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Soil Test Crop Response Based Fertilizer Prescription on Marigold Grown on Mollisols of Uttarakhand, India

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A B S T R A C T

Field experiments were conducted during the year 2013-14and 2014-15 in an Aquic Hapludoll at D7 block of Norman E. Borlouge Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar (290 N latitude and 79029' E longitude). To fulfill the objectives of the present investigation two experiments were conducted in the year 2013-14 and 2014-15. In first phase fodder Sorghum (var. Pant Chari-7) was taken as an exhaust crop and in second phase i.e. next season test crop Marigold (var. Pusa Narangi) was grown by dividing each strip in 24 plots having 21 treatments and 3 controlled plots. Response to selected combinations of three levels of FYM (0, 5 and 10 t ha^{-1}), four levels of nitrogen (0, 60, 120 and 180 kg ha^{-1}), four levels of Phosphorus (0, 30, 60 and 90 kgP2O5 ha-1) and four levels of potassium (0, 30, 60 and 90 kg K_2O ha^{-1}) for Marigold. The nutrient requirement for production of one quintal flower yield was 1.06, 0.34 and 1.32kg for nitrogen, phosphorus and potassium respectively. Contribution of nitrogen, phosphorus and potassium from soil for marigold was 26.23, 54.03 and 42.02. Contribution from fertilizer with FYM for marigold was 98.35, 40.25 and 168.68 Percent contribution of nutrient from fertilizer without FYM for marigold was 83.25, 38.96 and 168.91respectively. Contribution of nutrient from FYM for marigold was 46.81, 61.30 and 128.4 % Fertilizer adjustment equations for targeted yield of Marigold were developed with and without FYM with the help of basic data. Coefficient of multiple regression (R2) was found to be highly significant in case of marigold (0.473**) between grain yield, soil test values, added fertilizers, and interaction between added soil and fertilizers. Verification trials were conducted to test the validity of fertilizer adjustment equations and fertilizer application based on targeted yield approach was found to be superior over general recommended dose (GRD). Among different methods, organic C, Mehlich-1 P and neutral normal ammonium acetate-K can be taken as indices for determining N, P and K in Mollisol of Uttarakhand. Treatment T9 and T5was found to be as balanced fertilizer treatments in terms of yield of marigold. Findings from present study can successfully be utilized for the larger parts of Tarai region of Uttarakhand as effective guide for efficient and balanced fertilizer recommendation.

Introduction

African Marigold (*Tagetes erecta* L.) *cv.*Pusa Narangi Gainda belonging to the family Asteraceae is among one of the most commonly grown loose flowers and used extensively on religious and social functions in different forms. The flowers of Pusa Narangi can be kept remarkably well when they are harvested. Sometimes, the whole plant can be used for the decoration purpose. They are planted in beds for mass display, in mixed borders and can also be grown in pots. Marigold is a native of central and South America, especially Mexico. The generic name *Tagetes* is derived from the word "*Tages*", which is a name of Etruscan God, known for his beauty. Marigold is among the most commercially cultivated flowers in India and all over the world as well It accounts for more than half of the national loose flower production and is best suited for landscape planting in beds, pot, borders, baskets, etc. Its flowers are used in religious and in social functions, as loose flowers, flower decorations and in making garlands. Marigold is also grown for color extraction. Apart from the significance in ornamental horticulture, it has been valued for some another purpose too. It has some additional medicinal properties, *e.g.*, it acts as an anti-inflammatory, and anti-tumor agent, and as a remedy for healing wounds. Plant pharmacological studies have suggested that marigold flower extracts have some antiviral, antigenotoxic viral, cytotoxic anti-tumor, anti-inflammatory and lymphocyte activation properties (Paco *et al.*, 2006). In India, there is a huge potential for its cultivation and use of the ornamental plants and flowers because of their growing demand. Therefore, in the floriculture cultivation of this flower is receiving much attention in many countries. But the firm foundations on which this ornamental flower can be built up as an industry has to be supplied with a well-planned research and experimentation. Uttarakhand produces about 785 MT of Marigold from an area of 554 ha**.** Some of the commercial varieties of African marigold (*Tagetes erecta*) group are Giant Double, African Orange, Giant double, African Yellow, Pusa Narangigainda and Pusa Basantigainda. Importance of fertilizer to increase production is well recognized. Agricultural production is intensifying by the sharp increase in fertilizer consumption, but productivity gains of added nutrients are declining. Nutrient supply from chemical fertilizers is the key to increase the agricultural production. Enhanced land productivity results from the synergistic effects of chemical fertilizers, organic manures, bio-fertilizers and other locally available nutrient sources, which improve soil organic carbon, and nutrient status. Consequently chemical, physical and biological properties of soil. Since, plants derive nutrients from both soil and fertilizers, it is necessary for minimizing the wastage of fertilizer status in the soil to ensure their economic and judicial use. The need to use renewable forms of energy has revived the use of organic fertilizers worldwide. Soil testing is one of the important tools to access the fertility status of soil and provide the basis of nutrient requirement for a crop/cropping sequence. This helps to economize the cost of fertilizer use and will increase the fertilizer use efficiency. Today, we are overwhelmed to hear that Soil Test Crop Response (STCR) based prescription are gaining popularity due to their superiority over blanket general fertilizer recommendations. Field trials conducted in different agro-ecological zones with different cropping systems revealed that the STCR produced a higher yield and therefore maintains a better nutrient status as compared to the blanket fertilizers recommendation. Fertilizers will continue to play a key role in increasing the agricultural production as the crop yield may be increased

considerably by using the appropriate doses of fertilizers. Soil test-based fertilizer recommendation results in an efficient fertilizer use and maintenance of the soil fertility. In this technique fertilizers are recommended separately for different plots in a holding based on the soil test and present a uniform yield target depending upon the availability of fertilizer input. The efficiency of applied fertilizer nutrient and the nutrient already present in the soil is very much location specific and calibrations are needed for every set of the crop-soil climatic complex under the optimal agronomic practices. For this reason, the soil testing has become the foundation for fertilizing our soils in a balanced proportion and we must understand that about the nutrient losses from the soil. The soil test values should be correlated and calibrated for recommending the fertilizer requirement of a crop on a specific soil climatic zone. In the absence of such information, no precise fertilizer recommendations would be possible. Keeping these factors in view, an All India coordinated Research project on soil test-crop response correlation was started by the Indian Council of Agricultural Research in 1967-1968. The concept of formulating optimum fertilizer recommendation for targeted yield was first given by Troug, (1960), which was further modified by Ramamoorthy *et al.,* (1967). The relationship between yield of economic part and uptake of a nutrient will usually be linear. This suggests that by obtaining a given yield, a definite quantity of a nutrient must be taken up by the plant. Once this requirement is known for the given yield, the fertilizer used can be estimated by taking account of efficiency or contribution from the nutrient availability in the soil and from the fertilizer applied. The data obtained from the field experiment of Soil Test Crop Response provides a range in soil test values, nutrient uptake and yield levels, which enable us in calculating three basic parameters, *i.e.* nutrient requirement, the percent contribution of available nutrient from the soil and the percent contribution from the applied nutrient through chemical or organic sources. Field trials conducted in different agro-ecological zones with different cropping systems revealed that the STCR produce higher yields and maintains a better nutrient status in comparison to the blanket or soil test-crop response based inorganic fertilizers alone.

Materials and Methods

Materials and Methods The farm testing trials were conducted in Norman E Borlaug's Crop Research Center of G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India during the year 2013-14 on Mollisols of Uttarakhand. Soil samples (0-15 cm in depth) were collected, dried and passed through 2 mm sieve and analyzed for physico chemical properties as described by (Jackson 1973). Available nitrogen, by the alkaline permanganate method (Subbiah *et al.,* 1956); available phosphorus, by (Olsen *et al.,* 1954) and available potassium, by the ammonium acetate method (Hanway *et al.,* 1952) as described by (Jackson 1973).Pre-sowing soil samples were analyzed according to the standard procedures. Quantities of nitrogen, phosphorus and potassium were calculated with the help of fertilizer adjustment equations as follow. FN = 1.27T-0.32 SN, without FYM, FN = 1.08T-0.27 SN-0.48FYM-N with FYM

FP_2O_5 = 1.99T-3.18SP without FYM and 1.88T-3.09 SP-3.50FYM-P with FYM FK_2O= 0.94T-0.30SK without FYM Where - T = Yield target (t ha^{-1}) F.N. = Fertilizer N (kg ha^{-1}) $F.P_2O_5$ = Fertilizer P (kg ha^{-1}) $F.K_2O$ = Fertilizer K (kg ha^{-1}) SN = Soil available nitrogen (kg ha^{-1}) SP = Soil available phosphorus (kg ha^{-1}) SK = Soil available potassium (kg ha^{-1}). The crop received one third N and full dose of P_2O_5 and K_2O as

basal application and remaining half N were applied and 25 days after transplanting in marigold crop. Remaining nitrogen was applied as basal dose. Nitrogen was applied through urea and phosphorus through single super phosphate and potassium through muriate of potash. The marigold variety of test crop was PusaNarangi.

Results and Discussion

Soil characteristics the soil was mollisols in reaction with pH varying from 6.20-7.87 (6.65). The organic carbon content varied from 0.23-3.939 (2.25) soils were medium in available nitrogen (ranging from 31.36-128.58(73.78), low to medium in available phosphorus (ranging from 10.00-59 (31.62) kg ha^{-1}) and medium to high in available potassium (ranging from 112-192.64 (145.39) in Table 2. Available micronutrient status showed that experimental soil was well supplemented with micronutrients. Though these soils are most fertile, they are deficient in nitrogen and humus but moderately supplied with phosphorus and potassium. Yield targeting of rice based on soil test Experimental data on follow up trails as frontline demonstration, for each location during the period 2013 were conducted in farmers field and are given in Table 2. From the field experiment the basic data on nutrient requirement for producing one quintal grain yield of marigold, percent contribution of nutrients from soil (%CS) and fertilizer (%CF) were evaluated. These basic parameters were used for developing the fertilizer prescription equations under NPK alone. The nutrient requirement of N, P_2O_5 and K_2O were 1.06, 0.34 and 1.32 kg q^{-1} of grain yield, respectively (Table 1 and 2).

Table.1 Range and mean of the soil test value under different strips of marigold

Sl. No.	Particular	Strip I	Strip II	Strip	Average
		Range (Mean)	Range (Mean)	Range (Mean)	
1.	pH	6.55-7.25 (6.79)	6.22-7.87 (6.82)	6.20-6.78 (6.38)	6.20-7.87 (6.65)
. 2.	EC (ds/m)	0.103-0.201 (0.137)	0.205-0.252 (0.22)	0.201-0.212 (0.205)	0.103-0.252 (0.186)
3.	Organic carbon (%)	0.23-3.12 (1.95)	1.40-3.354 (2.64)	0.546-3.939 (2.20)	0.23-3.939 (2.25)
4.	Alkaline $KMnO_4$-N (Kg ha^{-1})	31.36-125.44 (68.44)	31.36-106.62 (68.40)	40.77-128.58 (84.49)	31.36-128.58(73.78)
5.	Olsen's-P (Kg ha^{-1})	10.00-52.00 (30.60)	10-38.82 (20.39)	10.00-59 (31.62)	10.00-59 (31.62)

Table.2 Economics of verification trials

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	13663.0	-	-	-		
T_2= GRD	120-60-60	13800.0	137	6850	6000.4	849.6	0.14
T_3=TYR$_1$	28-102-40	14833.3	1170.3	58515	6306.40	52208.6	8.27
T_4=TYR1+5t/ha FYM (IPNS)	66-94-37	15133.3	1470.3	73515	6319.6	65195.4	10.31
T_5=TYR$_1$+10t/ha FYM (IPNS)	65-88-43	14500.0	837	41850	2069.5	39780.5	19.22
T_6=TYR$_2$	111-151-64	14500.0	837	41850	2069.5	39780.5	19.22
T_7=TYR$_2$+5t/ha FYM (IPNS)	133-138-61	14300.0	637	31850	10018.9	21831.1	2.17
T_8=TYR$_2$+10t/ha FYM (IPNS)	80-134.65-58	15333.3	1670.3	83515	9046.386	74468.614	8.23
T_9= TYR$_1$+Zn	28-102-40	15733.3	2070	103500	6306.4	97193.6	15.41
T_{10}=TYR$_1$+B	28-102-40	14466.7	803.7	40185	6306.4	33878.6	5.37
T_{11}=TYR$_1$+Zn+B	28-102-40	18433.3	4770.3	238515	6306.4	232208.6	36.82
T_{12}=TYR$_1$+Zn+B+FYM	28-102-40-0	18300.0	4637	231850	6306.4	225543.6	35.76
T_{13}=FYM 5 t/ha	0-0-0-5	14233.3	570.3	28515	2500	26015	10.406
T_{14}=FYM 10 t/ha	0-0-0-10	17000.0	3663.3	183165	5000	178165	35.63

The percent contribution of nutrients from soil and fertilizers were found to be 26.23 and 83.25 for N, 54.03 and 38.96 for P_2O_5 and 42.02 and 168.51 for K_2O, respectively. It was noted that contribution of potassium from fertilizer for marigold was higher in comparison to soil. This high value of potassium could be to the interaction effect of higher doses of N, P coupled with priming effect of starter K doses in the treated plots, which might have caused the release of soil potassium form, resulting in the higher uptake from the native soil sources by the crop (Ray *et al.,* 2000). Similar type of higher efficiency of potassium fertilizer was also reported for rice by Ahmed *et al.,* (2002) in alluvial soils and for finger millet by (Kadu *et al.*,2007). Target yield of 45 q ha^{-1} has been achieved with comparatively lower application of N and P_2O_5 fertilizers but higher application of K_2O, in comparison to doses applied in farmer's practice and soil-based recommendations.

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