Indian Journal of Agricultural Sciences **87** (4): 500–4, April 2017/Article

Soil test and targeted yield based primary nutrient management of marigold (*Tagetus patula*) in an Inceptisol

M LAKSHMI DURGA[1], D V S RAJU[2], R N PANDEY[3], KANWAR PAL SINGH[4], PRABHAT KUMAR[5], RENU PANDEY[6], S GOPALAKRISHNAN[7] and SURESH CHANDRA[8]

ICAR-Indian Agricultural Research Institute, New Delhi 110 012

Received: 15 October 2016; Accepted: 14 December 2016

ABSTRACT

Field experiments was conducted on marigold (*Tagetus patula* L.) var. Pusa Arpita during 2014-16 using Ramamoorthy's inductive methodology for the quantification of soil test and crop requirement based integrated fertilizer prescription of primary nutrients for targeted yield of marigold at ICAR-Indian Agricultural Research Institute, New Delhi. The results of the experiment indicated that 0.46 kg N, 0.07 kg P and 0.49 kg K were required to produce one quintal of marigold flowers in Inceptisols of New Delhi. The contributions (%) from soil, fertilizer nutrients and FYM were found to be 46.33, 45.53 and 21.60 for N; 59.62, 20.42 and 8.87 for P and 47.22, 85.71 and 6.11 for K, respectively. The fertilizer prescription equations were developed and nomograms were formulated based on the equations for a range of soil test values and desired yield targets of marigold. Under NPK + 10 tonnes/ha FYM, 9.3, 10.17, and 3.09 kg/ha of fertilizer N, P_2O_5 and K_2O could be saved for attaining targeted yield of 30 tonnes/ha as compared to NPK fertilizer alone at a given soil test values of 100, 4 and 100 kg of N, P_2O_5 and K_2O, respectively.

Key words: Crop response, Fertilizer adjustment equations, Marigold, Nutrient prescription, Soil test

The conventional production systems in flower crops depends on blanket recommendations involving indiscriminate and imbalanced use of fertilizers accelerating ecological and environmental concerns in relation to soil plant system (Pandey *et al*. 2015). To maintain balance and manage soil variability in precision with crop needs, soil test based site and crop specific nutrient application helps the farmers by suggesting meaningful doses in relation to crop yield and quality (Satyanarayana 2011). Integrated use of chemical fertilizers with inorganic sources contributes to rapid mineralization of nitrogen, mobilization of phosphorous and indirectly improves the availability of potassium and other nutrients, there by sustaining soil health and fertility (Singh *et al*. 2014). In the current stress on sustainability issues, the design and implementation of proper nutritional programs involving soil test crop response based site specific integrated nutrient management (STCR-SSINM) is of prime importance to ensure agronomic, economic, social and environmental sustainability (Ortega 2015). Research in this frontline area is completely missing in flower crops, especially those grown in open field in which soil plays a major role in crop production.

Marigold is one such flower crop, widely grown outdoors around the world on account of its hardiness, ease in cultivation and extensive adaptation. Prospects of marigold commercialization is increasing at higher pace for its diversified uses, viz. loose flowers being used in social and religious ceremonies, ornamental landscape plant in borders and bedding, a source of carotenoid pigments for food colorants and nutritional supplements, essential oil for its bio-active compounds that are widely used as insecticides, nematicides, fungicides and compounding in high grade perfumes (Gupta and Vasudeva 2012). It is a heavy feeder of nutrients with positive response to plant nutrition (Polara *et al*. 2014). This flower crop occupied a sizable area (55.89 thousand ha) with significant production of 511. 31 thousand MT (NHB database 2015) where growers are more inclined to use unscrupulous amount of nutrients from fertilizer sources to meet the expected yield and quality. Balanced nutrition is one of the utmost important aspects which directly influence growth, yield and xanthophyll content in marigold (Ahmad *et al*. 2011).

Keeping these points in view, STCR studies involving integrated plant nutrition system (IPNS) was undertaken with an objective to recommend balanced manure fertilizer N, P

[1]Ph D Scholar (lakshmi.hort@gmail.com), [2]Senior Scientist (rajivalex@gmail.com), [3]Principal Scientist (rnpandeyssaciari@rediffmail.com), Division of Soil Science and Agricultural Chemistry, [4]Professor (kanwar_iari@yahoo.in), [5]Senior Scientist (prabhatflori@gmail.com), Division of Floriculture and Landscaping. [8]Cheif Technical Officer (suresh_har@yahoo.com), Division of Soil Science and Agricultural Chemistry. [6]Senior Scientist (renu_iari@rediffmail.com), Division of Plant Physiology and [7]Senior Scientist (gopalakrish@iari.res.in), Division of Genetics.

and K schedule for marigold (*Tagetus patula* L.).

MATERIALS AND METHODS

Two field experiments were conducted during August to May of 2014-15 and 2015-16 with marigold var. Pusa Arpita on typic Haplustepts at research farm of ICAR-Indian Agricultural Research Institute, New Delhi. The experimental site is located in the hot semi-arid agro ecological region of Northern plains of India at 28.4^0 N latitude and 77.1^0 E longitude at an altitude of 250 m above mean sea level. The soil of the experimental field is sandy loam in texture with a pH 8.3, electrical conductivity of 0.30 dS/m (Jackson 1973), alkaline permanganate oxidizable N 176 kg/ha (Subbiah and Asija 1956), 0.5 *N* sodium bicarbonate extractable P 19.6 kg/ha (Olsen *et al.* 1954), neutral *N* ammonium acetate exchangeable K 171 kg/ha (Hanway and Heidal 1934) and organic carbon 0.42% (Walkey and Black 1934). The DTPA-extractable (Lindsay and Norvell 1978) Zn, Cu, Fe and Mn were in sufficiency range, viz. 0.87, 0.64, 7.23 and 9.2 mg/kg, respectively.

The statistical design, layout, treatments and methodology followed in the present investigation were given by All India Coordinated Research Project (AICRP) of Indian Council of Agricultural Research (ICAR), New Delhi on Soil Test Crop Response (STCR) correlation based on 'Inductive cum targeted yield model as described by Ramamoorthy *et al*. (1967). Prior to test crop experiment on marigold, sufficient range of variation in soil fertility was deliberately created in the same field by dividing it in to three equal rectangular strips (I, II, III) and applied with no fertilizer in strip I (Low), N-P_2O_5-K_2O @ 200-150-150 kg/ha in strip II (medium) and 400-300-300 kg/ha in strip III (high) respectively. Further, farmyard manure (FYM) having N - 0.4 %, P - 0.2 % and K - 0.5% was applied @ 0, 5 and 10 tonnes/ha in each of the three strips across the fertility gradient. In this way, finally nine distinctly different fertility blocks (three in each of three strips) were created (Mahajan *et al*. 2014). The created fertility gradient was stabilized by growing fodder pearl millet during summer, 2014 so that fertilizer could become part of soil system by interacting with soil, plant rhizosphere and microbes. After the harvest of the fodder crop, soil samples (0 - 0.15 m) from each strip were collected and were analyzed for alkaline $KMnO_4$-N, $NHCO_3$-P and ammonium acetate-K by using standard analytical procedures as described above.

Subsequently, each strip was divided into 24 plots (4 × 2.5 m^2) making a total of 72 plots in three strips. The STCR correlation experiment on marigold was conducted in a fractional factorial randomized block design in which twenty one fertilizer treatments constituted from different combinations of four levels each of N (0, 60, 120 and 180 kg/ha), P_2O_5 (0, 40, 80 and 120 kg/ha), K_2O (0 40, 80 and 120 kg/ha), and three levels of FYM (0, 5 and 10 tonnes/ha) along with three controls (without fertilizer) were randomized in twenty four plots of each fertility strip in such a way that all the treatments occurred in both the directions and in all the three manure gradient levels. Full dose of FYM, P and K, and half the dose of N, were applied as basal dose and remaining dose of nitrogen was top dressed at 45 days after transplanting. Twenty eight days old seedlings of marigold were transplanted with a spacing of 45 × 45 cm^2 and recommended cultural practices were followed.

Soil samples were collected from each plot before planting and after harvesting of each test crop. The collected samples were air dried, passed through 2 mm sieve and used for analyzing available NPK. Marigold flower and plant samples were collected separately from each plot were dried in hot air oven at 65±2ºC, grounded to a homogenous powder and were chemically analyzed for N, P and K content as per the procedure described by Jackson (1973). Total N, P and K uptake by the crop was computed using the dry biomass yield of marigold flower and plant.

Using the data on marigold flower yield, nutrient uptake, initial soil available nutrient status, and fertilizer manure doses applied, basic parameters, viz. nutrient requirement (NR) for the production of 100 kg flowers and contribution efficiencies (%) of soil available nutrients (C_S), fertilizer (C_F) and FYM (C_{FYM}) were computed as outlined by Ramamoorthy *et al*. (1967). These parameters were used for the development of fertilizer prescription equations and ready reckoner of NPK fertilizer doses alone and in conjugation with manure (FYM) for a range of soil test values and desired yield targets (±10% of potential yield) of marigold.

RESULTS AND DISCUSSION

Descriptive statistics of pre planting soil available nutrients, flower yield and total nutrient uptake of two years mean data is presented in Table 1. Mean values of Alkaline $KMnO_4$-N, Olsen's-P and NH_4OAc-K during the two years of experimental study were observed as 189.24, 208.73, 219.46 kg/ha of N; 20.81, 25.91, 30.13 kg/ha of P and 211.62, 236.31, 250.81 kg/ha of K in strip I, II and III respectively. The soil available NPK values increased with increase in fertilizer doses and were the highest in $N_3P_3K_3$ of strip III, followed by strip II and lowest in strip I, which indicated that the establishment of marked fertility gradient by application of graded doses of fertilizers and FYM. Such extent of gradient build up has also been reported by Rawat *et al*. (2015) with a preliminary oat crop in mollisols of Uttarakhand, India. Variation in soil available nutrients within the strip was explained by coefficient of variation and it was less in soil available N in comparison with P and K. An operational range of variability was created with respect to soil NPK which is a major prerequisite for conducting STCR experiment (Santhi *et al*. 2011).

Range and mean values of flower yield and NPK uptake (Table I) revealed that the highest output and nutrient uptake were obtained from strip III followed by strip II and lowest in unfertilized strip. Mean flower yields from over all plots were in the ascending order of 29.33, 30.39 and 30.62 tonnes/ha in strip I, II and III respectively. However, the highest yield (34.29 tonnes/ha) was recorded in $N_3P_3K_3$ of strip II with FYM @ 5 tonnes/ha and lowest

Table 1 Descriptive statistics of available soil (0-0.15 m) nutrients status after the establishment of the soil fertility gradient, flower yield and total nutrient uptake of two years mean (2014-16)

Nutrients (kg/ha)	Strip I		Strip II		Strip III	
	Range	Mean±SD (CV)	Range	Mean± SD (CV)	Range	Mean± SD (CV)
Alkaline $KMnO_4$-N	162.42-208.79	189.24±12.23 (6.46)	174.31 -234.01	208.73±16.39 (7.85)	183.5-260.85	219.46±18.67 (7.41)
Olsen's- P	14.62-27.71	20.81±3.72 (17.87)	19.25-32.17	25.91±3.30 (12.74)	22.43-38.32	30.13±4.25 (14.12)
NH_4OAc- K	172.91-236.00	211.62±17.37 (8.20)	196.23-268.99	236.31±19.30 (8.16)	206.94-303.57	250.81±23.29 (9.28)
Flower yield (tonnes/ha)	17.85-33.26	29.33±4.51 (15.37)	18.95-34.29	30.39±4.46 (14.70)	19.42- 33.96	30.62±4.09 (13.37)
N uptake (kg/ha)	61.99-163.87	129.58±28.73 (22.17)	66.26-188.57	140.23±31.06 (22.15)	82.01-205.22	153.94±32.02 (20.80)
P uptake (kg/ha)	8.56-26.82	17.06±5.42 (31.77)	10.07-27.51	19.47±5.18 (26.63)	11.85-35.53	24.19±7.07 (29.25)
K uptake (kg/ha)	80.2-174.05	136.40±28.06 (20.57)	90.04-194.47	147.65±19.28 (13.05)	90.46-220.38	159.40±34.38 (21.56)

SD, Standard Deviation; CV, Coefficient of Variation (Standard Deviation/Mean × 100) in %.

(17.85 tonnes/ha) in control ($N_0P_0K_0FYM_0$). The mean flower yield in strip III was much closer to strip II as the plants grown under high nutrient status (strip III) failed to produce maximum flower yields due to comparatively high vegetative growth, indicating that beyond a certain limit, marigold does not respond to nutrient application. Such adverse effect of excess NPK application was reported in gladiolus by Singh *et al*. (2002). Present study showed a significant increasing trend in nutrient uptake from low to high gradient (strip I to strip III) with successive elevated doses of NPK and FYM. Treatment receiving $N_3P_3K_3$ +10 t FYM/ha in highest gradient recorded maximum uptake of NPK (205.22, 35.53 and 220.38 kg/ha respectively) due to higher shoot and root growth with increased production of biomass and these results were in conformity with Naik (2015) and Ahmed *et al*. (2011).

Basic parameters

Optimization of nutrients is highly essential to explore the genetic potential of the crop which is based on the contribution of applied nutrients and indigenous soil supplying capacity (Katharine *et al*. 2013). Nutrient requirement to produce one quintal of marigold flower was computed as 0.46 kg of N, 0.07 kg of P and 0.49 kg of K (Table 2). From this study it is concluded that marigold requires 7 times more of potassium and 6.57 times more of nitrogen in comparison with phosphorous. The lowest requirement of P might be attributed to its higher contribution from soil (residual effect from the preceding crop) to the total P uptake and FYM might have reduced the fixation of P by enhancing its efficiency (Mahajan *et al*. 2014). Order of percentage contributions of fertilizer nutrient to total nutrient uptake was observed as K>N>P which is in close conformity with Jadhav *et al*. (2013). With regard to N, more contribution was recorded from soil and fertilizers

Table 2 Nutrient requirement and *per cent* contribution of nutrients from soil, fertilizer and farmyard manure for marigold

Basic parameters	N	P	K
Nutrient requirement (NR) of flower (kg/q)	0.46	0.07	0.49
Per cent contribution from available soil nutrients (Cs)	46.33	59.62	47.22
Per cent contribution from fertilizer nutrients (C_F)	45.53	20.42	85.71
Per cent contribution from farmyard manure (C_{FYM})	21.60	8.87	6.11

due to sufficient available soil pool and split application of nitrogen fertilizer respectively. The contribution of FYM was highest for N which might have provided enough carbon for buildup of bacterial population to enhance N availability and the findings are in conformity with Ahmed *et al*. (2015). Sizable contribution of FYM was noticed towards the crop requirement of N followed by P and K which helps in saving of nutrients to be applied through costly fertilizers under integrated plant nutrition system (IPNS).

Fertilizer prescription equations

There are no STCR-IPNS studies on fertilizer NPK recommendation in marigold. Under such circumstances where NPK is the limiting factor for crop growth, yield and quality, soil test based fertilizer prescription equations for desired yield targets for marigold were formulated using the basic parameters and furnished in Table 3. Such kind of fertilizer prescription equations for different crops (potato, garlic and banana) have been documented by Chatterjee *et al*. (2010), Jadhav *et al*. (2013) and Panchbhai *et al*. (2014).

On the basis of these equations, a ready reckoner was prepared for a range of soil test values for yield target of

Table 3 Soil test based fertilizer prescription equations for targeted yield of marigold

Particulars	NPK alone	NPK + FYM
FN =	1.02 T – 1.02 SN	1.02 T – 1.02 SN – 0.47 FYMN
FP =	0.32 T – 2.92 SP	0.32 T – 2.92 SP – 0.43 FYMP
FK =	0.57 T – 0.55 SK	0.57 T – 0.55 SK – 0.07 FYMK

FN, FP and FK - fertilizer N, P and K (kg/ha), respectively; SN, SP and SK - soil test value of available N, P and K (kg/ha); FYMN, FYMP and FYMK - amount of N, P and K applied through farmyard manure, T- Targeted yield (tonnes/ha) of marigold.

ACKNOWLEDGEMENT

The award of a INSPIRE fellowship by the Department of Science and Technology, New Delhi, to Lakshmi Durga, M and Institutional support from Indian Agricultural Research Institute (IARI), New Delhi, India, is gratefully acknowledged. Authors are especially thankful to Division of Soil Science and Agricultural Chemistry, IARI, New Delhi, India for carrying out the present research work. The experimental set up designed under All India Coordinated Research Project (ICAR-Indian Institute of Soil Science) is gratefully acknowledged.

Table 4 Ready reckoner of soil test based fertilizer recommendations of N, P and K for 30 tonnes/ha of marigold flower yield with and without farmyard manure (FYM) @ 10 tonnes/ha

Soil test values (kg/ha)			Fertilizer dose with FYM (10 tonnes/ha)			Fertilizer dose (kg/ha) without FYM			% decrease over FYM		
N	P	K	N	P_2O_5	K_2O	N	P_2O^5	K_2O	N	P_2O_5	K^2O
100	4	100	185.19	76.76	112.06	204.18	85.45	115.63	9.30	10.17	3.09
120	8	120	164.84	65.08	101.05	183.82	73.77	104.61	10.33	11.78	3.40
140	12	140	144.49	53.41	90.03	163.47	62.10	93.59	11.61	13.99	3.80
160	16	160	124.13	41.73	79.01	143.12	50.42	82.57	13.27	17.24	4.31
180	20	180	103.78	30.05	67.99	122.76	38.74	71.55	15.46	22.43	4.98
200	24	200	83.44	18.37	56.97	102.41	27.06	60.54	18.52	32.11	5.90
220	28	220	63.08	6.69	45.95	82.06	15.39	49.52	23.13	56.53	7.21

30 tonnes/ha under NPK alone and NPK + FYM under IPNS (Table 4). Inclusion of IPNS component like farmyard manure in the present investigation resulted in reduction in fertilizer nutrient requirement for desired yield targets. Requirement of N, P and K fertilizers decreased with increase in soil test values. Under IPNS with 10 tonnes FYM/ha, requirement of NPK was further reduced and saving a significant quantity ranging from 9.30 to 23.13% FN, 10.17 to 56.53% FP and 3.09 to 7.21% FK when soil test values varying in between 100 - 220 kg N and K/ha and 4 to 28 kg P/ha respectively. Similar results were also reported by Ahmed *et al*. (2015), Panchbhai *et al*. (2014) and many other coworkers in different crops.

The findings of the present study clearly revealed that fertilizer prescription equations developed for NPK alone or under IPNS could be effectively used in Inceptisols of New Delhi and similar agro climatic conditions for achieving a targeted yield of 30 tonnes/ha. Supplying fertilizer nutrients using targeted yield approach considering nutrient requirement (0.46 kg of N, 0.07 kg of P and 0.49 kg of K) for the production of one quintal of marigold flower, contribution of nutrients from soil (46.33, 59.62 and 47.22% for N, P and K), fertilizer (45.53, 20.42 and 85.71% for N, P and K) and farmyard manure (21.60, 8.87 and 6.11% for N, P and K) for desired yield targets in the present experiment ensured balanced nutrient supply to marigold. This practice of fertilizing the crops on yield targets appears precise, meaningful and economically feasible and needs to be popularized among flower growers to attain sustainable yields.

REFERENCES

Ahmad I, Asif M, Amjad A and Ahmad S. 2011. Fertilization enhances growth, yield, and xanthophyll contents of marigold. *Turkish Journal of Agriculture and Forestry* **35**(6): 641–8.

Ahmed S, Basumatary A, Das K N and Medhi B K. 2015. Targeted yield based fertilizer prescriptions for autumn rice (*Oryza sativa* L.) in inceptisols of Assam, India. *Indian Journal of Agricultural Research* **49**(5): 437–41.

Chatterjee D, Srivastava A and Singh R K. 2010. Fertilizer recommendations based on targeted yield concept involving integrated nutrient management for potato (*Solanum tuberosum*) in *tarai* belt of Uttarakhand. *Indian Journal of Agricultural Sciences* **80**(12): 1 048–53.

Gupta P and Vasudeva N. 2012. Marigold - A potential ornamental plant drug. *Hamdard Medicus* **55**(1): 45–59.

Hanway J J and Heidel H. 1952. Soil analysis methods as used in Iowa state college soil testing laboratory. Iowa State College of Agriculture, **57**, pp 1–31.

NHB. 2015 National Horticulture Board, Indian Horticulture database 2015, Ministry of Agriculture, Government of India, p 286.

Jackson M L. 1973. *Soil Chemical Analysis*. Prentice Hall of India Private Limited, New Delhi.

Jadhav A B, Kadlag, A D, Patil V S, Deshpande A N and Durgude A G. 2013. Response of garlic to integrated nutrient management based on targeted yield concept in inceptisol. *Journal of the Indian Society of Soil Science* **61**(4): 347–50.

Katharine P S, Santhi R, Maragatham S, Natesan R, Ravikumar V and Pradip Dey. 2013. Soil test based fertilizer prescriptions through inductive cum targeted yield model for transgenic cotton on Inceptisol. *Journal of Agriculture and Veterinary Science* **6**(5): 36–44.

Lindsay W L and Norwell W A. 1978. Development of DTPA soil test for zinc. Iron, manganese and copper. *Soil Science Society of America Journal* **42**(3): 421–8.

Mahajan G R, Pandey R N, Datta S C, Kumar D, Sahoo R N and Parsad R. (2014). Fertilizer nitrogen, phosphorus and sulphur prescription for aromatic hybrid rice (*Oryza sativa* L.) using targeted yield approach. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences* **84**(3): 537–47.

Naik M R. 2015. Influence of nitrogen and phosphorus on flowering, N and P content of African marigold var. Cracker Jack. *International Journal of Farm Sciences* **5**(1): 42–50.

Olsen S R, Cole C V, Watanabe F S and Dean L A. 1954. Estimation of available phosphorus in soils by extracting with sodium bicarbonate. USDA circular 939, US Govt. Printing Office, Washington DC.

Ortega R. 2015. Integrated nutrient management in conventional intensive horticulture production systems. (*In*) Second International symposium on organic matter management and compost use in horticulture. *Acta Horticulturae* **1076**: 159–64.

Pandey R N, Janakiram T, Raju D V S, Lakshmi Durga M and Pradip Dey. 2015. Soil test based integrated nutrient management in flower crops. *Indian Horticulture* **60**(12): 42–4.

Polara N D, Gajipara N N and Barad A V. 2014. Effect of nitrogen and phosphorus on nutrient content and uptake in different varieties of African marigold (*Tagetes erecta* L.). *Bioscan* **9**(1): 115–9.

Ramamoorthy B, Narasimham R L and Dinesh R S. 1967. Fertilizer application for specific yield targets on Sonora 64 (wheat). *Indian Farming* **17**(5): 43–5.

Rawat S, Singh S, Gangola P and Gautam P. 2015. Studies on soil test crop response correlation for optimizing fertilizer recommendation to okra grown on Mollisol of Uttarakhand. *International Journal of Basic and Applied Agricultural Research* **13**(2): 254–7.

Santhi R, Bhaskaran A and Natesan R. (2011) Integrated fertilizer prescriptions for beetroot through inductive cum targeted yield model on an Alfisol, *Communications in Soil Science and Plant Analysis* **42**(16): 1 905–12.

Satyanarayana T, Majumdar K and Biradar D P. 2011. New approaches and tools for site-specific nutrient management with reference to potassium. *Karnataka Journal of Agricultural Sciences* **24**(1): 86–90.

Singh A K, Chauhan R K and Bisen J S. 2014. Role of soil organic matter in soil health sustainability. *Indian Journal of Agricultural Sciences* **5**(2): 291–7.

Singh W, Sehrawat S K, Dahiya D S and Singh K. 2002. Leaf nutrient status of gladiolus (*Gladiolus grandiflorus* L.) cv. Sylvia as affected by NPK application. *Haryana Journal of Horticultural sciences*, **31**(1-2): 49–51.

Subbiah B V and Asija G L. 1956. A rapid procedure for the estimation of available nitrogen in soil. *Current Science* **25**(8): 259–60.

Walkley A J and Black I A. 1934. Estimation of organic carbon by chromic acid titration method. *Soil Science* **37**(1): 29–38.