Int.J.Curr.Microbiol.App.Sci (2022) *11*(01): 255-265

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 11 Number 01 (2022)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2022.1101.031

Effect of Foliar Application of Nutrients and Plant Growth Regulators on Induction of Post-harvest New Vegetative Flush and on Physiological Behavior in Mango cv. Alphonso

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Keywords

Mangifera indica L, delicious taste, admirable flavour, appealing aroma and attractive colour

Article Info

Received:
08 December 2021
Accepted:
28 December 2021
Available Online:
10 January 2022

A B S T R A C T

The experiment was conducted during the cropping season of 2016-17 and 2017-18 at Department of Horticulture, College of Agriculture, Dapoli, Maharashtra on 35 years old uniform mango (cv. Alphonso) trees with an objective study the effect of nutrients, irrigation and plant growth regulators on induction of post-harvest vegetative flush in mango. In the investigation the physiological behaviour of the mango trees were assessed in relation to influence of nutrients, plant growth regulator sprays and irrigation. Treatments differed significantly for rate of photosynthesis at all stages. Among the treatments the treatment foliar application of 19:19:19 (Foliar grade) 2% with irrigation (T10) recorded highest rate of photosynthesis at bud break stage than control. Treatments differed significantly for rate of transpiration at all stages. The rate of transpiration increased from before bud break stage to flower initiation stage. Among the treatments, foliar application of 19:19:19 (Foliar grade) 2% with irrigation (T10) recorded lowest rate of transpiration at before bud break stage. The highest rate was recorded by control. The rate of stomatal conductance decreased from before bud break stage to flower initiation stage in all the treatments and differ significantly. Among the treatments foliar application of 19:19:19 (Foliar grade) 2% with irrigation (T10) recorded highest rate of stomatal conductance followed by foliar application of GA 100 ppm with irrigation (T11) at before bud break stage. The lowest rate was recorded by control.

Introduction

The mango (*Mangifera indica* L.) is the premier, most celebrated tropical fruit and known as 'King of the fruits' due to its delicious taste, admirable flavour, appealing aroma and attractive colour and other several desirable characters. It is the oldest fruit cultivated in world for over 4000 years. Mango has intimate association with religious, cultural, aesthetic and economical values since from long time and therefore it the national fruit of India. It is the most popular tropical fruit from Anacardiaceae

family originated from South East Asia, the Indo-Burma region.

India has the richest wealth of mango germplasm consisting of more than thousands of varieties growing all over the country. Among the popular cultivars, 'Alphonso' ranks tops and acclaimed as the best Indian mango variety. This cultivar is commercially grown in west coast of India comprising Maharashtra, Goa, Karnataka and Gujarat states.

Lack of environmental signals for mango flowering being a limiting factor for obtaining consistent production especially in Alphonso cultivar. In mango crop, the phenomenon of flowering and fruiting is complex. Davenport and Nunez-Elisea (1997) has described the conceptual model of mango flowering to simplify the interaction of external and internal factors responsible for regulating vegetative and reproductive shoot initiation and induction in mango trees in the tropical and subtropical environments. The flowering in mango is largely influenced by the biochemical constituents present in the floral stimuli at bud break stage. Further, the maturity of terminal shoots and the carbohydrate accumulation in leaves as well as shoot apex are also certainly associated with the synthesis of the floral stimulus in mango trees. The productivity improvement in current farming system is extensively depends on manipulation of the physiological processes of the crop by chemical means. In commercial mango plantations, it is advantageous to induce the post-harvest vegetative growth to attain regular, early and uniform flowering. Plant growth regulator like Gibberellic acid, nutrients like KNO3 19:19:19 (2%) and urea etc. are synthetic compounds normally used to promote and induce the vegetative growth in a desired way without altering the developmental patterns of plants. These plant growth regulators and nutrients alter the physiological processes in plants and gas exchange study can help to assess the response of crop in relation to physiological changes. The present investigation was therefore proposed to study the trend in physiological behaviour (Gas exchange) of mango cv. Alphonso as influenced by sprays of plant growth regulators, nutrients and irrigation.

Materials and Methods

The experiment was conducted during the cropping season of 2016-17 and 2017-18 at Department of Horticulture, College of Agriculture, Dapoli, Maharashtra on 35 years old uniform mango (cv. Alphonso) trees with an objective study the effect of chemicals, irrigation and plant growth regulators on induction of post-harvest vegetative flush in mango.

The experiment was laid out in randomized block design with three replications and twelve treatments viz., T1-Control, T2-Watering twice in a week as per pan evaporation readings, T3-Urea 3%, T4-KNO3 3%, T5-19:19:19 (Foliar grade) 2%, T6-GA3 100 ppm, T7-GA3 150 ppm, T8-Watering + Urea 3%, T9-Watering + KNO3 3%, T10-Watering +19:19:19 (Foliar grade) 2%, T11-Watering + GA3 100 ppm, T12-Watering + GA3 150 ppm. Foliar application of plant growth regulators and nutrients was made at two stages. In the experiment, the foliar application of PGRs and chemicals was done in month of May, first spray- 1st fortnight of May and second spray- 2nd fortnight of May as given in treatment details.

The data on gas exchange parameters viz, rate of photosynthesis and respiration, rate of transpiration and stomatal conductance were recorded at five stages i.e. before exposure of treatments, before bud break stage, bud break stage, at three weeks after flushing and at flower initiation stage.

All these physiological parameters were measured by using artificial light source between 10:00 to 12:00 by portable photosynthesis system (LICOR 6400xt, Loc. Inc. USA) in photon flux density (PFD) value 500 µmol-mol-2 s-1 and using the healthy third or fourth leaf of the mango cv. Alphonso. The experimental data were analysed according the procedure described by Panse and Sukhatme (1985).

Results and Discussion

The data pertaining to various gas exchange parameters viz, rate of photosynthesis and respiration, rate of transpiration and stomatal conductance was recorded at five stages i.e. before exposure of treatments, before bud break stage, bud break stage, at three weeks after flushing and at flower initiation stage in Table 1 to 4.

Rate of leaf photosynthesis

Photosynthesis is fundamental process and photosynthesis rate can be regulated by plant growth regulators by activating secondary messengers that play a crucial role in increasing the enzymatic activity of the plant.

The data presented in Table No.1 indicate that, the effect of foliar feeding of nutrients, plant growth regulators and irrigation on rate of photosynthesis at different stages (before exposure of treatments, before bud break, bud break stage, three weeks after flushing and flower initiation stage) in pooled analysis.

The data in table reveals that rate of photosynthesis was found to be increased from before bud break stage to bud break stage and then declines towards flower initiation stage.

Treatment T10 (Watering +19:19:19(foliar grade) 2%) maintain significantly highest rate of photosynthesis from before bud break stage to flower initiation stage and recorded highest rate of photosynthesis at bud break stage (8.43 µmol CO2 m-2s-1) which was at par with treatment T11 (Watering +GA 100 ppm) 8.29 µmol CO2 m-2s-1.Treatment T8 (Watering + Urea 3 %), T9 (Watering + KNO3 3 %) and T2 (Watering twice in a week as per pan evaporation readings) also recorded higher rate of photosynthesis and at par with each other than T1 (Control) which recorded significantly lower rate of photosynthesis.

The promotion in photosynthesis rate in the trees treated with nutrients and plant growth regulator has been reported by Malshe *et al.*, (2020). The similar results obtained by Leandro *et al.*, (2016). They found that rate of photosynthesis at flowering was higher in plants that receive full irrigation (100%ETc).

Rate of respiration

The data in Table No.2 reveals that rate of respiration was found to be increased from before bud break stage to bud break stage and then declines towards flower initiation stage.

Treatment T10 (Watering +19:19:19(foliar grade) 2%) maintain significantly highest rate of respiration from before bud break stage to flower initiation stage and recorded highest rate of respiration at bud break stage (-6.69 µmol CO2 m-2s-1) which was at par with treatment T11 (Watering +GA 100 ppm) -6.41 µmol CO2 m-2s-1.Treatment T8 (Watering + Urea 3 %), T9 (Watering + KNO3 3 %) and T2 (Watering twice in a week as per pan evaporation readings) also recorded higher rate of respiration and at par with each other than T1 (Control) which recorded lower rate of respiration. The change in respiration rate in the trees treated with nutrients and plant growth regulator has been reported by Malshe *et al.*, (2020).

Urban *et al.*, (2004) opined that the increase in mitochondrial respiration or decrease in partial pressure of carbon dioxide in intercellular space has direct negative influence on photosynthesis rate.

Table. 1 Effect of foliar feeding of nutrients, plant growth regulators and irrigation on rate of photosynthesis (µmole CO_2 m^{-2} Sec^{-1}) at different stages (pooled)

Treatment	Before exposure of treatments	Before bud break	Bud break stage	Three weeks after flushing	Flo initia sta
T_1-Control	2.45	3.83	4.76	4.22	**3.9**
T_2-Watering twice in a week as per pan evaporation readings	2.99	5.41	7.36	6.22	**5.4**
T_3-Urea 3%	2.59	4.91	6.22	5.78	**5.3**
T_4-KNO_3 3%	3.00	4.71	6.13	5.82	**5.2**
T_5-19:19:19 (Foliar grade) 2%	2.97	4.90	6.90	5.89	**5.3**
T_6-GA_3 100 ppm	2.80	5.05	6.61	6.00	**5.3**
T_7-GA_3 150 ppm	2.87	5.14	6.66	5.74	**5.3**
T_8-Watering + Urea 3%	2.98	5.61	7.06	6.76	**6.2**
T_9-Watering + KNO_3 3%	2.75	5.56	7.32	6.52	**6.1**
T_{10}-Watering +19:19:19 (Foliar grade) 2%	2.99	6.80	8.43	7.46	**6.6**
T_{11}-Watering + GA_3 100 ppm	2.94	6.59	8.29	7.32	**6.5**
T_{12}-Watering + GA_3 150 ppm	2.62	5.46	7.11	6.05	**5.7**
Mean	**2.83**	**5.33**	**6.91**	**6.15**	**5.6**
SEm±	0.17	0.25	0.15	0.16	**0.1**
C.D. at 5%	**NS**	**0.73**	**0.44**	**0.47**	**0.3**

Table. 2 Effect of foliar feeding of nutrients, plant growth regulators and irrigation on rate of respiration (µmole CO_2 m^{-2} Sec^{-1}) at different stages (pooled)

Treatment	Before exposure of treatments	Before bud break	Bud break stage	Three weeks after flushing	Flow initial stage
T_1-Control	-2.67	-4.50	-4.80	-3.96	**-3.48**
T_2-Watering twice in a week as per pan evaporation readings	-3.03	-5.41	-5.82	-5.29	**-4.97**
T_3-Urea 3%	-2.92	-5.03	-5.56	-5.17	**-4.49**
T_4-KNO_3 3%	-3.30	-5.23	-5.74	-5.11	**-4.43**
T_5-19:19:19 (Foliar grade) 2%	-3.09	-5.16	-5.73	-5.10	**-4.44**
T_6-GA_3 100 ppm	-3.32	-5.26	-5.72	-5.15	**-4.68**
T_7-GA_3 150 ppm	-3.16	-5.21	-5.67	-5.19	**-4.67**
T_8-Watering + Urea 3%	-3.20	-5.44	-5.79	-5.37	**-4.73**
T_9-Watering + KNO_3 3%	-3.12	-5.51	-5.79	-5.29	**-4.99**
T_{10}-Watering +19:19:19 (Foliar grade) 2%	-3.02	-6.11	-6.69	-5.90	**-5.62**
T_{11}-Watering + GA_3 100 ppm	-3.06	-5.95	-6.41	-5.81	**-5.30**
T_{12}-Watering + GA_3 150 ppm	-2.93	-5.26	-6.02	-5.23	**-4.93**
Mean	**-3.07**	**-5.34**	**-5.82**	**-5.22**	**-4.73**
SEm±	0.14	0.12	0.15	0.10	**0.11**
C.D. at 5%	**NS**	**0.35**	**0.45**	**0.31**	**0.31**

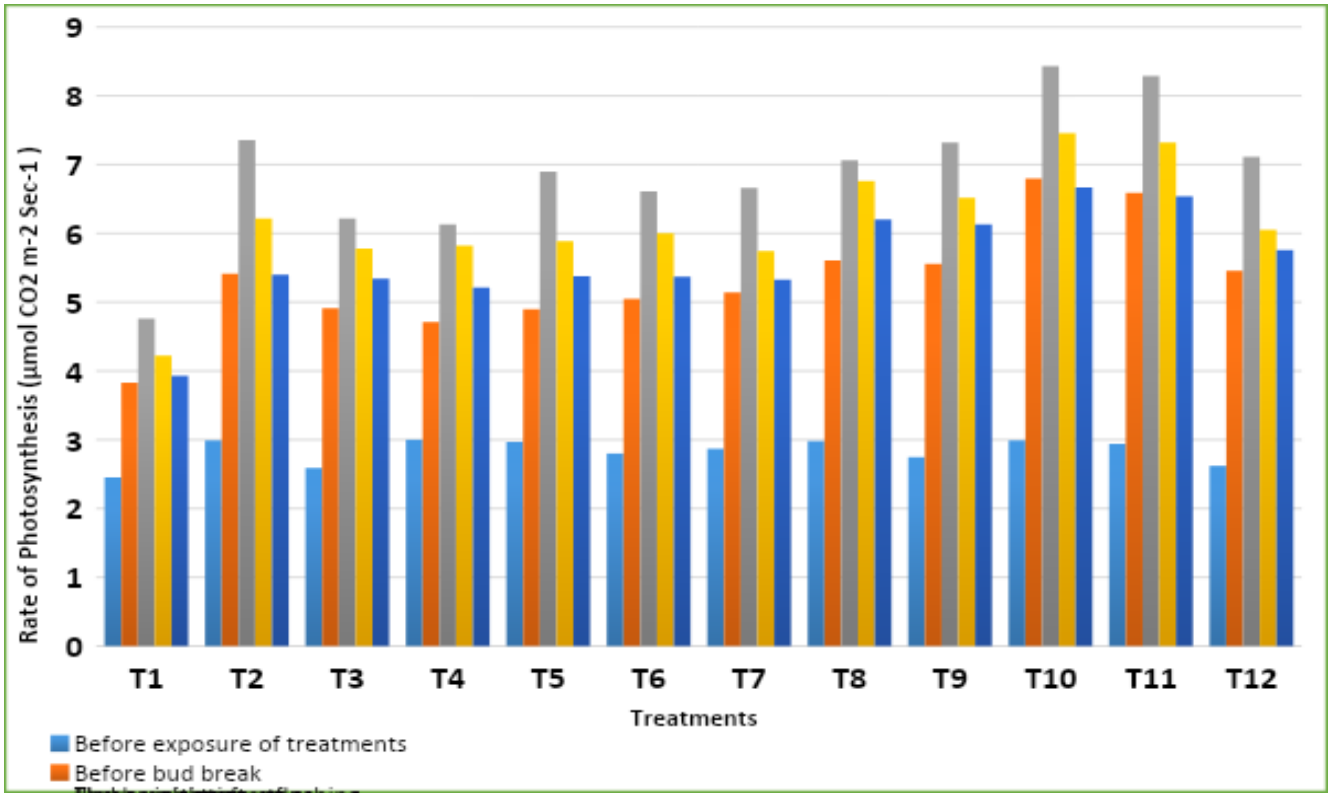
Table. 3 Effect of foliar feeding of nutrients, plant growth regulators and irrigation on rate of transpiration (µmole CO_2 m^{-2} Sec^{-1}) at different stages (pooled)

Treatment	Before exposure of treatments	Before bud break	Bud break stage	Three weeks after flushing	Flower initiatio stage
T_1-Control	2.24	3.83	4.18	4.65	**4.94**
T_2-Watering twice in a week as per pan evaporation readings	2.39	2.75	3.27	3.55	**4.04**
T_3-Urea 3%	2.28	3.21	4.05	4.42	**4.75**
T_4-KNO_3 3%	2.34	3.59	3.84	4.08	**4.56**
T_5-19:19:19 (Foliar grade) 2%	2.22	3.28	3.99	4.19	**4.51**
T_6-GA_3 100 ppm	2.26	3.44	3.93	4.27	**4.40**
T_7-GA_3 150 ppm	2.29	3.57	3.56	4.30	**4.58**
T_8-Watering + Urea 3%	2.42	2.88	3.37	3.41	**4.33**
T_9-Watering + KNO_3 3%	2.32	2.84	3.16	3.71	**4.03**
T_{10}-Watering +19:19:19 (Foliar grade) 2%	2.22	2.52	3.09	3.32	**3.88**
T_{11}-Watering + GA_3 100 ppm	2.30	2.61	3.08	3.38	**3.89**
T_{12}-Watering + GA_3 150 ppm	2.27	3.01	3.40	3.72	**3.92**
Mean	**2.30**	**3.13**	**3.58**	**3.92**	**4.32**
SEm±	0.08	0.11	0.09	0.06	**0.05**
C.D. at 5%	**NS**	**0.33**	**0.26**	**0.19**	**0.16**

Table. 4 Effect of foliar feeding of nutrients, plant growth regulators and irrigation on rate of stomatal conductance (µmole CO_2 m^{-2} Sec^{-1}) at different stages (pooled)

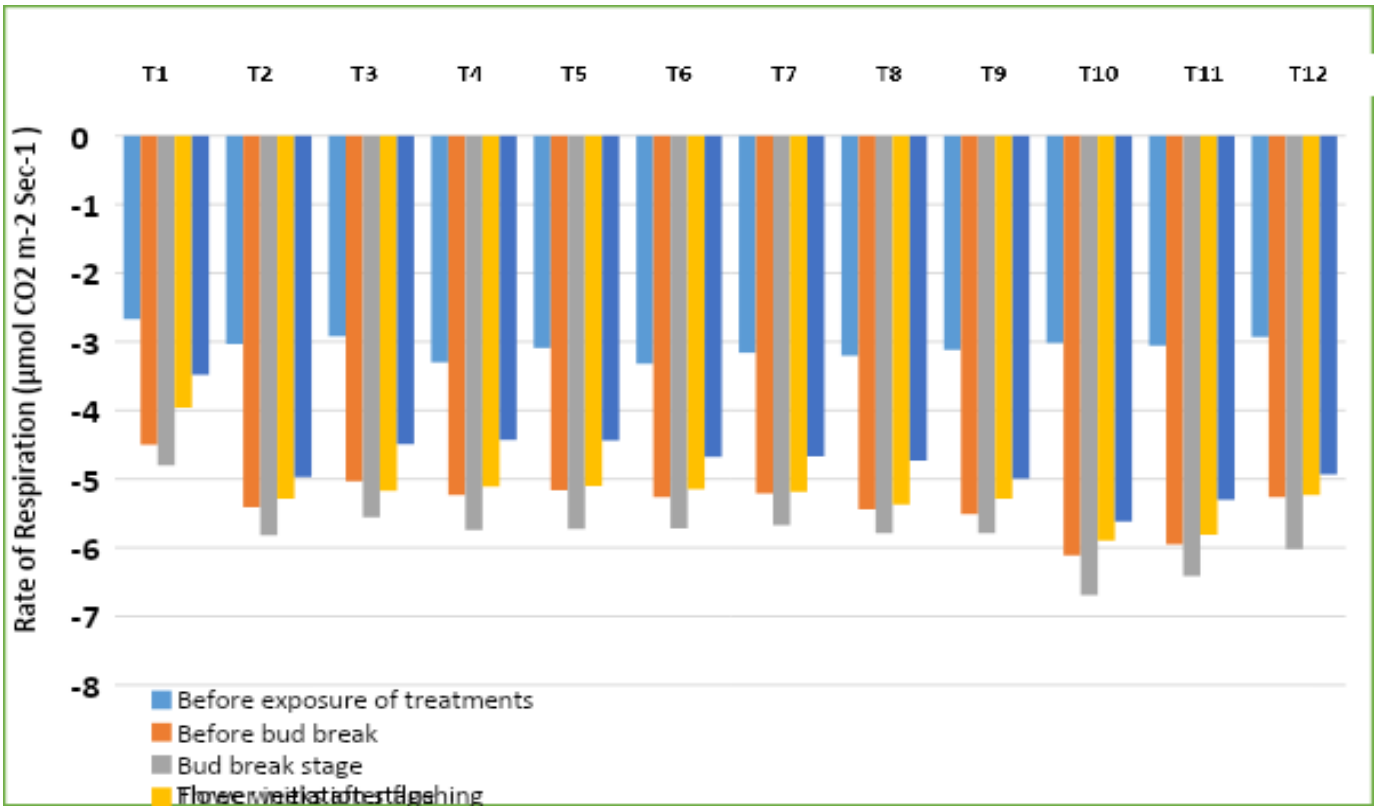
Treatment	Before exposure of treatments	Before bud break	Bud break stage	Three weeks after flushing	Flowe initiati stage
T_1-Control	0.143	0.145	0.124	0.110	**0.095**
T_2-Watering twice in a week as per pan evaporation readings	0.143	0.197	0.146	0.136	**0.129**
T_3-Urea 3%	0.143	0.165	0.133	0.125	**0.119**
T_4-KNO_3 3%	0.144	0.162	0.131	0.121	**0.102**
T_5-19:19:19 (Foliar grade) 2%	0.142	0.165	0.142	0.132	**0.125**
T_6-GA_3 100 ppm	0.143	0.172	0.140	0.131	**0.123**
T_7-GA_3 150 ppm	0.143	0.173	0.142	0.133	**0.127**
T_8-Watering + Urea 3%	0.142	0.177	0.146	0.136	**0.126**
T_9-Watering + KNO_3 3%	0.145	0.177	0.145	0.135	**0.130**
T_{10}-Watering +19:19:19 (Foliar grade) 2%	0.146	0.211	0.170	0.155	**0.146**
T_{11}-Watering + GA_3 100 ppm	0.146	0.210	0.166	0.148	**0.143**
T_{12}-Watering + GA_3 150 ppm	0.148	0.176	0.144	0.133	**0.121**
Mean	**0.144**	**0.180**	**0.140**	**0.130**	**0.120**
SEm±	0.0	0.01	0.00	0.00	**0.00**
C.D. at 5%	**NS**	**0.01**	**0.01**	**0.01**	**0.01**

Fig.1 Effect of foliar feeding of nutrients, plant growth regulators and irrigation on rate of photosynthesis (µmol CO_2 m^{-2} Sec^{-1}) at different stages



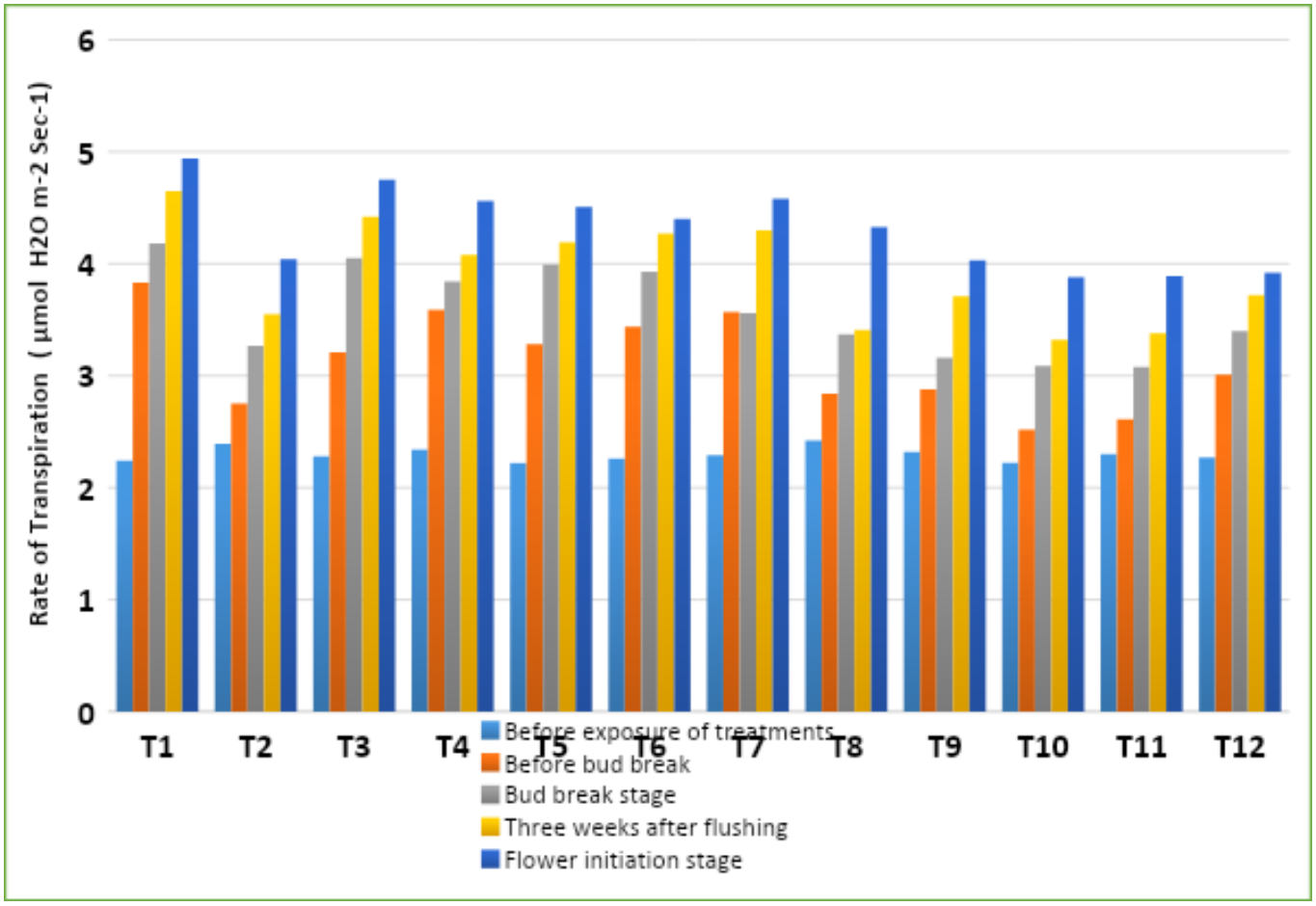
T1-Control
T2-Watering twice in a week as per pan evaporation readings
T3-Urea 3%
T4-KNO3 3%
T5-19:19:19 (Foliar grade) 2%
T6-GA3 100 ppm
T7-GA3 150 ppm
T8-Watering + Urea 3%
T9-Watering + KNO3 3%
T10-Watering +19:19:19 (Foliar grade) 2%
T11-Watering + GA3 100 ppm
T12-Watering + GA3 150 ppm

Fig.2 Effect of foliar feeding of nutrients, plant growth regulators and irrigation on rate of respiration (µmol CO_2 m^{-2} Sec^{-1}) at different stages



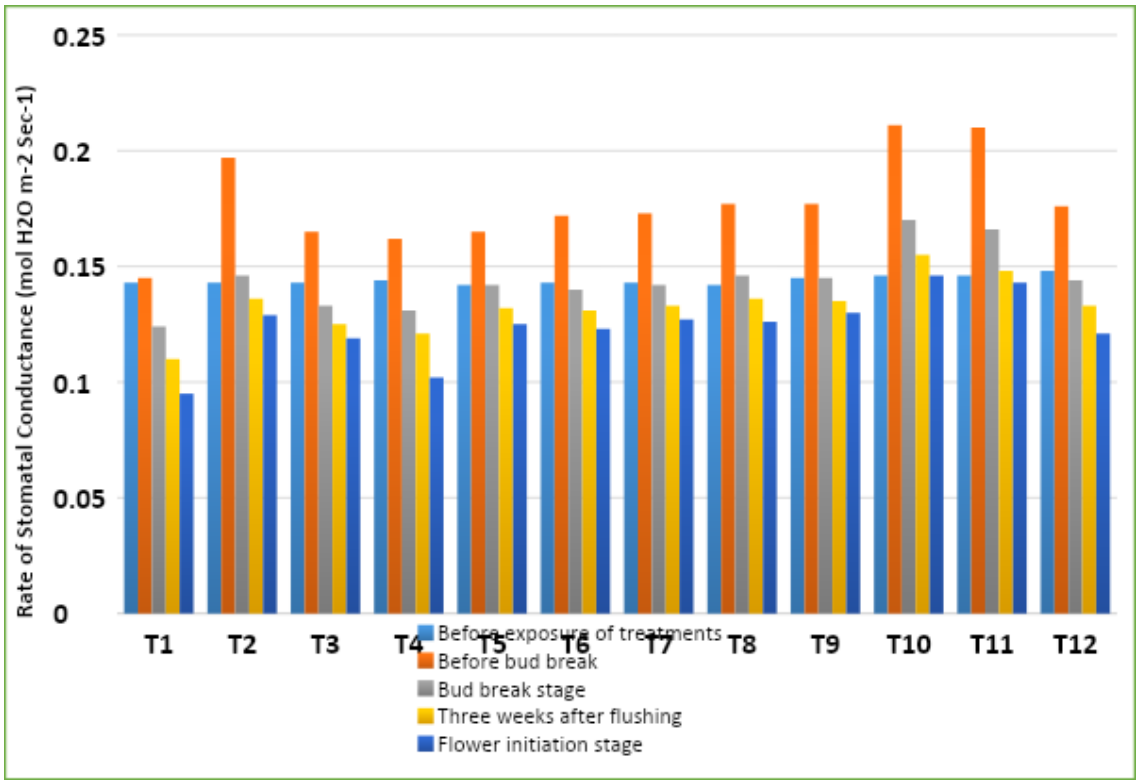
T1-Control
T2-Watering twice in a week as per pan evaporation readings
T3-Urea 3%
T4-KNO3 3%
T5-19:19:19 (Foliar grade) 2%
T6-GA3 100 ppm
T7-GA3 150 ppm
T8-Watering + Urea 3%
T9-Watering + KNO3 3%
T10-Watering +19:19:19 (Foliar grade) 2%
T11-Watering + GA3 100 ppm
T12-Watering + GA3 150 ppm

Fig.3 Effect of foliar feeding of nutrients, plant growth regulators and irrigation on rate of transpiration (µmole H_2O m^{-2} Sec^{-1}) at different stages



T1-Control
T2-Watering twice in a week as per pan evaporation readings
T3-Urea 3%
T4-KNO3 3%
T5-19:19:19 (Foliar grade) 2%
T6-GA3 100 ppm
T7-GA3 150 ppm
T8-Watering + Urea 3%
T9-Watering + KNO3 3%
T10-Watering +19:19:19 (Foliar grade) 2%
T11-Watering + GA3 100 ppm
T12-Watering + GA3 150 ppm

Fig.4 Effect of foliar feeding of nutrients, plant growth regulators and irrigation on rate of Stomatal (mole H_2O m^{-2} Sec^{-1}) at different stages



T1-Control
T2-Watering twice in a week as per pan evaporation readings
T3-Urea 3%
T4-KNO3 3%
T5-19:19:19 (Foliar grade) 2%
T6-GA3 100 ppm
T7-GA3 150 ppm
T8-Watering + Urea 3%
T9-Watering + KNO3 3%
T10-Watering +19:19:19 (Foliar grade) 2%
T11-Watering + GA3 100 ppm
T12-Watering + GA3 150 ppm

Rate of transpiration

The rate of transpiration increased from before bud break stage to flower initiation stage (Table No.3). The treatment T10 (Watering +19:19:19(foliar grade) 2%) maintained significantly lowest rate of transpiration from before bud break stage to flower initiation stage which was at par with treatments T11(Watering + GA 100 ppm), T2 (Watering twice in a week as per pan evaporation readings) and T9 (Watering + KNO3 3 %).Treatment T8 (Watering + Urea 3 %)T12 (Watering + GA 150 ppm) and T3 (Urea 3%) also maintained lowest rate of transpiration and at par with each other. The significantly highest rate of transpiration was recorded by treatment T1 (Control)

At before bud break stage treatment T10 (Watering +19:19:19(foliar grade) 2%) recorded significantly lowest rate of transpiration (2.52 µmole H2O m-2

Sec-1) which was at par with treatment T11 (Watering + GA 100 ppm) 2.61 µmole H2O m-2 Sec-1, T2 (Watering twice in a week as per pan evaporation readings) 2.75 µmole H2O m-2 Sec-1and T9 (Watering + KNO3 3 %) 2.84 µmole H2O m-2 Sec-1. The significantly highest rate of transpiration was recorded by treatment T1 (Control) 3.83 µmole H2O m-2 Sec-1

Stomatal conductance

The rate of stomatal conductance decreased from before bud break stage to flower initiation stage (Table No.4).The treatment T10 (Watering +19:19:19(foliar grade) 2%) maintained significantly highest rate of stomatal conductance from before bud break stage to flower initiation stage which was at par with treatment T11(Watering + GA 100 ppm) at before bud break stage. Treatment T2 (Watering twice in a week as per pan evaporation readings), T9 (Watering + KNO3 3 %), T8 (Watering + Urea 3 %) and T12 (Watering + GA 150 ppm) also maintained highest rate of stomatal conductance. The significantly lowest rate of stomatal conductance was recorded by treatment T1 (Control).

The transpiration and stomatal conductance in any plant cell are the important physiological measures to assess the plant water relationship (Terryl *et al.*, 1989). The stomatal conductance is linked with high leaf temperature and increased transpiration per stomatal conductance unit (Codon *et al.*, 2002).

Rakshe (2011) and Burondkar *et al.*, (2012) studied the transpiration rate and stomatal conductance in mango. Bhalerao (2013) also assessed the stomatal conductance of mango which supported the present findings.

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How to cite this article:

Nageshkumar S. Pachpor, A. K. Shinde, A. V. Mane, S. V. Sawardekar, P. M. Haldankar and Gokhale, N. B. 2022. Effect of Foliar Application of Nutrients and Plant Growth Regulators on Induction of Post-harvest New Vegetative Flush and on Physiological Behavior in Mango cv. Alphonso. *Int.J.Curr.Microbiol.App.Sci.* 11(01): 255-265. doi: https://doi.org/10.20546/ijcmas.2022.1101.031