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Integrated nutrient management in calendula (*Calendula officinalis* L.) grown in partially reclaimed sodic soil condition

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Abstract

To study the effect of nutrient management on growth and flower yield of Calendula, field experiments were carried out during 2009 and 2010. Results indicated that significantly higher plant height (40.6 cm), number of leaves (142) at 90 days, total number of flowers plant^{-1} (126), total fresh weight of flowers (87.5 q ha^{-1}) and dry weight of flowers (25.0 q ha^{-1}) were observed by the application of 10 t farmyard manure (FYM) + ½ NPK + spraying of micronutrients followed by sole application of recommended dose of inorganic fertilizer (i.e. NPK@ 80:30:30 kg ha^{-1}) which was at par with application of half dose of recommended dose of inorganic fertilizer supplemented with half dose of organic fertilizer. Application of 20 t FYM ha^{-1} improved the soil physico-chemical parameters i.e. pH, EC, organic carbon and available NPK in comparison to control.

Keywords: calendula, farmyard manure, micronutrients

Calendula or pot marigold (*Calendula officinalis* L.) is cultivated as an attractive garden plant with yellow to orange flowers. The petals of this plant are considered edible and an edible yellow dye is obtained from the petals, which is used to colour and flavour rice, soups etc. It is also used as a hair rinse, adding golden tints to brown hair. In the traditional system of medicine, the bright orange petals serve as an antiseptic and are an excellent remedy for inflammation and skin diseases (Sakharkar *et al.* 2000). Its cultivation is stimulated not just by the pharmaceutical industry but also by the manufactures of cosmetics.

Excessive use of chemical fertilizers cause environmental pollution and alter the balance of the ecosystem that is one of the major problems additionally these chemicals have contributed to the loss of soil quality. A move towards sustainable and organic production will reduce the impact of agriculture on the environment, so the use of organic matter as nutrient inputs is a good strategy for crop production with minimal environmental pollution (Liu *et al.* 2009). So the current study was conducted to explore the possibility of developing a nutrient management plan for Calendula in a partially reclaimed sodic soil.

The present investigation was laid out at Aurawan Research Centre of CSIR-National Botanical Research Institute, Lucknow, UP. The farm site is located between latitude 26°43′03"N

and longitudes 80° 50′02″E at an altitude of 120 m above the mean sea level. The climate of this region is characterized by long and intensive hot summer, low and irregular rainfall and long mild winter. The area receives an annual rainfall of 80-100 cm, 70% of which is concentrated in the month of July-September. The field experiments were carried out during 2008–2009 and 2009–10, to study the effect of nutrient management on *Calendula*. The soil was a silt loam with pH- 8.6, EC- 0.27 dSm^{-1}, organic carbon- 4.1 g kg^{-1}, available N 110 kg ha^{-1}, available P 18.5 kg ha^{-1} and available K 276 kg ha^{-1}. Raising of nursery was done in first week of November and about one month old seedlings (var. Gold Star) were transplanted in first week of December at the spacing of 30 cm × 30 cm during both the years of experimentation. The experiment consisted of five treatments i.e. Control (T_1), 20 t FYM ha^{-1} (T_2), recommended dose of NPK (80:30:30 kg ha^{-1}) (T_3), 10 t FYM ha^{-1} + ½ NPK (T_4) and 10 t FYM ha^{-1} + ½ NPK + Spraying of 0.5% micronutrients (T_5) with four replications in randomized block design. Half dose of N in form of urea and full doses of P in form of DAP and K in form of MoP, were applied at the time of transplanting and remaining dose of N was applied in 2 equal splits at 30 and 60 days after transplanting (DAT). In the treatment T_5, spraying of micro-nutrients @ 0.5% (Multiplus micronutrient containing Zn- 6.0%, Fe- 3.0%, Mn- 1.5% and Cu- 0.5%) was done at 20, 40 and 60 DAT. The soil pH and EC were analyzed through 1:2 (Soil: Water) suspension, organic carbon by Walkley & Black (1934) rapid titration method, available N by alkaline $KMnO_4$ method as described by Subbiah & Asija (1956), available P by the method Olsen *et al.* (1954) and available K by flame photometery as described by Jackson (1973). The observations on growth and flower yield of calendula, were recorded on five random plants and data statistically analysed by Panse & Sukhatme (1961).

The results showed that the maximum growth of plants, reflected by plant height and number

Table 1. Effect of the treatments on plant height, number of flowers $plant^{-1}$, fresh weight of flowers and dry weight of flowers (mean of 2 years)

Treatments	Plant height (cm)	Number of leaves $plant^{-1}$	Number of flowers $plant^{-1}$	Number of branches $plant^{-1}$	Wt. of flowers (g $plant^{-1}$)		Wt. of flowers (q ha^{-1})	
	90 DAT	90 DAT			Fresh	Dry	Fresh	Dry
T_1- Control	26.5	71	62	3.8	84	21	93.2	23.3
T_2- 20 t FYM ha^{-1}	35.9	110	105	6.4	121	31	134.3	34.4
T_3- NPK (80:30:30 kg ha^{-1})	39.1	116	113	6.8	128	35	142.1	38.9
T_4-10 t FYM + ½ NPK	38.7	112	110	6.5	125	34	138.8	37.7
T_5-10 t FYM + ½ NPK + spraying of micronutrient	42.6	142	126	8.4	140	40	155.4	44.4
SE (m) ±	1.0	3	4	0.7	5	2	5.6	2.1
CD (P<0.05)	2.3	6	8	1.5	11	4	12.2	4.7

of leaves plant^{-1} was recorded by the application of 10 t FYM + ½ NPK + spraying of micro-nutrients (T_5) at 90 DAT (Table 1). Rahmani *et al.* (2009) during his investigation also reported that plant height and number of leaves were increased significantly by the application of FYM, NPK and their combination at all the stages. Naguib *et al.* (2005) also reported that supplementing foliar application of micronutrients with recommended dose of fertilizer, increased all the parameters of *Calendula*.

Growth and quality of medicinal plants were shown to be strongly affected by soil conditions and application of well decomposed FYM, resulted in increased growth and flower production of Calendula (Paim *et al*. 2010). Flowering characteristics *viz*., number of flowers plant^{-1}, number of branches plant^{-1} and weight of flowers (fresh and dry both), were also significantly increased by all the treatments over control (Table 1). Application of FYM (T_2) and full dose of NPK (T_3) were at par and significantly higher in comparison to control. Highest number of flowers plant^{-1}, number of branches and weight of flowers plant^{-1} were recorded by the application of 10 t FYM + ½ NPK + spraying of micro-nutrients (T_5) followed by 10 t FYM + ½ NPK (T_4). Application of 20 t FYM (T_2), NPK @ 80:30:30 kg ha^{-1} (T_3) and 10 t FYM + ½ NPK (T_4) produced statistically equal number of flowers plant^{-1} (105, 110 and 113 respectively) which were significantly higher in comparison to control (62). However, maximum number of flowers plant^{-1} (126) was recorded by the application of 10 t FYM + ½ NPK + spraying of micro-nutrients (T_5) which was significantly higher than all the treatments (Table 1). Number of branches plant^{-1} was also affected by different treatments. Maximum number of branches (8.4) was recorded by the application of 10 t FYM + ½ NPK + spraying of micro- nutrients (T_5) which was significantly higher than all the treatments. Mohamed & Abdella (2013) also reported that foliar application of micronutrients mixtures 400 ppm produced significantly higher vegetative and flowering traits.

Maximum weight of fresh flowers (140 g plant^{-1}) was recorded by the application of 10 t FYM + ½ NPK + spraying of micronutrients. Similar trend was also recorded in dry weight of flowers (Table 1). Singh *et al.* (2008) reported that application of FYM + 75% N ha^{-1} was produced better to plant growth, advanced the flowering and resulted in maximum production of fresh flowers. FYM may improve soil pH, cation exchange capacity (CEC) and nutrient levels besides improving moisture holding capacity. In our finding also, maximum improvement in soil pH (8.3) was recorded by

Table 2. Changes in soil properties after harvest of the Calendula (after 2 years)

Treatments	pH	EC (dS m^{-1})	OC (g kg^{-1})	Avail. N (kg ha^{-1})	Avail. P (kg ha^{-1})	Avail. K (kg ha^{-1})
T_1- Control	8.5	0.25	4.0	107.0	17.1	269.0
T_2- 20 t FYM ha^{-1}	8.3	0.18	4.5	158.0	22.7	343.0
T_3- NPK (80:30:30 kg ha^{-1})	8.5	0.22	4.1	113.0	21.5	290.0
T_4-10 t FYM + ½ NPK	8.4	0.21	4.2	128.0	20.8	315.0
T_5-10 t FYM + ½ NPK + spraying of micronutrient	8.4	0.20	4.2	124.0	20.7	313.0
Initial	8.6	0.27	4.1	110.0	18.5	276.0

EC - Electrical conductivity, OC - Organic carbon

the application of 20 t FYM ha^{-1} (T_2) followed by pH 8.4 in the treatment T_4 (10 t FYM + ½ NPK) and T_5 (10 t FYM + ½ NPK + spraying of micro nutrients). Application of 20 t FYM ha^{-1} (T_2) improved all others parameters i.e. EC, organic carbon and available NPK respectively followed by the treatment T_4 and T_5 (Table 2).

Overall, our data indicated that combined application of FYM with inorganic fertilizer and supplementing with micronutrients resulted in the markedly better vegetative and flowering characteristics in calendula.

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