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Soil Test Crop Response Based Fertilizer Prescription for Urd Grown on Mollisol of Uttarakhand, India

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ABSTRACT

A field experiment was conducted during spring 2014-2015 at the Norman E. Borlaug Crop Research Centre of the G.B. Pant University of Agriculture and Technology, Pantnagar (29^0 N latitude and $79\ ^0$ 29' E longitude), as per technical programme of All India Coordinated Research Project on the soil test crop response correlation. The experiment was conducted in "two-phases". In the first phase soil fertility gradient was developed by dividing the experimental field into "three strips" and applying graded doses of fertilizers in them (Strip I no fertilizer), Strip II (100, 100 and 100 kg/ha N, P_2O_5 and K_2O/ha) respectively, and strip III (200, 200 and 200 kg N, P_2O_5 and K_2O) respectively and growing of exhaust crop sorghum (*var*. Pant Chari-7). In the second phase, *i.e*. next season test crop Urd (*var*. Pant Urd-7) was grown. Response to "select" combinations of "three-levels" of FYM (0, 5 and 10 t/ha), "four-levels" of nitrogen (0, 10, 20 and 30 kg/ha), four levels of phosphorus (0, 20, 40 and 60 kg/ha) and four levels of potassium (0, 30, 60 and 90 kg/ha) at different fertility levels of Urd bean was studied. The values of the organic carbon, Alkaline $KMnO_4$ extractable N, Olsen's P and Neutral normal ammonium acetate extractable K in the experimental field ranged between 0.22-0.75 per cent, 112-178 kg/ha, 12.20-20.02 kg/ha and 100.2-178.85 kg/ha, respectively. In the present investigation the total straw yield ranged from 64.93-233.76 q/ha and total grain yield ranged from 17.26-181.72q/ha. The nutrient requirement for production of one quintal of Urd bean grain was found to be 3.18 kg of nitrogen, 0.63 kg of phosphorus and 2.54 kg of potassium. The percent contribution of nitrogen, phosphorus and potassium was 38.15, 72.61 and 36.51, from soil, whereas from other sources as FYM was 78.34, 17.05, 38.21; chemical fertilizer 169.81, 17.19 and 94.98 and conjoint use of chemical fertilizer with FYM 187.65, 15.88 and 96.08 concerning NPK respectively. With the help of these data fertilizer recommendations at different yield targets and soil test value can be calculated. Findings from present study can successfully be utilized for the larger parts of Tarai region of Uttarakhand as an effective guide for efficient and balanced fertilizer recommendations.

Introduction

Fertilizer is among the costliest inputs in agriculture and the use of the right amounts of fertilizer is fundamental for farm profitability and environmental protection (Kimetu *et al.*, 2004). To enhance farm profitability under different soil-climate conditions, it is necessary to have information on optimum doses for crops. Traditionally, to determine the optimum fertilizer doses of the most appropriate method is to apply the fertilizer on the basis of a soil test and crop response studies. During 1956-57 the semi-quantitative soil test calibrations were evolved and advocated for its use. Subsequently, in India, the quantitative refinements in the fertilizer recommendations based on the soil and plant analysis were made during 1967-68 through the All India Coordinated Research Project for Investigation on Soil test crop response correlation (STCRC). The ICAR project on soil test crop response correlation used the targeted yield approach to develop a relationship between crop yields on the one hand and soil test values and fertilizer inputs on the other. Black gram (*Vigna mungo* L.) is one of the major rainy season pulse crop also known as Urd or Mash grown throughout India. It is consumed in the form of "dal". In India, It is grown on 2.70 million hectare area with the production of 0.94 million tonnes. The yield potential of black gram is very low because of the fact that the crop is mainly grown in rain-fed conditions with poor management practices and also due to various physiological, biochemical as well as inherent factors associated with the crop. Apart from the genetic makeup, the physiological factor, namely insufficient portioning of assimilates, poor setting due to the flower abscission and lack of nutrients during critical stages of crop growth, coupled with a number of diseases and pests (Mahala *et al.*, 2001) were the reasons for the poor yield. India is the largest producer as well as consumer of black gram. Black gram accounts for about ten percent of India's total pulse production. It is cultivated in India in about 3.24 million hectares with average productivity at 469 kg/ha. The production of the black gram was 1.82 mt in 2010-11, with around 78 percent production of Kharif season and 0.42 mt from Rabi season. The average production in India over the last decade was 1.4 mt per annum. The major black gram producing a state in India is Andhra Pradesh, Maharashtra, Madhya Pradesh, Tamil Nadu and Uttar Pradesh. Bihar has the highest productivity with 800 kg/ha followed by Uttarakhand (786 kg/ha) and West Bengal (714 kg/ha). Andhra Pradesh is the largest producing state contributing for about 19 percent of total country's output, followed by Maharashtra and Madhya Pradesh, with 20 percent and 13 percent respectively. India imported 0.71 mt of black gram in 2009-10, showing a rise of 60 percent over the consumption of the previous year. India imports nearly 85 per cent of black gram requirements of Myanmar followed by Singapore and Thailand. Application of fertilizer by the farmer without information on soil fertility status and nutrient requirement of crop, soil and crop will be affected adversely. Soil testing is one of the best scientific means for quick and reliable estimation of soil fertility status. A greater economy in fertilizer use can be made, if fertilizers are applied on the basis of the soil test. This practice ensures balanced fertilization, higher yield and more profitability. The fertility gradient field experimental technique of (Ramamoorthy *et al.*, 1967) for evolving soil test and targeted yield based fertilizer recommendation (STCR) to crop is unique in the sense that response of crops to applied nutrient is studied on representative soils, where variations in soil fertility had been created earlier by applying different amount of fertilizer nutrients to the preceding crop. The approach circumvents the effect of soil heterogeneity, management practices and climatic conditions on the response through native and fertilizer nutrients. Fertilizer recommendation based on soil test crop response correlation (STCR) concept is more quantitative, precise and meaningful because the combined use of soil and plant analysis is involved in it. While developing the STCR targeted yield equation contribution of nutrients from the soil, fertilizer and organics is taken into consideration. Similarly, by taking these into consideration nutrient requirement (NR) to produce a quintal of grain or any economic produce are considered. It gave a real balance between applied nutrients and the available nutrients already present in the soil. Besides, it takes into account the farmer's ability to invent for raising the crops. Besides balanced nutrition of growing crops, this approach gives due consideration to soil fertility and strikes a real balance between the nutrients already available in the soil and those required by the crops to achieve a predetermined yield target.

Materials and Methods

A field experiment was carried out at the Norman E. Borlaug's Crop Research Centre College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar India to develop a scientific basis for prescribing fertilizer recommendations for urd (*Vigna mungo*) as the test crop. The soil of the experimental site was clay loam in texture, pH was 7.80 with the high level of organic carbon, medium available potassium, low available nitrogen, very low phosphorus.

Treatment structure, soil and plant analysis

The field experiment *viz.,* fertility gradient experiment with exhaustive fodder sorghum (*var. Pant Chari-7*), the test crop experiment the test verification with Urd (Pant Urd-31) were conducted at Norman E. Borlaug's Crop Research Centre College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar India on *Aquic Hapludoll* during 2014-15.

The details of the crops and important cultural operations carried out in the experiment are described below. The treatment structure and layout design as followed in the All India Coordinated Research Project for investigations on soil test crop response correction (AICRP-STCR) based on "Inductive cum Targeted Yield Model" was adopted for the experimentation.

Gradient experiment

Prior to the test crop experimentation, the fertility gradient experiment was conducted by dividing the experimental field into three rectangular strips (Low, medium and high). The layout of the experiment was based on the fertility gradient approach developed by (Ramamoorthy *et al.,* 1967). The needed variation in soil fertility levels was deliberately created by dividing the field into three equal strips (Low, Medium and High) which were applied with three fertility gradient doses of NPK (0X, X, 2X). These were applied in Low, medium and high strip respectively. An exhaustive crop of fodder sorghum was grown to enable the applied fertilizer to undergo a transformation in the soil by plant and microbes. Fodder sorghum was harvested and recorded the fodder yield was recorded similarly, soil samples were also collected and analyzed to check the fertility gradient developed.

Test crop experiment

After the establishment of fertility gradient in the experimental field, each fertility strip was divided into "three blocks" to impose "three levels" of FYM (F_1 – 0.00, F_2 – 5.00 and F_3 – 10.00 t ha^{-1}). Each block was again divided into eight-plots so that totals 72 plots were made. Before applying the FYM and NPK, soil samples (0- 15 cm) from all these plots were collected and analyzed for alkaline-$KMnO_4$-N outlined by (Subbaiah *et al.*, 1956); Olsen's-P and NH_4OAC-K method as described by (Jackson 1973). The experiment was laid out in fractional factorial design comprising of 21 treated plots and 3 control treatments in each strip covering totally 72 plots which was composed of 63 treated plots and 9 control plots and Urd crop was tested with four levels of N (0, 10, 20 and 30 kg ha^{-1}) P (0, 20, 40 and 60 kg ha^{-1}) and K (0, 30, 60 and 90 kg ha^{-1}). The experiment was conducted as per the approved guidelines of All India Coordinated Research Project (AICRP) on Soil Test Crop Response Correlations (STCR). A half dose of N fertilizer along with a full dose of P and K was applied at Urd sowing and remaining half dose of N was applied in two splits. At harvest, grain and straw yield was recorded from all the plots, and expressed in kg ha^{-1}. Representative plant samples were collected from the test crops, washed thoroughly with running water followed by double distilled water. The plant samples were then dried at 60^0 C to attain a constant weight, ground and analyzed for nitrogen, phosphorus and potassium contents by following standard procedure outlined by (Jackson 1973) and nutrient uptake was computed.

Data computation

Initial soil data, yield and nutrient uptake by the crop were used for obtaining nutrient required to produce a quintal of grain yield (NR), contribution of nutrients from the soil (% CS), contribution of nutrients from fertilizers (% CF) and contribution of nutrients from organic matter (C-FYM) using following formulae.

NR (kg q^{-1}) = Nutrient uptake (NPK) (kg ha^{-1}) by grain + straw Grain yield or any economic produce (q ha^{-1})

% CS = Nutrient uptake (NPK) (kg ha^{-1}) by grain + straw in control plot Soil test values (Av. NPK) in control plot (kg ha^{-1}) X 100

% CF = {Nutrient uptake by grain + straw in treating plot} − {[Soil test values in treated plot] X [% Contribution (NPK) from soil] 100 Nutrient doses applied in treated plot (kg ha^{-1}) X100

% C − FYM = {Total uptake of NPK in organic plot (kg ha^{-1})} − {[Mean CF of control plot] X [STV in organic plot (kg ha^{-1})] 100 Amount of NPK added through FYM (kg ha^{-1}) X100

These basic parameters were transformed into a simple, workable fertilizer adjustment equations for calculating specific yield target based on soil test values following the procedure of (Ramamoorthy *et al.,* 1967).

Results and Discussion

The range and mean of soil test values and yield of treated and control plots are presented in Table 1. In treated plots grain yield ranged from 51.92 to181.72 with an average yield of 240.06 q/ha. In control plots grain yield ranged from 103.84 to210 with an average of 123.95 q/ha.

Fertilizer without FYM

Fertilizer recommendations as per the need of nutrients for the targeted yield are based on the initial soil test values. Grain yield ranged from 2.59-23.37 q ha^{-1} therefore 20, 25 and 30 q ha^{-1} yield was selected to calculate nutrient requirements for a target yield of Urd bean without the use of FYM. The STV ranged for nitrogen are 31.36-134.85, for phosphorus 8.72 to 41.04 kg/ha and for potassium 32.48 to 198.24. Therefore, soil test value was considered within that range to calculate the nutrient requirements for target yield without the conjoint use of FYM. To achieve 30 q ha^{-1} yield target, 39.33 kg nitrogen ha^{-1} was needed at the soil test value of 75 kg alkaline $KMnO_4$-N ha^{-1} nitrogen, whereas for the same yield target at 100 kg soil test value for alkaline $KMnO_4$-N ha^{-1}, 33.71 kg of nitrogen as fertilizer was required (Table 2 and 3). Further, if the soil tests value of nitrogen reaches to 125 kg ha^{-1} then to reach the same yield target 28.09 kg N ha^{-1} needed. Further, if the soil test value of nitrogen reaches to 150 kg/ha the fertilizer nitrogen required would be 22.48 kg/ha as presented in Table 4. Similarly, fertilizer phosphorus requirement to targeted yield of 30 q ha^{-1} at a lower soil test value, *i.e.* 15 kg ha^{-1} of Olsen's phosphorus was 46.58 kg ha^{-1}. At the soil test, value of 20 kg of Olsen's P ha^{-1} to achieve same yield target (30 q ha^{-1}) requirement of fertilizer phosphorus was 25.46 kg ha^{-1}. However, where the soil test value reaches 25 kg Olsen's P ha^{-1}, the fertilizer phosphorus was 4.34 kg ha^{-1} needed as presented in (Table 4). The potassium fertilizer requirement for a targeted yield of 30 q ha^{-1} where the soil test value of potassium was 100 kg ha^{-1} NH_4OAC-K, and 41.78 kg fertilizer potassium was required. While at 125 kg ha^{-1} and 150 kg ha^{-1} soil test values of potassium, need of potassium fertilizer for same yield target were 32.17 and 22.56 kg ha^{-1}, respectively given in table 4. Further the need of potassium fertilizer at the soil test value of 175 kg/ha was about 12.95 kg/ha as presented in table 4, N, P and K requirement also shown in figure 1, 2 and 3 respectively.

Fertilizer requirement of Urd with 10 ton FYM

Fertilizer recommendations as per the need of nutrients for the targeted yield based on the initial soil test values. Grain yield ranged from 9.0 to 18.2 q ha^{-1} therefore 20, 25 and 30 q ha^{-1} yields was selected. The STV ranged for nitrogen as 112.3 to 200.6, for phosphorus 13.0 to 24.24 and for potassium 101.9 to 245.0. Therefore, soil test value considered within that range to calculate the nutrient requirements for target yield with the conjoint use of FYM (10 tones). To achieve 30 q ha^{-1} yield target, 28.89 kg nitrogen ha^{-1} was needed at the soil test value of 75 kg alkaline $KMnO_4$-N ha^{-1} nitrogen, whereas for the same yield target at 100 kg soil test value for alkaline $KMnO_4$-N ha^{-1}, 23.27 kg of nitrogen as fertilizer was required. Further, if the soil test value of nitrogen reaches to 125 kg ha^{-1} then to reach the same yield target 17.66 kg N ha^{-1} needed and when the soil test value reaches 150 kg/ha the fertilizer nitrogen required at the yield target of 30 q/ha was 12.04 kg/ha as presented in (Table 5) figure 4. Similarly, fertilizer phosphorus requirement to targeted yield of 30q ha^{-1} at a lower soil test value, *i.e.* 15 kg ha^{-1} of Olsen's phosphorus was 45.51 kg ha^{-1}. At the soil test, value of 20 kg of Olsen's P ha^{-1} to achieve same yield target (18 q ha^{-1}) requirement of fertilizer phosphorus was 24.39 kg ha^{-1} at the soil test value of 25 kg of Olsen's-P ha^{-1} the fertilizer phosphorus required was in 3.27 and the fertilizer phosphorus requirement was in negative at the soil test value of 35 kg/ha at the same yield target as presented in (Table 5) figure 5. The Potassium fertilizer requirement for a targeted yield of 30 q ha^{-1} where the soil test value of potassium was 100 kg ha^{-1} NH_4OAc-K, 40.79 kg fertilizer potassium was required. While at 125 kg ha^{-1} and 150 kg ha^{-1} soil test values of potassium, need of potassium fertilizer for same yield target were 31.18 and 21.57 kg ha^{-1}, respectively and at last at the soil test value of 175 kg ha^{-1} at the same yield target the fertilizer dose was 11.96 kg/ha as presented in (Table 5) and figure 6.

Available Nitrogen extracted by alkaline-$KMnO_4$ method of the experimental field varied from 87.89 to 464.12 kg N ha^{-1} with a mean 251.22kg N ha^{-1}.

Table.1 Ranges and averages of yield and soil test value of Urd under different strips

Variable	Range	Mean
Organic carbon (%)	0.68-1.06	0.76
$KMnO_4$-N	31.36-134.84	63.59
Olsen-P	12.82-41.03	27.93
NH_4OAc-K	32.48-198.24	85.74
Grain yield (q ha^{-1})		
Treated plots	51.92-181.72	240.06
Control plots	103.84-210	123.95

Table.2 Basic data and fertilizer adjustment equations for urd yield in Mollisol

Nutrients	Basic Data				Fertilizer adjustment equation
	NR (kg q^{-1})	**C_S (%)**	**C_F (%)**	**C_{FYM} (%)**	
N	3.18	38.15	169.81	78.35	**FN** = 1. 69T-0.20 SN-0.42FYM-N
P_2O_5	0.63	72.61	17.19	17.05	**FP**=9.09T-10.46 SP-2.45FYM-P
K_2O	2.54	36.51	94.98	38.21	**FK**=3.17T-0.46SK-0.48FYM-K

Where, FN, FP, FK = fertilizer N, P_2O_5, K_2O, kg ha^{-1};
The NR = Nutrient requirement (kg) to produce one tonne of grain production,
C_S = Contribution of nutrients from soil nutrient (%),
C_F = Contribution of nutrients from applying fertilizer nutrient (%),
C_{FYM} = Contribution of nutrients from applying FYM (%);
T = Yield target (t ha^{-1});
SN, SP, SK = Soil available NPK (kg ha^{-1});
ON, OP, OK = FYM NPK (kg ha^{-1})

Table.3 Fertilizer adjustment equations for urd

Fertilizer dose	With FYM	Without FYM
Nitrogen Dose (Kg ha^{-1})	FN = 1.69T-0.20 SN-0.42FYM-N	FN = 1.87T- 0.23 SN
Phosphorus Dose (kg ha^{-1})	9.09T-10.46 SP-2.45FYM-P	8.39T-9.67SP
Potassium Dose (Kg ha^{-1})	3.17T-0.46SK-0.48FYM-K	3.23T-0.46SK

Table.4 N, P and K requirement for different yield targets of Urd without using FYM

Soil test value (kg ha^{-1})	Yield Target (q ha^{-1})		
Alkaline $KMnO_4$-N (Kg ha^{-1})	**20**	**25**	**30**
	Fertilizer nitrogen		
75	20.60	29.96	39.33
100	14.98	24.35	33.71
125	9.37	18.73	28.09
150	3.75	13.11	22.48
Olsen's- P (Kg ha^{-1})	Fertilizer Phosphorus		
15	9.93	28.26	46.58
20	-	7.14	25.46
25	-	-	4.34
Ammonium Acetate-K (Kg ha^{-1})	Fertilizer Potassium		
100	15.04	28.41	41.78
125	5.43	18.80	32.17
150	-	9.19	22.56
175	-	-	12.95

Table.5 N, P and K requirement for different yield targets of Urd using 10 tones FYM

Soil test values (kg ha^{-1})	Yield Target (q ha^{-1})		
Alkaline $KMnO_4$-N	**20**	**25**	**30**
	Fertilizer nitrogen		
75	10.16	19.53	28.89
100	4.55	13.91	23.27
125	-	8.29	17.66
Olsen's- P	Fertilizer Phosphorus		
15	8.86524	27.18985	45.5144
20	-	6.070011	24.39462
25	-	-	3.27
Ammonium Acetate –K	**Fertilizer Potassium**		
100	14.05	27.42	40.79
125	1.44	17.81	31.18
150	-	8.20	21.57

Table.6 Apparent nutrient balance during experiment

Sl No	Particulars	Strip I		Strip II		Strip III		Whole field	
		Initial	**Post**	**Initial**	**Post**	**Initial**	**Post**	**Initial**	**Post**
1.	**Organic carbon (%)**	0.16-1.20 (0.59)	0.46-1.39 (1.02)	0.81-1.64 (1.19)	0.39-1.22 (0.88)	0.39-1.64 (1.03)	0.39-1.64 (1.03)	0.16-1.20 0.59	0.39-1.64 (1.03)
2.	**Available nitrogen (kg N ha^{-1})**	62.72-200.70 (138.50)	112.89-388.86 (250.88)	112.89-263.42 (145.30)	87.80-363.77 (232.06)	75.26-213.24 (145.30)	100.35-464.12 (267.24)	75.26-263.42 (145.25)	87.80-464.12 (251.22)
3.	**Available phosphorus (kg P ha^{-1})**	41.77-60.23 (50.35)	2.46-22.17 (16.02)	51.49-66.06 (59.18)	4.92-21.95 (13.85)	38.86-95.20 (61.40)	5.6-22.17 (16.68)	10.60-67.03 (16.04)	2.46-22.17 (14.88)
4.	**Available potassium (kg K ha^{-1})**	60.48-151.87 (97.38)	116.2-185.92 (142.22)	69.88-227.13 (138.09)	111.55-260.28 (180.49)	100.8-227.13 (166.93)	102.25-241.69 (144.39)	60.48-227.13 (135.16)	102.25-260.28 (154.80)

Table.7 Yield of urd seed under various treatments

Treatment details (N: P_2O_5:K_2O:FYM)	Yield (q/ha)
T_1= Control	12.98
T_2= GRD	14.27
T_3= TYR_1	15.57
T_4=TYR_1+5t/ha FYM (IPNS)	16.87
T_5=TYR_1+10t/ha FYM (IPNS)	18.60
T_6= TYR_2	18.17
T_7= TYR_2+5t/ha FYM (IPNS)	15.15
T_8= TYR_2+10 t/ha FYM (IPNS)	15.57
T_9= TYR_1+Zn	32.45
T_{10}= TYR_1+B	16.87
C.D. at 5%	0.409
SE(m)	0.137

Table.8 Economics of verification trial on urd

Treatments	Fertilizer dose N-P-K FYM (kg/ha)	Actual yield (kg/ha)	Additional yield (kg/ha)	Value of additional yield (Rs.)	Cost of fertilizer (Rs.)	Net benefit (Rs. ha^{-1})	B/C ratio
T_1= Control	0-0-0	1298	-	-	;-	-	-
T_2= GRD	20-40-60	1947	649	51920	3634	48286	13.24
T_3=TYR1	19-23-19	1557	259	20720	1832.02	18887.98	10.30
T_4=TYR_1+5T/ha	18-22-16	1687	389	31120	1699.16	29420.84	17.31
T5=TYR_1+10t/ha FYM (IPNS)	16-20-15	1860	562	44960	1550.24	43409.76	28.01
T_6=TYR_2	4-65-30	1817	519	41520	3931.16	37588.84	9.56
T_7=TYR_2+5t/ha FYM (IPNS)	25-65-30	1515	217	17360	4223.9	13136.1	3.10
T_8=TYR_2+10t/ha FYM (IPNS)	24-65-30	1557	259	20720	4209.96	16510.04	3.92
T_9= TYR_1+Zn	19-23-19	1557	259	20720	1832.02	18887.98	10.30
T_{10}=TYR_1+B	19-23-19	1687	389	31120	1832.02	29287.98	15.98

Fig.1 Nitrogen requirement of urd at different soil test value and yield target without using FYM

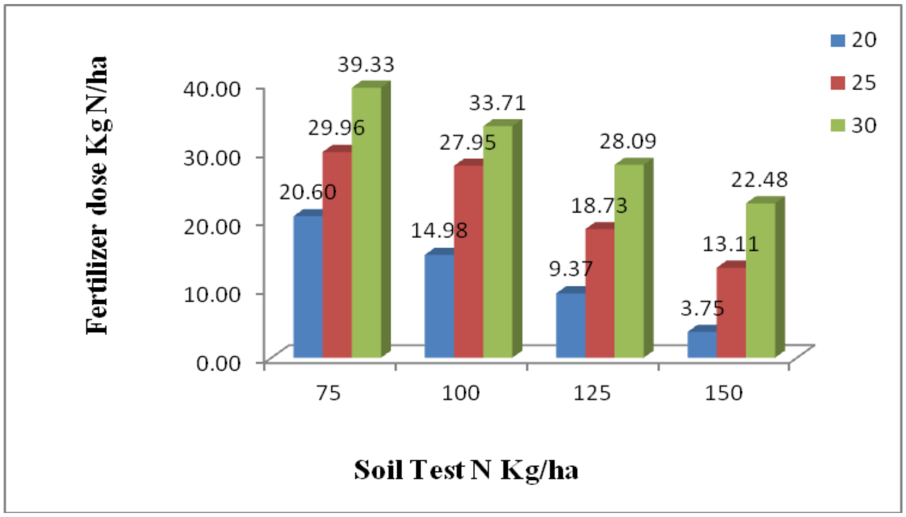


Fig.2 Phosphorus requirement of urd at different soil test value and yield target without using FYM

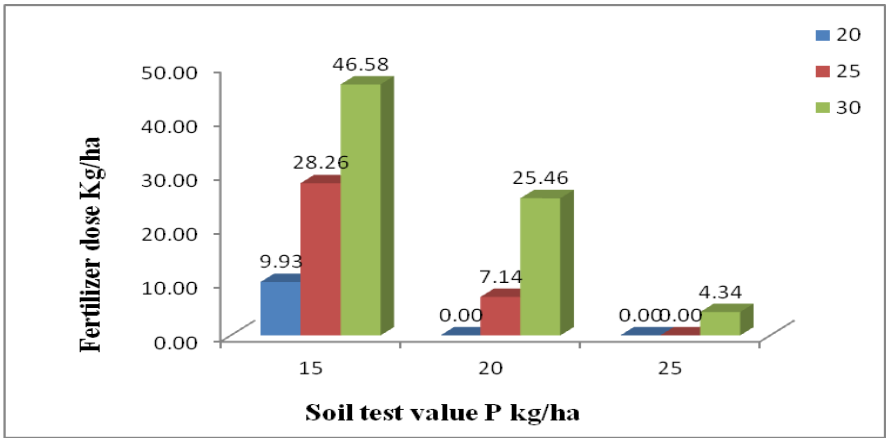


Fig.3 Potassium requirement of urd at different soil test value and yield target without using FYM

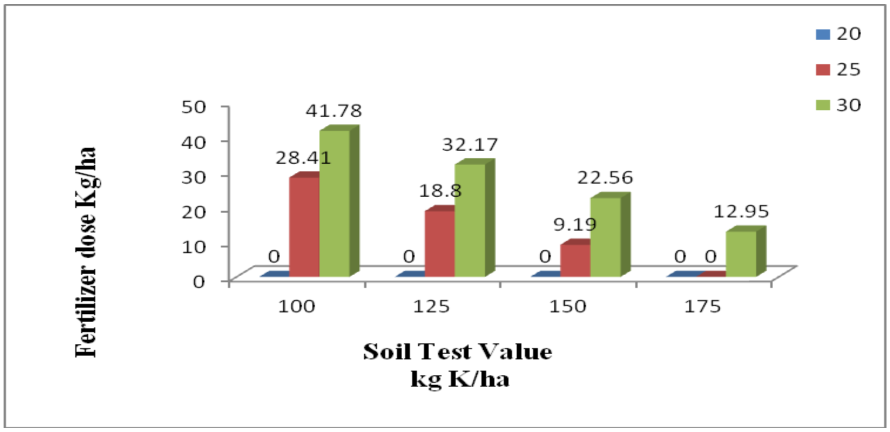


Fig.4 Nitrogen requirement of Urd at different soil test value and yield target

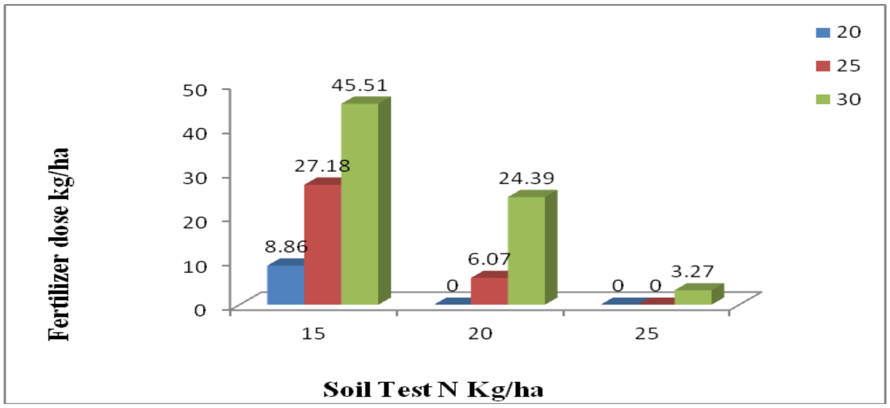


Fig.5 Phosphorus requirement of Urd at different soil test value and yield target

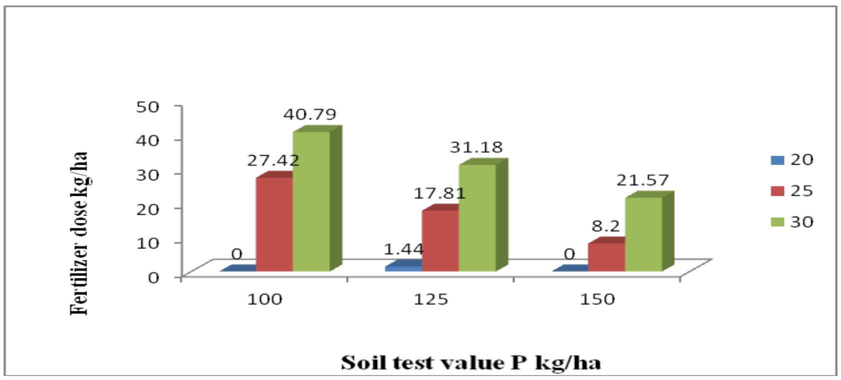
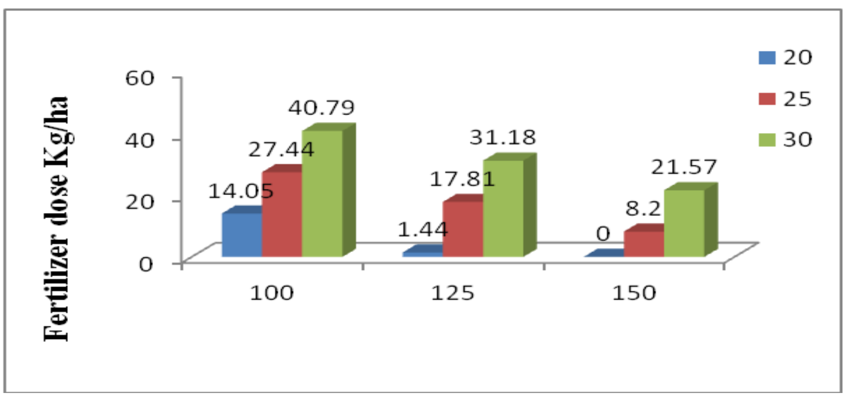


Fig.6 Potassium requirement of Urd at different soil test value and yield target



Strip wise variation ranged from 112.89 to 388.86 with a mean of 250.88 in strip I, 87.80 to 363.77 kg N ha^{-1} with a mean of 232.06 kg N ha^{-1} in strip II and 100.35 to 464.12 with a mean of 267.24 kg N ha^{-1} in strip III. The average value of Nitrogen was highest in strip III followed by strip I and strip II, respectively.

Available Phosphorus content of the entire experimental field ranged from 2.46 to 22.17 kg P ha^{-1} with a mean value of 14.88 kg P ha^{-1}.

Strip wise range varied from 2.46 to 22.17 with a mean value of 16.02 kg P ha^{-1} in strip I, 4.92 to 21.95 with a mean value of 13.85 kg P ha^{-1} in strip II and 5.6 to 22.17 kg P ha^{-1} with a mean value of 16.68 kg P ha^{-1} in strip III. The average value of Phosphorus was highest in strip III followed by strip I and strip II, respectively. These post harvest values used for fertilizer recommendation by targeted yield approach for next crop in the cropping system.

Available Potassium content of the entire experimental field ranged from 102.25 to 260.28 kg P ha^{-1} with a mean value of 154.80 kg K ha^{-1}. Strip wise range varied from 116.2 to 185.92 with a mean value of 142.22 kg K ha^{-1} in strip I, 111.5 to 260.28 with a mean value of 180.49 kg K ha^{-1} in strip II and 102.2 to 241.69 kg K ha^{-1} with a mean value of 144.39 kg P ha^{-1} in strip III. The average value of Phosphorus was highest in strip II followed by strip III and strip I, respectively. These post harvest values used for fertilizer recommendation by targeted yield approach for next crop in the cropping system (Table 6).

Verification trial for Urd

The verification trials are important for the calibration of results obtained on research farm are required to be tested for their validity. Verification trials have a great demonstration value of showing the importance of soil testing for fertilizer recommendations to farmers and result in wider acceptability of soil testing to the farming community. The objective of these trials is (i) to test the validity of results obtained from the main experiment before recommendation to the extension agencies and (ii) to show the farmers the greater profitability of the soil test based fertilizer recommendation than general recommended dose. The validity of the targeted yield equations developed for urd during Rabi season in 2014-15 was tested in Rabi season of 2014-15 by conducting verification trials on the same location. The results obtained in verification trial are presented in table 7 Among the treatments, all treatments gave significantly higher yield over control (Table 7). Among the treatments TYR_1+Zn (T_9) gave a significantly higher yield as compared to general recommendation (T_2). The controls (T_1) were less efficient in producing seed yield of Urd. Fertilizer application based on target yield approach was found to be superior over general recommended dose (GRD). An increase in profits over farmers' practice and general recommended dose of fertilizers was observed with increasing yield targets in urd and other pulse crops with or without FYM which might be due to the efficiency factor tended to increase in crop yield (Kadam and Sonar, 2006, Hariprakash and Subramanian, 1994 and Anonymus, 2000).

B/C ratio was reported to follow the order among the treatment:

$\mathbf{T_5>T_4>T_2>T_{10}>T_9=T_3>T_6>T_8>T_7}$\

Therefore, hence concluded, these fertilizer adjustment equations developed for the integrated nutrient management system are useful for prescribing fertilizer doses to Urd for the *tarai* region of Mollisols and adjoining areas having similar soil and agro-climatic conditions. Keeping in view the poor socioeconomic condition of the farmers with very low income, a yield target of 25 q ha^{-1} was taken so that even at the very low input cost farmers can achieve economical yield target

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