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Nutrient Expert: An ICT Tool of Agricultural Institution for Economic Development of Maize Growing Farmers in Jharkhand

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ABSTRACT

Background: Nutrient expert is a computer based software for site specific nutrient management which advocates location specific requisite quantities of nutrients application in crops to achieve targeted yield by narrowing down the difference between actual yield and potential yield. The current study aimed to study efficiency of nutrient expert over other fertilizer recommendations on maize varieties.

Methods: An experiment was conducted to test six maize varieties against state fertilizer recommendation, nutrient expert based fertilizer recommendation and farmers' fertilizer practice during *Kharif* season of 2017. The nutrient expert software was used to calculate dose of nutrient expert for targeted yield of 8 t/ha.

Result: The result indicated significant improvement by nutrient expert based fertilizer recommendation for grain yield, stover yield, net return and nutrient uptake of nitrogen, phosphorus and potassium in grain and stover of maize. Among maize varieties, CMH-08-350 recorded significantly higher grain yield, stover yield, net return and nutrient uptake of maize than PMH-3, CMH-08-287, PMH-1 and HQPM-1.

Key words: Farmers fertilizer practice, Maize varieties, Nutrient expert, State fertilizer recommendation.

INTRODUCTION

Maize is one of the predominant crop of Jharkhand as the favourable climatic conditions favour its cultivation in all the three seasons. Although the use of external inputs has driven the crop productivity gains in the state but, average maize yield in the state is still very low than the potential yield. There are several reasons for low productivity in maize among which lack of balanced nutrient application is one of the most important reasons. The lack of suitable fertilizer recommendations for hybrid maize for different ecology and seasons are provoking farmers to go for unscientific fertilizer application or the state recommended fertilizer rates (Jat *et al.*, 2013). The state fertilizer recommendation is common for all over the state without considering the crop nutrient requirement, land situation and variability in soil fertility status. That's why even with ample amount of fertilizer use, the maize yields in the state are not increasing congruently. Application of location specific requisite quantities of nutrients at appropriate time is the key aspect to enhance maize productivity (Dass *et al.*, 2012). Soil analysis is the principle field assessment tool for the development of fertilizer recommendations. However, several constraints such as lack of access to soil testing laboratories, the relatively high cost of analysis, *etc*. hinders small and resource-poor farmers to get accurate agronomic information. An effective nutrient management involves application of balanced application of nitrogen, phosphorus and potassium at right time through appropriate methods along with secondary and micronutrients application as per crop need through use of organic and inorganic fertilizer sources (Prasad, 2009). Therefore, site specific nutrient management (SSNM) seems to be the possible means of tapping the unexploited potential of the crop which advocates for balanced nutrient application as per crop need for a set yield target (Johnston, 2009). Nutrient expert is computer based software for maize developed in accordance to concept of SSNM principles. This computer-based tool is very easy to use and provides site specific fertilizer recommendation for hybrid maize to farmers through use of existing site information and resources available to the farmers. The tool integrates 4R principles (Right amount, right method, right time and right place) under SSNM concept (Ferguson, 2002). It provides location specific fertilizer recommendation to achieve higher yield by narrowing down the gap between actual yield and potential yield (Raun, 2002). To judge the usefulness of nutrient expert, an

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experiment was conducted to find out efficiency of nutrient expert based fertilizer recommendation (NEFR) over other fertilizer recommendation on different maize hybrids.

MATERIALS AND METHODS

Experimental site

An experiment was conducted at agronomy research farm of Birsa Agricultural University, Ranchi to test the efficiency of nutrient expert based fertilizer recommendation for maize crop in Jharkhand state during the *kharif* season of 2017-18. The crop received a total rainfall of 590.2 mm during the experimental period. The maximum temperature ranges between 26.4°C to 32.0°C whereas minimum temperature varies from 11.7°C to 23.3°C during the maize cultivation period. The experimental crop was grown in a typical medium land condition with good drainage facility. The soil texture was sandy loam with 63.2, 22.2 and 14.6 per cent of sand, silt and clay contents respectively. The experimental soil possesses pH level of 6.13 indicating slightly acidic nature. The soil chemical properties showed 4.2 g organic carbon content per kg of soil in addition to 242.7, 18.72 and 164.8 kg/ha available nitrogen, phosphorus and potassium, respectively.

Nutrient expert software

Nutrient expert is computer based software for maize developed on the concept of SSNM principles that provides nutrient recommendations with or without soil-testing data (Pampolino, 2012) by obtaining the information on (a) crop growing environment (b) physical and chemical properties of the soil (c) cropping system (d) crop residue incorporation and use of fertilizer and (e) current yields of farmers. This software is free of cost available at http://software.ipni.net/article/nutrient-expert. Xu (2014) described in detail the software configuration of Nutrient expert for maize which works on five segments (Fig 1). The first segment i.e. current nutrient management practice described the quantity of organic and inorganic nutrients applied by farmers and yield attained by farmers. The planting density segment suggest whether farmer is adopting optimum maize population and if farmer is not adopting optimum planting density then it specifies both plant and row spacing to achieve the desired plant population. The SSNM rates segment first of all measures the nutrient supply capacity of soil considering the influence from crop residue incorporation, addition of organic manures and legume effect and finally estimated the yield response of crops to nutrient application to work out the nutrient requirement for the crop to achieve the targeted yield. The sources and splitting segment provides location specific ideal nutrient rates with fertilizer sources along with timing of fertilizer application as basal or split application at critical stages of crop growth. The profit analysis segment analyses the cost of cultivation and the profitability occurred by the farmers in following NE-based fertilizer recommendation.

Experimental details and crop management

The cropping history of experimental site was dominated by maize (*Zea mays*)-linseed (*Linum utissium*) cropping

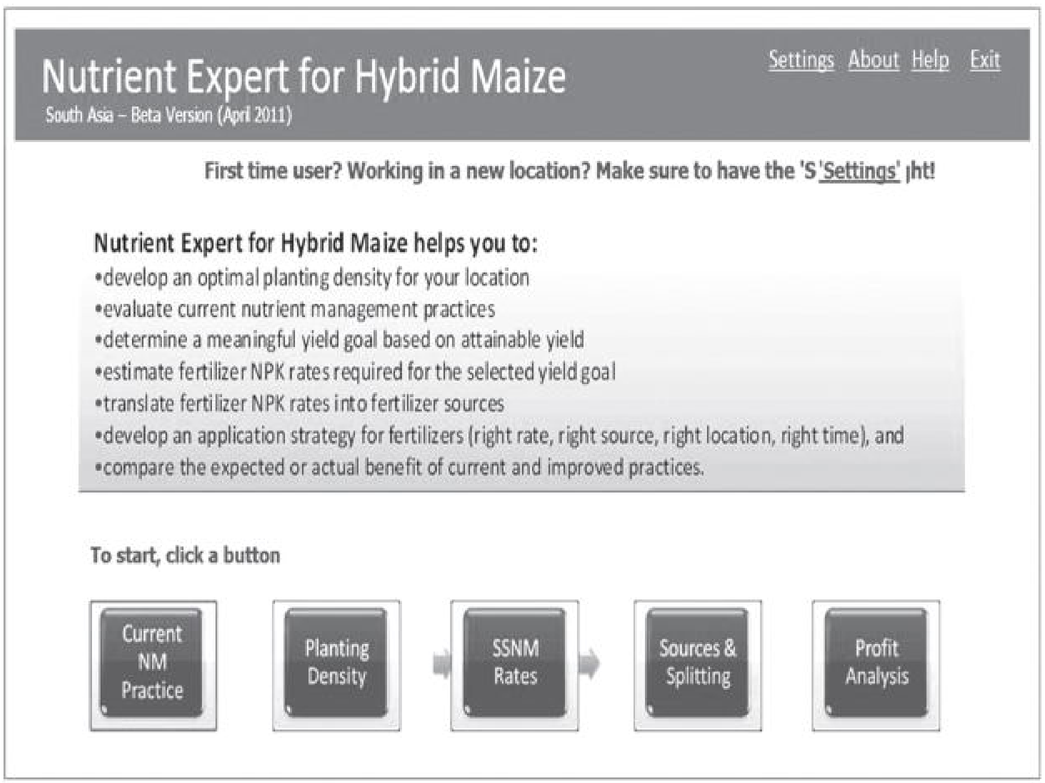
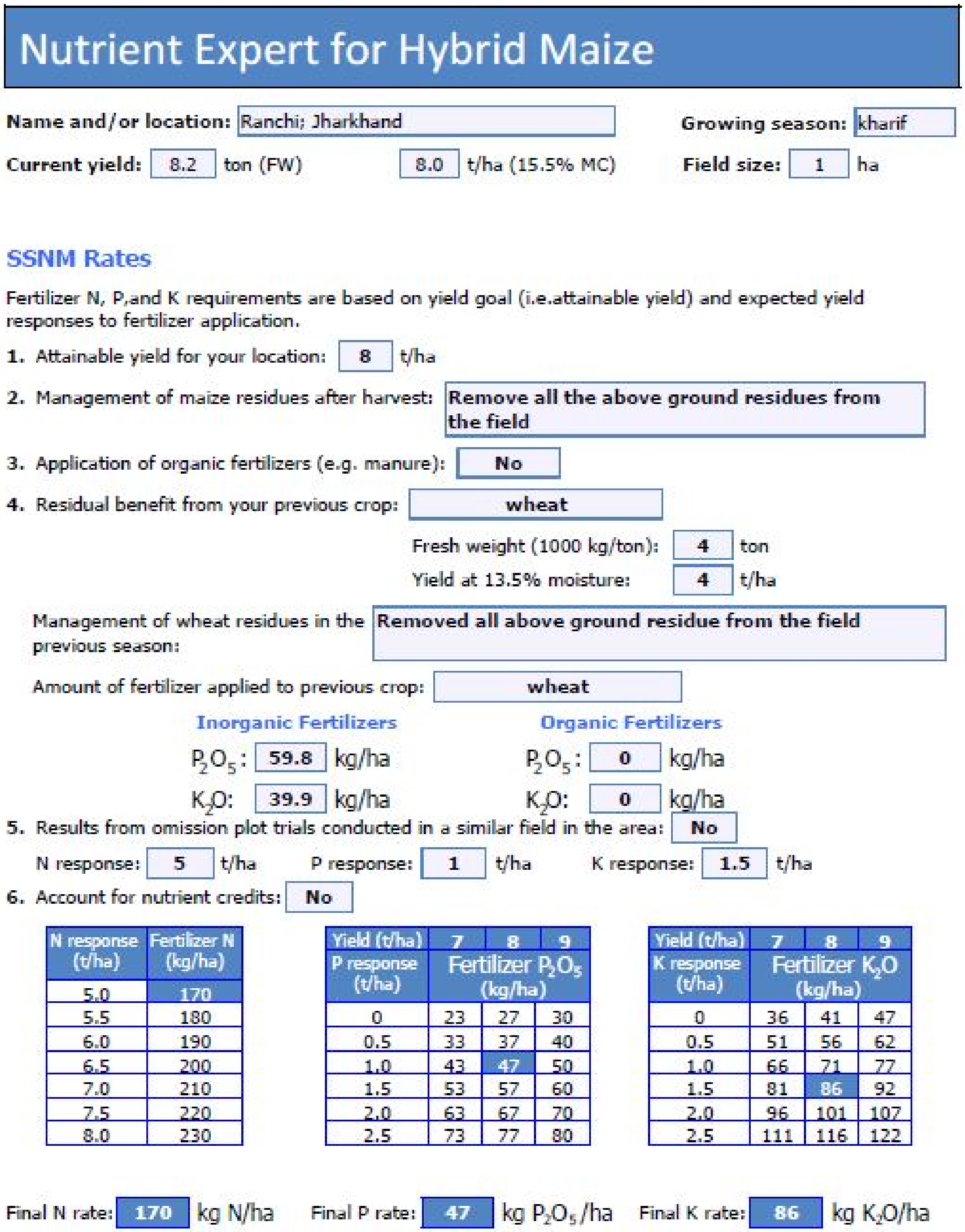


Fig 1: Nutrient–Expert decision support system software for hybrid maize.

system for the past five years before start of the present experimentation. The experiment was undertaken in split plot design with three replications to evaluate six maize varieties PMH-1, PMH-3, CMH 08-350, CMH 08-287, CMH 08-292 and HQPM-1 kept in main plot and three fertilization practices namely state fertilizer recommendation (SFR): 150:60:40 kg NPK/ha, Nutrient expert based fertilizer recommendation (NEFR): 170: 47: 86 kg NPK/ha and Farmer fertilizer practice (FFP): 100: 50: 0 kg NPK/ha kept in subplots. Nutrient expert software was used to calculate the dose of NEFR for targeted yield of 8 t/ha (Fig 2). To achieve the optimum plant population, the seed rate of 20 kg/ha was used with 75 cm row to row and 20 cm plant to plant spacing. The extra plants were removed from the experimental field through thinning at 15 days after sowing and these plants were utilized for gap filling to maintain the



N response (t/ha)	Fertilizer N (kg/ha)
5.0	170
5.5	180
6.0	190
6.5	200
7.0	210
7.5	220
8.0	230

Yield (t/ha)	7	8	9
P response (t/ha)	Fertilizer P_2O_5 (kg/ha)		
0	23	27	30
0.5	33	37	40
1.0	43	47	50
1.5	53	57	60
2.0	63	67	70
2.5	73	77	80

Yield (t/ha)	7	8	9
K response (t/ha)	Fertilizer K_2O (kg/ha)		
0	36	41	47
0.5	51	56	62
1.0	66	71	77
1.5	81	86	92
2.0	96	101	107
2.5	111	116	122

Fig 2: Calculation of fertilizer dose for maize crop at Kanke region of Jharkhand through nutrient expert.

plant population. Two manual weeding was performed at 20 and 40 days after sowing along with pre-emergence application of chemical herbicide Atrazine @ 1.5 kg/ha for weed control. The nutrient requirement of each treatment were met through use of urea, di-ammonium phosphate (DAP) and muriate of potash (MOP) to supply nitrogen, phosphorus and potash respectively. Full dose of P_2O_5 and K_2O along with 1/3rd of the nitrogen was applied as basal application while, the remaining nitrogen was top dressed in two equal doses at knee-high stage and tasseling stage.

Plant and soil sampling

Harvesting of maize was done when the crop reached to its physiological maturity. The cobs of each plot were harvested from the net plot area. The stalks were also cut quite close to ground and bundled separately for each treatment. The harvested cobs and stalk were sun dried to reduce the moisture content and then weighted to record the cob and stalk yield. These cobs were threshed separately and finally, the grain yield (kg/plot) was recorded. The cob, grain and stover yield obtained from each plot were finally converted into kg/ha.

Economic analysis

Based on prevailing market price the cost of each and every items which was incurred in technology incorporation for crop raising were estimated to calculate the cost of cultivation The gross returns were assessed by multiplying the quantity of total produce (grain + straw) with the prevailing market price of the produce. The subtraction of cost of cultivation from the gross returns represents the net return. The benefit: cost ratio was worked out by dividing net return with cost of cultivation. The prices of inputs incurred in raising the crop and price of the sell produce are governed by market demand, availability, time, government policies and several other factors therefore, the economics presented in this paper can be used as a suggestive measure which may be changed according to situation.

Statistical analysis

Statistical analysis of different parameters was done through analysis of variance method (Panse and Sukhatme, 1985) to calculate the critical difference (CD) which was used to compare the mean values of different treatments. Fisher Snedecor's 'F' test were employed to test the variation sources at 5% probability level.

RESULTS AND DISCUSSION

Yield

The use of nutrient expert generated site specific nutrient recommendations to achieve the targeted yield. Therefore, nutrient expert based fertilizer recommendation (NEFR) by meeting the actual needs of nutrient by the crop produced significantly higher cob, grain and stover yield (Table 1) than state fertilizer recommendation (SFR) and farmer fertilizer practice (FFP). Similarly, SFR application also significantly enhanced the cob, grain and stover yield of maize over FFP. The higher yield under NEFR was observed by providing need based nutrient requirement in crop which facilitated enhanced growth and development of crop and better photosynthates partitioning thereby improved yield traits and yield (Mehta *et al.*, 2011). Among maize hybrids, the maximum cob yield, grain yield and stover yield was

Table 1: Effect of maize hybrids and nutrient management practices on yield and economics of maize.

Treatment	Yield			Economics			
	Cob yield (kg/ha)	Grain yield (kg/ha)	Stover yield (kg/ha)	Cost of cultivation (`/ha)	Gross return (`/ha)	Net return (`/ha)	BC ratio
Maize varieties							
PMH-1	7130	5886	10440	26682	73298	46616	1.72
PMH-3	7849	6508	10965	26682	80911	54228	2.00
CMH-08-350	8690	7140	11734	26682	88749	62067	2.29
CMH-08-287	7525	6265	10891	26682	77939	51256	1.88
CMH-08-292	8268	6803	11339	26682	84584	57902	2.13
HQPM-1	6818	5583	10032	26682	69568	42886	1.60
SEm±	183	154	242	-	1893	1893	0.07
CD (P=0.05%)	577	485	764	-	5960	5960	0.22
Nutrient management							
SFR	8250	6904	11680	26798	85810	59013	2.20
NEFR	9154	7745	12556	28892	96111	67218	2.33
FFP	5737	4442	8464	24357	55604	31247	1.28
SEm±	147	134	241	-	1657	1657	0.06
CD (P=0.05%)	430	393	703	-	4835	4835	0.18
CV (%)	8.11	9.00	9.38	-	8.88	13.39	13.69

SFR: State fertilizer recommendation, NEFR: Nutrient expert fertilizer recommendation, FFP: Farmer fertilizer practice.

Table 2: Effect of maize hybrids and nutrient management practices on nutrient uptake of maize.

Treatments	Nutrient uptake (kg/ha)					
	Nitrogen		Phosphorus		Potassium	
	Grain	Stover	Grain	Stover	Grain	Stover
Maize varieties						
PMH-1	86.88	52.85	16.87	8.68	30.46	104.97
PMH-3	94.30	54.65	18.19	8.89	32.73	107.30
CMH-08-350	101.96	57.37	19.47	9.30	34.93	111.93
CMH-08-287	91.79	54.86	17.71	8.93	31.92	107.86
CMH-08-292	98.78	55.98	18.85	9.13	33.91	109.92
HQPM-1	83.02	50.99	15.58	8.04	28.66	100.34
SEm±	2.61	1.20	0.41	0.30	0.85	2.55
CD (P=0.05%)	8.23	3.77	1.31	0.94	2.68	8.03
Nutrient management						
SFR	100.75	58.64	19.64	9.56	34.68	114.56
NEFR	113.33	63.91	21.57	10.17	39.74	124.47
FFP	64.29	40.80	12.12	6.76	21.88	82.14
SEm±	1.91	1.01	0.36	0.20	0.65	2.41
CD (P=0.05%)	5.58	2.95	1.06	0.58	1.91	7.02
CV (%)	8.75	7.87	8.69	9.58	8.63	9.53

SFR: State fertilizer recommendation, NEFR: Nutrient expert fertilizer recommendation, FFP: Farmer fertilizer practice.

recorded with CMH-08-350 which was significantly higher than PMH-3, CMH 08-287, PMH-1 and HQPM-1. However, it was at par to the maize hybrid CMH-08-292 since the potentiality of the cultivars differs depending on their genetic constitution and the management practices employed in the field. The better vegetative growth of maize hybrid CMH 08-350 also led to enhanced stover yield of maize due to better conversion efficiency of photosynthate that produced higher yield attributes and ultimately the yield (Raj, 2018).

Economics

There are several factors such as cost of seed, fertilizer, weedicide, insecticide, pesticide, labour, diesel, electricity and weather conditions that governs the cost of cultivation. Similarly, the gross return depends upon price of the produce which was governed by market demand, government policies, *etc*. Therefore, economics of maize production varies from region to region and also year to year. The NEFR recorded the highest cost of cultivation due to higher amount of fertilizer used and more number of labour involvement in handling of produce whereas FFP had the lowest cost of cultivation (Table 1) due to reduced quantity of fertilizer used and less number of labour involvement. The NEFR resulted in significant enhancement in gross return and net return of maize than SFR and FFP while, the benefit: cost ratio obtained with NEFR and SFR were at par but significantly higher than FFP. The higher value of economic parameters with NEFR was due to higher grain and stover yield associated with nutrient expert (Singh, 2018). The cost of cultivation was similar in case of maize hybrids as identical management practices were followed in all maize hybrids. The economic parameters of gross return, net return and benefit: cost ratio were highest with maize hybrid CMH 08-350 followed by CMH 08-292 and these two showed significant superiority over PMH-3, CMH 08-287, PMH-1 and HQPM-1. The variation in economic parameters among the maize hybrids was due to differences in yield potentiality of maize hybrid (Kumar, 2014).

Nutrient uptake

The NEFR based nutrient application recorded significantly higher NPK uptake by grain and stover than SFR and FFP (Table 2). The higher uptake of nutrient under NEFR was might be due to supply of adequate amount of nutrient as per crop need along with right placement of nutrient at right time and through appropriate method that facilitated better nutrient uptake. In contrast, inadequate or lower quantity of nutrient application without considering the crop nutrient requirement under SFR and FFP resulted in lower nutrient uptake due to synergistic or antagonistic effect on other nutrient (Biradar, 2012). The NPK uptake in grain was highest in CMH 08-350 which was significantly higher than CMH 08-287, PMH-1and HQPM-1 but, comparable to CMH 08-292 and PMH-3. Similarly, the nitrogen uptake by stover was recorded highest with CMH 08-350 with significant superiority over PMH-1and HQPM-1. However, the phosphorus and potassium uptake by stover in CMH 08-350 was significantly higher over HQPM-1. Genetic variation among hybrid for yield potentiality and nutrient content were responsible for causing significant variation in NPK uptake among maize hybrids.

CONCLUSION

The high variation in yield with fertilizer application as per recommendation of nutrient expert suggests its importance in nutrient management to achieve higher yield potentiality of maize by meeting the requirement of nutrient as per crop needs. The amount of nutrient to be applied to the maize crop is location specific and it may vary from place to place, preceding crops grown and package and practices followed by the farmers, *etc*. It can be concluded that maize hybrid CMH-08-350 grown with NEFR (170:47:86 kg NPK/ha) is most advantageous and economically feasible for maize cultivation at Kanke, Ranchi region of Jharkhand.

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