Biological Forum – An International Journal **14(1): 785-789(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Effect of amendments on Growth and Nutrient uptake of African marigold (*Tagetus erecta*) under Paper and Pulp Mill Effluent Irrigated Soil

***Ezra John J.*[1], *P. Thangavel*[1]*, *G. Balasubramanian*[1], *T. Kalaiselvi*[2] *and E. Kokiladevi*[3]**

[1]*Department of Environmental Sciences, TNAU, Coimbatore, (Tamil Nadu), India.*
[2]*Department of Agricultural Microbiology, TNAU, Coimbatore, (Tamil Nadu), India.*
[3]*Department of Agricultural Biotechnology, TNAU, Coimbatore, (Tamil Nadu), India.*

(Corresponding author: P. Thangavel)*
(Received 02 November 2021, Accepted 03 January, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: In spite of water shortages green areas in cities have increased due to use of alternative water sources for irrigation. Alternative water sources usually have a lot of salt in them, as a result, salinity threatens the survival of various plants. Paper and pulp mill effluent is generally alkaline and increases the salinity of soil when irrigated for long duration. Therefore, developing agronomic strategies and salt tolerant varieties for successful cultivation of crops in saline soils is explored in recent years. Hence, this study was aimed to assess the potential of different amendments (without amendment (A_1), 50 % Gypsum requirement (A_2), Poultry manure at 5 t ha^{-1} with 0.1 % Pink pigmented facultative methylotroph (PPFM) as foliar spray (A_3) and 5 t ha^{-1} Pressmud compost along with CSR BIO 35 kg ha^{-1} (A_4)) to improve the crop growth of marigold (*Tagetes erecta* L.) under salt stress. Application of organic amendments increased the biomass and flower yield of marigold when compared with non-amended plot. Total biomass was higher in A_3 (73.3 %) and A_4 (69.9 %) plots than the control plot. Among all the treatments, highest flower yield of 67.6 q ha^{-1} was recorded in the treatment amended with Poultry manure at 5 t ha^{-1} with 0.1 % PPFM as foliar spray. Uptake of major nutrients N, P and K was found to be high in organic amendments treated plot than control. Also, uptake of ions such as Na, Ca, Cl, Mg and SO_4 were significantly high in organic amendment applied plots. Hence, under saline stress, despite the uptake of sodium ion the organic amendments also improved the growth and yield of marigold.

Keywords: Salinity, African marigold, Organic amendments, Paper and pulp mill effluent, ion uptake.

INTRODUCTION

In agriculture, the quality of irrigation water is assumed to have an impact on soils and agricultural crops (Kumar and Chopra, 2010). The numerous elements introduced into the soil profile by paper and pulp mill wastewater irrigation have an impact on crop development and soil qualities, as well as their relative mobility in the soil profile. Cations, for example, tend to concentrate in the top layers of cation exchange sites in soil (Kumar *et al*., 2010). However, wastewater irrigation introduces a wide range of nutrients and minerals into the soil environment (Kumar and Chopra, 2012). Other elements found in pulp mill effluent, such as magnesium (Mg), sodium (Na), chloride (Cl), and sulphur (S), have been linked to crop toxicities and nutrient imbalances, increases in soil salinity, and deterioration of soil structure, all of which have been linked to decreased long-term crop productivity. The use of saline water may reduce agricultural yields, whereas the use of sodic water may damage the physicochemical qualities of the soil, resulting in crop yield reductions.

Salinity is one of the most important environmental factors that limit plant growth. Plant growth is severely hampered by salinity in the soil and irrigation water (Rezende *et al*., 2010). Changes in the nutritional balance during salinity stress result in greater levels of Na^+/Ca^{2+}, Na^+/K^+, Na^+/Mg^{2+}, Cl/NO_3 and Cl/H_2PO_4, causing plant growth retardation (Munns *et al*., 2008; Rasouli *et al*., 2013). Sodium and Chloride can alter nutrition absorption and ion toxicity in plants by increasing the osmotic pressure of soil solution (Musavi *et al*., 2015). In most plants, high salinity results in a larger amount of Na+ and Cl- ions, but a decrease in N, P, K+, and Ca^{2+} (Song *et al*., 2008). The use of manures (farm yard manure, chicken manure), press mud, and compost (municipal solid waste, food wastes) improve soil structure by increasing the nutrient status of saline soils (Niamat *et al*., 2019; Sundhari *et al*., 2018).

Marigold is an important ornamental plant that is frequently utilised in environmental planning in polluted soil (Riaz *et al*., 2013). Because of its fragrant nature and essential oil content, it is widely employed in the cosmetic and perfume industries. Marigolds is a popular seasonal flowering plant that can be seen in public parks, gardens, and along the roadside. Marigold feature dark green foliage and attractive yellow, deep orange, and white blooms (Jamali *et al*., 2021). The effects of amendments on marigold plants (*Tagetes erecta* L.) under salinity stress developed by paper and pulp mill effluent irrigation were investigated in the present study. Under saline conditions, plant height, fresh weight, flower yield and ion uptake were determined.

MATERIALS AND METHODS

A. Study area

The field experiment was conducted on Pandipalayam, Karur district, Tamil Nadu, India (N 11.02455 , E 77.9916°), the region known as "Treated Effluent Water Lift Irrigation Society" (TEWLIS). Since, the only irrigation source in the region is treated pulp and paper mill effluent of alkaline pH ranging from 7.20 - 8.32 with an electrical conductivity of 2.1 - 3.1 dS m^{-1} it effluent has changed the cropping pattern, soil fertility, and land use of TEWLIS area (Balusamy *et al*., 2013). The changes occurred in this period do not necessarily suggest degradation. Initial soil characteristics were assessed for determining the salinity in the soil (Table 1).

Table 1: Initial characteristics of the field.

Sr. No.	Parameter	Values
1.	EC (dS m^{-1})	1.12
2.	pH	8.46
3.	ESP	12.6
4.	Organic carbon (%)	0.36
5.	Available nitrogen (kg ha^{-1})	295
6.	Available phosphorus (kg ha^{-1})	15.2
7.	Available potassium (kg ha^{-1})	462
8.	CEC (cmol (p^{-1}) kg^{-1})	15.34

B. Experimental setup

The field was divided into four splits for imposing treatments. The treatments were control (A_1), 50 % Gypsum requirement (A_2), Poultry manure at 5 t ha^{-1} with 0.1 % Pink pigmented facultative methylotroph as foliar spray (A_3) and 5 t ha^{-1} Pressmud compost along with CSR BIO 35 kg ha^{-1} (A_4). They were applied and ploughed 30 days before planting. The amendments were selected based on earlier studies of their efficacy in amelioration of saline soil (Abdel-Fattah, 2012; Goss *et al*., 2013; Seth *et al*., 2005; Thuvasan *et al*., 2018). All the data represent mean of five replicates.

Fig. 1. Experimental field in Paper and pulp-mill effluent irrigated soil.

C. Chemical analysis of plant material

The whole plant was harvested after 130 days of cultivation. The plant samples were oven-dried at 70°C and ground into a fine powder. For each plot 5 samples of 50 mg each was weighed out and digested with 13 mL nitric acid and 2 mL H_2O_2 using a microwave digestion instrument (Ximénez-Embún *et al*., 2002). The concentrations of Na^+, Mg^{2+}, K^+ and Ca^{2+} was measured using MP-AES. The anions Cl^- and SO_4^- were analysed in plant sample by the method followed by (Lastiri-hernández *et al.*, 2019). Biomass from each treatment plot was harvested and dry matter production (DMP) at g m^{-2} was measured (Moseki & Buru, 2010). This was used to calculate total dry matter production for a hectare.

RESULTS AND DISCUSSION

A. Growth parameters of Marigold

The impact of amendments and microbial inoculum on marigold performance was recorded after 130 days of planting. The plant height from the tip of the plant to ground level was recorded at harvest stage and presented in Table 2. The highest plant height (34.50 cm) and number of branches (21.6) was in the Poultry manure @ 5 t ha^{-1} + PPFM @ 1 % (A_3) applied treatments. The lowest biomass was recorded in control (A_1) at 2.06 t ha^{-1} due to the salinity stress of paper and pulp mill effluent irrigated soil. Previous research has shown that salt stress causes growth retardation and weight loss. Under salinity stress (6 dS m^{-1}), shoot fresh

weight and dry matter production of *Tagetes erecta* was declined (Sun *et al*., 2018). Chrysargyris *et al*. (2018) also reported reduction in plant height and biomass at a concentration of 100mM NaCl. Here, application of organic amendments and biofertilizer had increased the plant biomass and growth parameters in the salinized soil.

Flower yield. The total flower yield and biomass production of African Marigold in TEWLIS area soil was presented in Table 2. The treatment A_2 (50 % Gypsum requirement) recorded low flower weight (5.12 g) and A_3 highest flower weight (8.02 g). The number of flowers/plants were high (23.4) in the treatment applied with Poultry manure @ 5 t ha^{-1} + PPFM @ 1 % (A_3) and the lowest flower/plant (12.5) was recorded in A_1 (Control). The flower yield was highest (67.6 q ha^{-1}) in the Poultry manure @ 5 t ha^{-1} + PPFM @ 1 % (A_3) applied treatments followed by Pressmud compost @ 5 t ha^{-1} + CSR BIO @ 35 kg ha^{-1} (A_4) applied treatments (62.9 q ha^{-1}) and lowest yield (39.6 q ha^{-1}) was recorded in the Control (A_1) treatment. The biomass production was found to be high (3.57 t ha^{-1}) in treatment A_3 (Poultry manure @ 5 t ha^{-1} + PPFM @ 1 %) when compared to control A_1 (2.06 t ha^{-1}). Adding amendments reduces the salinity-sodicity stress of plants growing in the amended soil (Chaganti & Crohn, 2015).

Table 2: Impact of amendments and microbial inoculum on growth and yield parameters of African Marigold.

Parameters	A_1	A_2	A_3	A_4	Mean
Plant Height (cm)	20.60 ±0.34	32.50 ±0.88	34.50 ±0.51	31.90 ±0.58	29.88
Diameter of flower (cm)	4.61 ±0.08	4.95 ±0.13	7.84 ±0.12	5.62 ±0.10	5.76
Weight /flower (g)	5.12 ±0.08	7.82 ±0.21	8.02 ±0.12	7.95 ±0.14	7.23
Number of flowers / plants	12.5 ±0.20	19.6 ±0.53	23.4 ±0.34	22.1 ±0.40	19.40
Total flower yield (q/ha)	39.6 ±0.65	54.8 ±1.49	67.6 ±0.99	62.9±1.14	56.23
Biomass (t/ha) at harvest	2.06 ±0.03	3.22 ±0.09	3.57 ±0.05	3.50 ±0.06	3.09

B. Nutrient and salt uptake by Marigold

Macro-nutrient uptake. Ion uptake by marigold at harvest stage was recorded based on the nutrient content and dry matter. Ion uptake gives the amount of nutrient removed by the plants (Table 3.). The N uptake by marigold was found to be higher in the treatment plot amended with Pressmud compost @ 5 t ha^{-1} + CSR BIO @ 35 kg ha^{-1} (A_4) (99.64 kg ha^{-1}), followed by the plot A_3 (98.78 kg ha^{-1}). The pressmud improves the soil nutrient status, owing to which the nitrogen content is high in treatment A_3 (Kumar and Chopra, 2016). The lowest N uptake was recorded in A_1 (Control) with the value 52.78 kg ha^{-1}. The higher amount of P removal was made by the plants in the treatment plot A_4 (Pressmud compost @ 5 t ha^{-1} + CSR BIO @ 35 kg ha^{-1}) (25.22 kg ha^{-1}) and the lowest removal (13.20 kg ha^{-1}) was observed in control plot (A_1). The P uptake found to be very low compared to N uptake. The phosphorus availability is reduced due to poor structured soils resulting in lower concentrations in the biomass (Zoghdan and Ali, 2019). The K uptake was found to be 87.03 kg ha^{-1} in the treatment plot amended with Poultry manure @ 5 t ha^{-1} + PPFM @ 1 % (A_3), which was 47.9% higher than the control plot A_1 (Table 3). The potassium is considered as the limiting nutrient in saline soils which was ameliorated due to the addition organic manures especially poultry manure. It has been found that adding organic manures increased the availability of nutrients such as potassium, nitrogen, and phosphorus. According to Chowdhury *et al*. (2019), soil amendments with farmyard and poultry manure increased rice cultivars' growth, grain and straw yields, K^+/Na^+ ratio, and nutrient uptake under saline conditions, resulting in improved plant salt tolerance.

Table 3: Impact of Phyto-desalination with amendments and microbial inoculum on ion uptake (kg ha^{-1}) by African Marigold at harvest stage.

Parameters	Amendments				
	A_1	A_2	A_3	A_4	Mean
DMP (t ha^{-1})	0.52	0.81	0.89	0.88	0.77
N (kg ha^{-1})	13.20	20.77	24.69	24.91	20.89
P (kg ha^{-1})	3.30	4.66	6.19	6.31	5.11
K (kg ha^{-1})	11.32	18.98	21.76	20.08	18.03
Ca (kg ha^{-1})	14.25	26.86	25.73	26.55	23.34
Mg (kg ha^{-1})	5.13	9.45	11.04	10.59	9.05
Na (kg ha^{-1})	51.32	84.51	99.25	92.64	81.93
Cl (kg ha^{-1})	58.65	94.54	106.40	105.87	91.36
SO_4 (kg ha-1)	12.14	19.19	21.68	21.56	18.64

Note: A_1 – Control, **A_2 –**50 % Gypsum requirement, **A_3 –** Poultry manure @ 5 t ha^{-1} + PPFM @ 1 %; **A_4 –** Pressmud compost @ 5 t ha^{-1} + CSR BIO @ 35 kg ha^{-1}.

C. Calcium, Magnesium, Sodium, Sulphate and Chloride Uptake

The secondary nutrients, calcium, magnesium and sulphur uptake was also recorded and given in the Table 3. The calcium uptake was 46.9% and 46.3 % higher in the treatments A_2 and A_4 respectively, than the control A_1 (57.00 kg ha^{-1}). Plants under salinity stress require a high Ca^{2+} concentration to continue growth (Hadi and Karimi, 2012). The marigold plants in the treatment amended with 50% Gypsum requirement has removed 102.91 kg ha^{-1} of calcium from the soil. The magnesium uptake was found to be higher than calcium and sulphur uptake. The link between salinity and ion uptake, on the other hand, is complicated. There may be an increase or decrease in uptake or salinity may have no effect on the plant's microelement content. The Mg (44.150 kg ha^{-1}) and SO_4^- (86.71 kg ha^{-1}) uptake was found to be higher in A_3 (Poultry manure @ 5 t ha^{-1} + PPFM @ 1 %). The Na and Cl uptake were found to be 53.4% and 49.5% higher in the treatment plot amended with Poultry manure @ 5 t ha^{-1} + PPFM @ 1% (A_3) than the control (A_1) (Table 3).

CONCLUSION

The Alternative water sources usually have a lot of salt in them, this leads to development of salinity that threatens the survival of various plants. Organic amendment application releases acids during decomposition and help in reducing the salinity stress and improves crop growth. In this study it is evident that application of organic amendments increased the biomass by 73.3% and flower yield by 69.9 %. It also helps in uptake of essential nutrients like Ca^+ and K^+ which is generally unavailable in saline and sodic soils. Hence the application of organic amendments has significant effect on cultivation of marigold under paper and pulp mill effluent irrigated soil.

Acknowledgement. The authors are thankful to Department of Environmental Sciences, Tamil Nadu Agricultural University, Coimbatore, India for providing us necessary facilities to undertake the study

Conflict of Interest. None.

REFERENCES

Abdel-Fattah, M. K. (2012). Role of gypsum and compost in reclaiming saline-sodic soils. *J. Agric. Vet. Sci*, *1*(3), 30-38.

Balusamy, A., Udayasoorian, C., Shanmugam, T. R., Jayabalakrishnan, R. M., & Vinoth Kumar, K. (2013). Environmental and Socio-Economic Impact of Treated Paper Mill Effluent Irrigation in Karur District of Tamil Nadu. *Madras Agricultural Journal*, *100*, 336–342.

Chaganti, V. N., & Crohn, D. M. (2015). Evaluating the relative contribution of physiochemical and biological factors in ameliorating a saline–sodic soil amended with composts and biochar and leached with reclaimed water. *Geoderma*, *259*: 45-55.

Chowdhury, S., Bhusan, D., Hashem, M. A., & Hoque, M. A. (2019). Organic amendments for mitigating soil salinity in rice. Research in Agriculture Livestock and Fisheries, *6*(1): 11-17.

Chrysargyris, A., Tzionis, A., Xylia, P., & Tzortzakis, N. (2018). Effects of salinity on tagetes growth, physiology, and shelf life of edible flowers stored in passive modified atmosphere packaging or treated with ethanol. Frontiers in plant science, *9*: 1765.

Goss, M. J., Tubeileh, A., & Goorahoo, D. (2013). A review of the use of organic amendments and the risk to human health. *Advances in agronomy*, *120*: 275-379.

Hadi, M. R., & Karimi, N. (2012). The role of calcium in plants' salt tolerance. *Journal of plant nutrition*, *35*(13): 2037-2054.

Jamali, M. F., Jamali, F. A., Miano, T. F., Abbasi, Z. A., Otho, S. A., Talpur, K. H., & Jakhro, M. I. (2021). Growth and Flowering Response of Marigold (Tagetes erecta) to Salt Stress. *Pakistan Journal of Agricultural Research*, *34*(4), 792.

Kumar, V., & Chopra, A. K. (2012). Effects of paper mill effluent irrigation on agronomical characteristics of Vigna radiata (L.) in two different seasons. *Communications in soil science and plant analysis*, *43*(16): 2142-2166.

Kumar, V., & Chopra, A. K. (2016). Effects of sugarcane pressmud on agronomical characteristics of hybrid cultivar of eggplant (*Solanum melongena* L.) under field conditions. *International Journal of Recycling of Organic Waste in Agriculture*, *5*(2), 149-162.

Kumar, V., Chopra, A. K., Pathak, C., & Pathak, S. (2010). Agro-potentiality of paper mill effluent on the characteristics of Trigonella foenum-graecum L. (Fenugreek). *New York Science Journal*, *3*(5): 68-77.

Lastiri-Hernández, M. A., Álvarez-Bernal, D., Ochoa-Estrada, S., & Contreras-Ramos, S. M. (2020). Potential of Bacopa monnieri (L.) Wettst and Sesuvium verrucosum Raf. as an agronomic management alternative to recover the productivity of saline soils. *International Journal of Phytoremediation*, *22*(4): 343-352.

Moseki, B., & Buru, J. C. (2010). Ionic and water relations of *Sesuvium portulacastrum* (L.). *Scientific Research and Essays*, *5*(1): 35-40.

Munns, R. tester M., 2008. *Mechanisms of salinity tolerance. annual Review of Plant biology*, *59*, 651-681.

Musavi, F., Lak, S., Shokuhfar, A., & Modhaj, A. (2015). Evaluation of sugarcane (Saccharum officinarum L.) different genotypes to the uptake and transport of ionic in salt stress conditions. *In Biological Forum - An International Journal*, *7*(1): 1719-1724.

Niamat, B., Naveed, M., Ahmad, Z., Yaseen, M., Ditta, A., Mustafa, A., & Xu, M. (2019). Calcium-enriched animal manure alleviates the adverse effects of salt stress on growth, physiology and nutrients homeostasis of Zea mays L. *Plants*, *8*(11): 480.

Rasouli, F., Pouya, A. K., & Karimian, N. (2013). Wheat yield and physico-chemical properties of a sodic soil from semi-arid area of Iran as affected by applied gypsum. *Geoderma*, *193*: 246-255.

Rezende, A. A. P., De Matos, A. T., Silva, C. M., & Neves, J. C. L. (2010). Irrigation of eucalyptus plantation using treated bleached Kraft pulp mill effluent. *Water Science and Technology*, *62*(9): 2150-2156.

Riaz, A. T. I. F., Younis, A., Taj, A. R., Karim, A., Tariq, U., Munir, S., & Riaz, S. I. T. W. A. T. (2013). Effect of

drought stress on growth and flowering of marigold (*Tagetes erecta* L.). *Pak. J. Bot*, *45*(S1): 123-131.

Seth, R., Chandra, R., Kumar, N., & Tyagi, A. K. (2005). Utilization of composted sugar industry waste (pressmud) to improve properties of sodic soil for rice cultivation. *Journal of Environmental Science & Engineering*, *47*(3): 212-217

Mucina, L. & Rutherford, M.C. (eds) (2006). The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia 19*. South African National Biodiversity Institute,

Pretoria Sun, Y., Niu, G., Perez, C., Pemberton, H. B., & Altland, J. (2018). Responses of marigold cultivars to saline water irrigation. *HortTechnology*, *28*(2): 166-171.

Sundhari, T., Thilagavathi, T., Baskar, M., Thuvasan, T., & Eazhilkrishna, N. (2018). Effect of gypsum incubated organics used as an amendment for sodic soil in green gram. *Int. J. Chem. Stud*, *6*: 304-308.

Sundhari, T., Thilagavathi, T., Baskar, M., Thuvasan, T., & Eazhilkrishna, N. (2018). Effect of gypsum incubated organics used as an amendment for sodic soil in green gram. *Int. J. Chem. Stud*, *6*: 304-308.

Ximénez-Embún, P., Rodríguez-Sanz, B., Madrid-Albarrán, Y., & Cámara, C. (2002). Uptake of heavy metals by lupin plants in artificially contaminated sand: preliminary results. *International Journal of Environmental & Analytical Chemistry*, *82*(11-12): 805-813.

Zoghdan, M., & Ali, O. (2019). The integrated levels impacts of farmyard manure with phosphorus fertilizers and irrigation on soil properties and wheat productivity under saline soils in North Delta, Egypt. *Journal of Soil Sciences and Agricultural Engineering*, *10*(2): 123-131.

How to cite this article: Ezra John J., P. Thangavel, G. Balasubramanian, T. Kalaiselvi and E. Kokiladevi (2022). Effect of amendments on Growth and Nutrient Uptake of African marigold (*Tagetus erecta*) under Paper and Pulp Mill Effluent Irrigated Soil. *Biological Forum – An International Journal*, *14*(1): 785-789.