient use and improve the productivity of crops by the International Plant Nutrition Institute (IPNI); Nutrient Expert®, that follows SSNM principle and depends on the initial soil nutrient status.

NE utilizes the information given by local expert to suggest meaningful yield for that location and formulate a fertilizer management strategy. (Satyanaryan *et al*., 2013). Very few researcheshave been conducted in Nepal regarding the SSNM in yield, production and productivity. Therefore, the present study was done to with the objective (1) to assess the profitability of maize and (2) to estimate the yield and productivity of maize using Nutrient Expert® - Hybrid Maize and compare the yield of field specific fertilizer recommendation by Nutrient Expert with the existing blanket recommendation and farmer fertilization practice for maize.

Material and methods

This study was conducted in Eastern Nepal in Jhapa district. Field experiments were carried out in 7 farmers' fields at Garamani, Jhapa. Preliminary survey was done in the site with the Nutrient Expert Hybrid Maize questionnaire. The information collected from the farmers was then processed in the model and simulated attainable yield for each farmer field was obtained. Randomized Complete Block Design with 3 treatment and 7 replications was set up. Three treatments were NE(Nutrient Expert recommendation), GR (Government recommendation), and FFP (Farmer Fertilizer Practices). Gross plot size of 25 m^2 for each treatment was maintained. Dekaleb variety was sown from 2nd week of March in farmer field. Fertilizer sources used wereurea,DAP and MOP. Urea was split applied two times (basal and top dressed at 45 Days after sowing). All P and K fertilizer was applied one application as basal. Maize varieties and plant population, weeds, pests and diseases controlled were followed by local best management practices. Harvesting was done manually from last week of July. Net plot size of $1m^2$ (from where all yield attributing data was taken was maintained. Similarly, the actual yield was taken from 10 m^2. Observations taken were Plant No. (ha^{-1}), Cob no. (ha^{-1}), Length of ear (cm), Average. No of row ear^{-1}, No. of kernel ear^{-1}, Shelling% Test wt. (g), Yield at 15.5% (tha^{-1}), cost of production (NRs), average revenue (NRs), profit (NRs), partial and total factor productivity, benefit-cost ratio.

Data entry and analysis was done using: Microsoft word for data processing, MS excels for data input, table, Charts, graphs& simple statistical analysis, IBM SPSS Statistics 21.0, Gens Stat 2008 for statistical analysis was done at 0.05% level of significance.

Results and Discussion

Productivity characters

Table 1: Effect of different nutrient management on plant number, cob number, average ear per plant, Length of ear, Average number of row, Average number of kernel per kernel row of Hybrid maize at Gramani, Jhapa, 2016

Treatment	Plant No. Per hectare ('1000)	Cob No. per Hectare ('1000)	Length of ear (cm)	Average no. of row per ear	Average no. of kernel per kernel row
Farmer Fertilizer Practice (FFP)	68.57^{b}	67.71^{b}	17.45^{b}	13.486^{a}	35.789^{b}
Government Recommendation (GR)	68.14^{b}	68.14^{b}	17.77^{ab}	13.114^{a}	36.029^{b}
Nutrient Expert (NE)	76.17^{a}		18.59^{a}	12.457^{b}	38.200^{a}
SEm ((±)	0.573	1.079	0.249	0.1834	0.1779
LSD (P<0.05)	0.680**	2.408**	0.679**	0.4741**	0.3911**
CV%	3.8	4.5	6.4	5.3	3.5

NS= non-significant; Significant "*"; highly significant "**"

Treatment means followed by common letter/letters within column are not significantly different among each other based on Tukey at 0.05.

Table 2: Effect of Different nutrient management practices in Yield, test weight and shelling% of hybrid maize at Garamani, Jhapa, 2016

Treatment	Shelling%	Test wt.(g)	Yield at 15.5% ($tonha^{-1}$)
Farmer Fertilizer Practice (FFP)	50.84^{c}	251.486^{c}	6.431^{c}
Gov. recommendation (GR)	54.36^{a}	280.800^{b}	6.546^{b}
Nutrient expert (NE)	53.39^{b}	327.504^{a}	7.607^{a}
SEm (±)	0.641	0.2489	0.0529
LSD (P=0.05)	1.1.07**	0.4781**	0.07607**
CV%	4.21	5.1	3.8

NS= non-significant; Significant "*"; highly significant "**"

Treatment means followed by common letter/letters within column are not significantly different among each other based on Tukey at 0.05.

Yield attributing characters like plant no, cob no, length of ear, test weight, average no of kernel per kernel row, shelling percentage and yield were significantly affected by the different nutrient management practices. The lowest number of plants and cob number (Table 1) were found in the GR treatment which was statistically at par with the farmers practice. The reason could be due to improper use of several crop management related practices, mostly the lower dose of fertilizer application. The higher number of plants and cob number were in NE was due to application of higher dose of nitrogen in NE. Nitrogen significantly affected number of plants at harvest (Khan. A *et al*., 2005).

The lowest cob length (Table: 1) was observed in FFP which was significantly different with the rest two treatments. Highest length was found in the NE. The reason might be due to more photosynthetic activities of the plant on account of adequate supply of Nitrogen (Khan, *et al*., 2008) and nitrogen is an essential requirement for ear and kernel growth (Crawford *et al*., 1982). And the N content is higher in the treatment NE compared to GR and FFP. These results are also supported by the findings of Amjad (1998) and Akhtar *et al*. (1999) who reported a significant increase in cob diameter and cob length on the higher dose of nitrogen. The highest number of row per ear (Table: 1) was found in the FFP which was statistically at par with GR but the lowest number of row was in NE. Varying single nutrient like N can increase the maize seed size (Eck, 1984) so, the higher N might cause decrease in the number of row per year in NE. In contrast, the highest kernel number per kernel row (Table: 1) was found in the NE, which was significantly different with the other treatments. The lowest was found in FFP. Increase in the number of kernels per row as a result of increased plant density has significant effects on the yield (Turgut, 2000). Nitrogen stress reduced kernel number. Narrow rows significantly increased kernel number per unit area and grain yield. (Barbieri, P. A *et al*., 2000).

The highest yield and test weight was observed in NE while lowest in FFP. Khan, M.A. Malik *et al*., (2008) suggested that the increase in yield was attributed to increase in cob length, cob diameter, test weight and number of grains per cob. NE has increased the plant population per hectare and this increased plant population for short season hybrid maize increases cumulative intercepted photo synthetically active radiation, which compensates for a short growing season to achieve higher yield (Table:2) and avoids the long crop-gap with substantially less irrigation (Edwards *et al*., 2005). Under normal incident radiation, kernel number was associated with crop and ear growth rate at flowering following linear + plateau functions (Uhart, S. A. *et al*., 1995). The lowest yield in FFP was due to the imbalanced use of the fertilizer and the improper fertilizer management practices (Paudyal *et al*., 2001) Mostly the lower dose of fertilizer application to such a degree, has great scope to decrease actual yield under FFP by the dint of application of lower fertilizer (especially N) dose (Ghimire *et al*., 2015). Similar result was reported by Satyanarayana, *et al*., (2012). Highest shelling% was found in GR while lowest was in FFP.Increase in plant density delays maturity and decreases shelling percentage. Sangoi *et al*., (2002) also accorded the similar decrease in shelling percentage with the increase in plant population.

Profitability characters

Table 3: Profitability ratios of different nutrient management practices in Hybrid Maize Production at Garamani, Jhapa, 2016

Treatment	Partial factor Productivity(PFP)	Total Factor Productivity (TFP)	B:C Ratio	Observed Cost (NRs)	Average Revenue(NRs)	Profit (NRs)
Farmer's Practice (FFP)	0.421^b	0.1601^c	3.003^c	40374^a	160768^c	120394^c
Government Recommendation (GR)	1.291^a	0.2204^b	4.511^b	29695^b	163643^b	133948^b
Nutrient Expert (NE)	1.446^a	0.2536^a	5.340^a	30107^b	190179^a	160072^a
SEm(±)	0.144	0.00861	0.1065	1088.1	1322.2	1744.9
LSD (P=0.05)	0.1622**	0.00967**	0.2670**	2370.2**	1916.4**	3151.8**
CV%	2.9%	3.1%	2.5%	3.2%	0.8	1.3%

NS= non-significant; Significant "*"; highly significant "**"
Treatment means followed by common letter/letters within column are not significantly different among each other based on Tukey at 0.05.

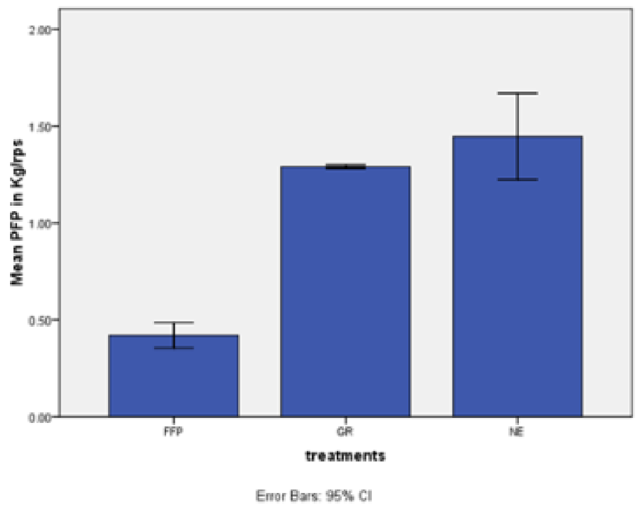

Fig 1:

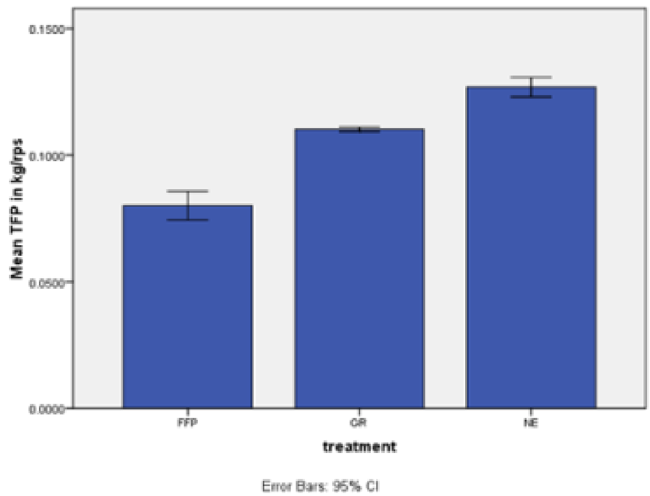

Fig 2:

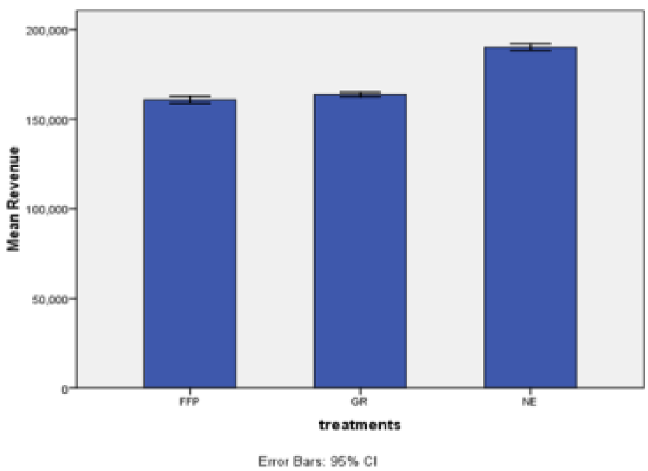

Fig 3:

Effect of different treatments in PFP (Fig 1), TFP (Fig 2) and average revenue (Fig 3) respectively

Highly significant results were obtained in the revenue of hybrid maize (Table: 3 and Figure 3). The highest revenue was accorded in NE (NRs 190179), followed by GR (NRs 163643) and the lowest revenue was accorded in FFP (NRs

160768). This showed that NE was significantly over to FFP by 1.18 times. Similar result was found in Indonesia, Philippines, Karnataka and Tamil Nadu of India by providing an efficient nutrient management strategy tailored to field specific condition using Nutrient Expert mode (Satyanarayana, *et al.,* 2012). NEHM increased profit by US$ 270 per hectare and In the Philippines, NEHM increased profit by US$ 379 hectare compared with FFP (Pampolino *et al.*, 2012).

Highly significant results were accorded in partial factor productivity (PFP) and Total Factor Productivity (TFP) of hybrid maize (Table: 3 and Figure 1 and 2). The results showed highest PFP (1.446) which was statistically at par with GR while the lowest was of FFP (0.421) which was statistically different with the two treatments GR (0.2204) and lowest was in FFP (0.1601). Partial factor productivity measures normally show higher rates of growth than TFP because growth in productivity could result from more intensive use of inputs, including fertilizer and machinery, rather than TFP increase. Singh (2004) suggested that application of a unit fertilizer is economical, if the value of the increase in the crop yield due to the quantity of fertilizer added is greater than the cost of fertilizer used. Here, with the unit fertilizer increased in the NE, yield was also increased with the cost of fertilizer involved.

Highly significant result was accorded in the B: C ratio (Table: 3).The highest B: C was obtained in NE (5.340) which was significantly different than the two treatments, followed by GR (4.511). The lowest result was recoded in FFP (3.003) which was significantly different than the other treatments. The reason behind the highest B: C was due to the higher benefits over cost in NE showing its superiority amongst the others. Highest Profit (Table: 3) was accorded in NE (NRs 160158) followed by GR (NRs 133948) and lowest in FFP (NRs 120394). Higher profit was due to lower cost and higher yield in NE due to appropriate management practices). Xinpeng Xu *et al.*, (2013) reported NE method significantly reduced the total fertilizer cost compared with FFP, decreased by 36 US$/ha (13.4%) across all sites conducted in the seven provinces of China

Conclusions

New method, Nutrient Expert for Hybrid Maize decision support system was developed based on analysis of relationships among yield response and the results from this trial suggested that NE decision support system can maintain comparable grain yield attributing characters, yield and economics. As a generic but flexible, and location-specific fertilizer recommendations method, Nutrient Expert for Hybrid Maize can be considered to be an alternative method to increase yield and economics that can be used without soil testing, which is quite feasible for small-holders that could not afford soil testing or soil testing is not timely or available. Although NE is currently developed to be used for those who have access to a computer as a starting point, future work should be considered to reach more users.

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