Biological Forum – An International Journal **14(4a): 56-61(2022)**

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

Effect of Preharvest Foliar Application of Bio-stimulants and Nutrients on improving Yield of Bhagwa Pomegranate under Central Dry Zone of Karnataka

Krithika C.K. [1]***, Sridhar R.***[2*]***, Shivakumar B.S.*** [3]***, Kantharaj Y.***[4] ***and Ganapathi M.***[5]

[1]*PG Scholar, Department of Fruit Science, College of Horticulture, Mudigere (Karnataka), India.*
[2]*Assistant Professor, Department of Fruit Science, College of Horticulture, Hiriyur (Karnataka), India.*
[3]*Professor and Head, Department of Fruit Science, College of Horticulture, Mudigere (Karnataka), India.*
[4]*Assistant Professor, Department of Post Harvest Technology, College of Horticulture, Mudigere (Karnataka), India.*
[5]*Assistant Professor, Department of Crop Physiology and Senior Farm Superintendent ZAHRS,*
College of Horticulture, Mudigere (Karnataka), India.

(Corresponding author: Sridhar R)*
(Received 25 September 2022, Accepted 03 November, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Pomegranate is a high value crop as it is a good source of antioxidants and it has gained more importance in human health. In spite of these good characters, pomegranate production is not increasing as per the expectation due to the various biotic and abiotic stresses. As a fact, foliar application of bio-stimulants and nutrients is an effective strategy employed in fruit crops to induce changes in physiological activities of plant tissues which stimulates stress-induced responses to decrease biotic and abiotic stresses, which are more prevalent in the dry zone thus aiding in increasing the productivity, quality and profitability. In this present study, preharvest foliar spray of methyl jasmonate (0.5 mM and 1 mM), salicylic acid (300 and 500 ppm), kaolin (3% and 6%), calcium chloride (0.2% and 0.4%) and sulphate of potash (0.5% and 0.8%) sprays effects were investigated on yield attributes of pomegranate. Among the different treatments, kaolin at 3% (T_6) was found to be superior with respect to the yield attributes such as fruit length, fruit diameter, fruit volume, rind weight, rind thickness, rind-aril ratio, aril weight per fruit, number of arils per fruit, 100 aril weight per fruit, seed weight, fruit weight, number of fruits per plant, yield, marketable fruits and unmarketable fruits which were on par with salicylic acid (300 ppm) (T_4) compared to control (T_1) for all the above parameters.

Keywords: Pomegranate, Bhagwa, Bio-stimulants, Nutrients, Yield.

INTRODUCTION

Pomegranate (*Punica granatum* L.) belonging to the Lythraceae family has attracted mankind since time immemorial, earlier due to its magical therapeutic use and now due to alluring returns as well as consumer awareness towards its innumerable health benefits. It is one of the favourite dollar earning table fruits of tropical and sub-tropical regions and also the oldest known edible fruit. It can withstand a considerable amount of drought, has versatile adaptability, less gestation period, low maintenance cost, therapeutic values with better keeping quality besides very good export potential. Despite good character, many problems are associated with pomegranate production such as abiotic factors like high temperature, untimely rainfall and severe dry spell, affecting the yield of pomegranate.

Bio-stimulants like be useful for reducing the deteriorating factors acting on stress bearing capacity of the plant, thereby increasing the yield of pomegranate. The application of bio-stimulants not only enhance nutrition efficiency but also provide tolerance against stress condition (Prakash *et al.,* 2022). They play a magnificent role in endogenous hormone production and keeping the level of the hormones in balance. They have a great influence over the up-regulation and down regulation of several genes involved in plant growth and development (Norrie, 2015).

On the other hand, pomegranate production is governed by several factors like soil, climate, irrigation status, varieties, pest and disease situation and nutritional status of the plant. A deficiency of various nutrients causes a drastic reduction in the growth, yield and quality of pomegranate. Hence due importance to nutrients is essential as they affect productivity, quality and profitability. Hegazi *et al.* (2014) referred kaolin as a hydrous aluminosilicate that reduces the adverse effects of heat stress on fruits and leaves and plays an essential role in defense mechanisms against biotic and abiotic stresses thus helping in boosting production. The foliar application of calcium enables the stabilization of cell membranes, as well as acts as a cytoplasmic secondary messenger at the time of plant stress (Davarpanah *et al.*, 2018). Calcium can protect pomegranates from physiological deterioration, delaying maturity and ameliorating the fruit quality (Bonomelli and Ruiz 2010), regulating the plant root water absorption and reducing the cracking in pomegranate (Sharma and Belsare 2011). Potassium is a key element in plant nutrition that maintains innumerable functions within the plant body, such as enzyme activation, osmotic balance, stomatal closure and opening, water uptake, stress relief and photosynthetic transport within the plant (Goud and Kumar 2021). Solhjoo *et al*. (2017) demonstrated the role of potassium in the water regulation of plants and tolerance to environmental stresses such as drought and high and low temperatures is related to the productivity of the trees and the quality of the fruits. Thus, nutrients are known to be vital for fruit yield, which helps in enhancing photosynthetic efficiency. Hence, the main objective of this study was to evaluate the effect of the preharvest application of biostimulants and nutrients on the yield of Bhagwa pomegranate.

MATERIALS AND METHODS

A. Experimental site, plant materials and treatments

The present study was carried out in the farmer's field in Doddaullarthi village, Challakere taluk of Chitradurga district. The experimental site is located in the Central Dry Zone (Zone-IV) of Karnataka. The experiment was laid out in Randomized Block Design, comprising eleven treatments *viz*., T_1 - control, T_2 - methyl jasmonate @ 0.5 mM, T_3 - methyl jasmonate @ 1 mM, T_4 - salicylic acid @ 300 ppm, T_5 - salicylic acid @ 500 ppm, T_6 - kaolin @ 3 %, T_7 - kaolin @ 6 %, T_8 - calcium chloride @ 0.20 %, T_9 - calcium chloride @ 0.40 %, T_{10} - sulphate of potash (SOP) @ 0.50 %, T_{11} - sulphate of potash(SOP) @ 0.80 % with three replications, sprayed at an interval of 30 days at 85, 115, 145 and 175 days after first irrigation. During the summer (April), the highest temperature reached 36.2 °C, while the temperature dropped to 22.7°C. During the cropping period (December 2021 to June 2022), the mean maximum and minimum temperatures recorded were 31.26°C and 18.65°C, respectively. Fruits were harvested in the first picking on 1st week of June, when most of the fruits in the tree were ready for the harvest considering the maturity indices like color change, glossy appearance and on attaining the full size and shape of the fruit. Fruits were harvested in the morning hours. However, five fruits of the representative sample of each treatment were drawn from the harvested fruits of the individual tree. The harvested fruits were placed in plastic crates with proper cushioning and immediately transferred to the laboratory for analytical determinations.

B. Yield attributes

Five fruits from each treatment with the true representation of the individual treatment were selected and used further to determine the fruit morphological characteristics. Fruit length, diameter and rind thickness were measured with the help of digital vernier callipers (Mitutoya Model 500-147). The selected fruits were measured from the base to the tip of the fruit to record the fruit length. The fruit diameter was measured by adjusting the vernier callipers around the horizontal axis. The rind thickness at minimum three points on the fruit rind were noted and the average was taken as rind thickness.The water displacement method was used to determine the fruit volume. Rind, aril, seed and fruit weight were measured with the help of electronic balance (Mettler Toledo-JE303GE). Five fruits from each treatment having true representation of the respective treatment were selected and each fruit was weighed to determine the fruit weight. After peeling the rind from the selected fruits, the rind and aril weight of the individual fruit were weighed and their sum total was averaged to compute the mean rind and aril weight. Arils from the selected fruits were separated from the rind and the total number of arils in each fruit was accounted for. Seed weight was accounted for by crushing the arils from each fruit with the help of muslin cloth from which the seeds were extracted and weighed. The rind to aril ratio was estimated mathematically by dividing the weight of the rind with the weight of the aril and the data obtained was expressed as ratio. The number of fruits per plant were accounted by counting all the fruits in the plant at the stage of establishment and at the time of harvest. The yield per plant was computed by harvesting the total number of fruits from the selected plants and weighing them individually.

C. Marketable and unmarketable fruits

The marketable and unmarketable fruits were distinguished based on their appearance and size. Fruits showing sunburn, cracked appearance, thrips infestation and fruits damaged by bacterial blight incidence were accounted and the fruits which were found to be below consumer level acceptance were considered as unmarketable fruits whereas fruits free from pest and disease incidence with better appearance were considered as marketable fruits and their percentage was computed by dividing with the total number of fruits.

RESULTS AND DISCUSSION

Fruit length, fruit diameter and fruit volume. According to the data given in Table 1, the results concerning fruit size (length, diameter and volume) indicate that different concentrations of bio-stimulants and nutrients influenced the fruit size significantly, whereas the application of kaolin, salicylic acid and SOP had a marked influence in increasing fruit size.

The maximum fruit length, fruit diameter and fruit volume were noted with T_6 - kaolin @ 3 % application (8.73 cm, 8.43 cm and 393.03 cc, respectively), while the minimum fruit length, fruit diameter and fruit volume (6.70 cm, 6.87 cm and 271.88 cc respectively) were recorded in control T_1. Moreover, the results are in parallel with the previous findings of Erez and Glenn (2002) who reported that in many fruits, cell division occurs for a limited period after anthesis and this period seems to be very sensitive to high temperature. Exposure to high temperature leads to a reduction of the number of cell divisions in the developing fruit, thereby possibly reducing the potential fruit size. Reduced fruitlet temperature by the application of kaolin may lead to a longer period of cell division and hence increase the fruit size potential (Abdel-Sattar *et al.*, 2017). In this respect, leaf and fruit temperature were decreased with the application of kaolin at 3 % as reported by Ennab *et al.* (2017) in mandarin. The findings of Harhash *et al.* (2019); Ghanbarpour *et al.* (2018); Hegazi *et al.* (2014) in pomegranate and Ali and Zayat (2019) in orange are in accordance with the results obtained.

Table 1: Effect of bio-stimulants and nutrients on fruit physical characteristics of pomegranate cv. Bhagwa.

Treatments	Fruit length (cm)	Fruit diameter (cm)	Fruit volume (cc)	Rind weight (g)	Rind thickness (mm)	Aril weight per fruit (g)	Rind-aril ratio	Seed weight (g)
T_1 – Control	6.70	6.87	271.88	97.76	2.80	173.38	0.56	29.80
T_2 - Methyl jasmonate @ 0.5 mM	7.97	8.03	338.71	105.05	3.13	219.45	0.48	28.97
T_3 - Methyl jasmonate @ 1 mM	7.60	7.50	293.53	102.46	3.07	208.40	0.49	29.39
T_4 -Salicylic acid @ 300 ppm	8.47	8.30	357.68	110.34	3.40	232.30	0.47	27.19
T_5 - Salicylic acid @ 500 ppm	8.27	8.07	350.71	108.05	3.23	226.06	0.48	28.45
T_6 – Kaolin @ 3 %	8.73	8.43	393.03	119.09	3.53	257.63	0.46	27.08
T_7 - Kaolin @ 6 %	8.30	8.13	351.42	108.42	3.27	227.56	0.48	27.78
T_8 - Calcium Chloride @ 0.20 %	7.33	7.27	280.88	102.34	2.97	202.49	0.51	29.69
T_9 - Calcium Chloride @ 0.40 %	7.93	7.87	311.46	104.24	3.10	213.41	0.49	29.11
T_{10} - SOP @ 0.50 %	8.33	8.20	353.35	108.46	3.33	229.17	0.47	27.39
T_{11} – SOP @ 0.80 %	8.40	8.23	354.96	110.26	3.37	231.53	0.47	27.27
S.Em ±	**0.32**	**0.18**	**1.67**	**1.41**	**0.12**	**1.81**	**0.01**	**0.24**
C.D. @ 5%	**0.93**	**0.54**	**4.93**	**4.15**	**0.36**	**5.34**	**0.02**	**0.70**

Rind weight and Rind thickness. Regarding rind weight and rind thickness, from Table 1 it is clear that foliar application of bio-stimulants and nutrients significantly increased the rind weight and thickness. Spraying kaolin @ 3 % significantly increased the rind weight (119.09 g) and thickness (3.53 mm), which showed on par results with salicylic acid @ 300 ppm in comparison to the rest of the treatments. Increased fruit size and weight directly influenced the weight and thickness of the rind. This may be due to enhanced source to sink relationship in plants and increased uptake of metabolites, ultimately increasing the weight and thickness of the rind. These findings are in conformity with the findings of Abdel-Sattar *et al.* (2017), who reported the increased rind weight in pomegranate with kaolin application. Similarly, increased rind thickness was also reported by Ismail *et al.* (2018) in pomegranate with the application of kaolin 2 %. Also, the application of kaolin particle film increased the peel thickness in orange (Ali and Zayat, 2019) and mandarin (Ennab *et al.,* 2017).

Aril numbers and arils weight per fruit. Kaolin @ 3 % exhibited the most promising results by significantly increasing the number of arils per fruit (Fig. 1) (615.65), aril weight per fruit (257.63 g) and 100 aril weight per fruit (43.89 g). Whereas the minimum results (492.67, 173.38 g, 36.81 g respectively) were noticed in control T_1 (Table 1 and 2). Foliar application of kaolin 3 % showed 32.70 % increase in aril weight per fruit than the untreated fruits. Moreover, the application of salicylic acid @ 300 ppm, SOP at 0.50 % and 0.80% also gave increments in the aril numbers and weight during our study. These findings are similar to the results of El-Rhman (2010); El-Akkad *et al.* (2016); Ismail *et al.* (2018) in pomegranate. Jifon and Syversten (2003) reported that 30 % lower midday photoinhibition of photosynthesis was found in kaolin treated grape fruit leaves than in untreated leaves. Therefore, we can presume that reduced leaf surface temperature and minimum evaporative losses helped in maintaining the optimum microclimate of kaolin sprayed trees enhancing the supply of photosynthates to the fruits leading to increased cell division and thus increasing the number of aril numbers and weight per fruit.

Rind-aril ratio and seed weight. The maximum (0.56) rind to aril ratio was recorded in the T_1 control. It was minimum (0.46) in T_6 - kaolin @ 3 %, with the minimum seed weight (27.08 g). However, the maximum seed weight (29.79 g) was recorded in control T_1. The decrease in rind-aril ratio and seed weight may be due to increased aril weight and reduced rind and seed weight this might be due to the enhanced nutrient availability and reduced evaporative losses leading to better water conductance in the plant system. The findings were in line with that of Ismail *et al.* (2018); El-Rhman (2010) in pomegranate.

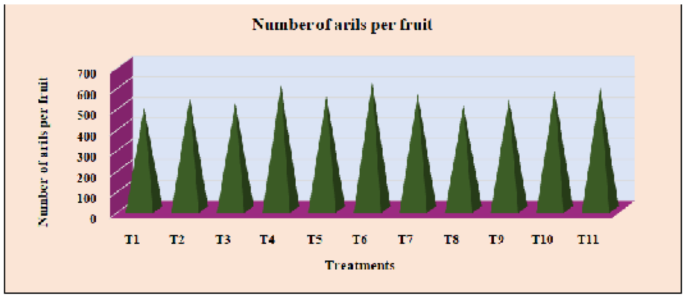

Fig. 1. Effect of bio-stimulants and nutrients number of arils per fruit of pomegranate cv. Bhagwa.

Fruit weight. The data pertaining to the average fruit weight is presented in Table 2. Eight treatments in the present investigation had shown the fruit weight more than 300 g. Fruit weight was increased markedly with T_6 - kaolin @ 3 % (376.37 g) with 28.24 per cent increase compared to control, followed by T_4 - salicylic acid @ 300 ppm (342.90 g). T_4 was found to be on par with T_{11} – SOP @ 0.80 % with fruit weight 341.73 g. From the results, it is obvious that control showed the lowest fruit weight (270.07 g) compared to the treated ones. Ghanbarpour *et al*. (2018) in his study stated that the use of kaolin positively affected the fruit weights due to a reduction in fruit skin temperature by reflecting sunlight, and improving the internal water balance within the fruit, most likely owing to continuous and balanced nutrient availability and uptake throughout the growing season to the plant. Parallel studies of El-Rhman (2010); Ismail *et al.* (2018); Weerakkody *et al.* (2010); El-Akkad *et al.* (2016) in pomegranate, Abd-Allah *et al.* (2013) in mango, Ennab *et al.* (2017) in mandarin and Ali and Zayat (2019) in orange also proved that kaolin has a significant role in increasing fruit weight.

Number of fruits per plant. Pertaining to the results in Table 2 it is evident that all the treatments showed a meliorating increase in the number of fruits per plant. Kaolin at 3 % showed the most positive influence overthe number of fruits per plant (78.33) while control T_1 recorded a minimum number of fruits per plant (64.33). Additionally, the highest increments in number of fruits per plant were also noticed by spraying salicylic acid, SOP, calcium chloride and methyl jasmonate in comparison to the control. Gullo *et al*. (2020) proclaimed that the reflective action of kaolin at the time of flowering, fruit bud differentiation and fruit maturation phase lowered the rind temperature and reduced the flower and fruit bud dropping. Glenn *et al.* (1999) stated that the formation of thin particle film on the fruit surface in kaolin treated fruits inhibited the entry of biotic agents and increased the build-up of photosynthates, thus increasing fruit retention and ultimately increasing the number of fruits. This result agrees with previous observations carried out by Ghanbarpour *et al*. (2018); Hegazi *et al.* (2014) in pomegranate, Gullo*et al*. (2020) in sweet orange, Ali and Zayat (2019) in orange, Zaghloul *et al.* (2017); Ennab *et al.* (2017) in mandarin.

Yield. The results demonstrated in Table 2 made it clear that the foliar application of kaolin, salicylic acid, SOP, calcium chloride and methyl jasmonate significantly increased the yield per plant when compared to the control. Interestingly, the application of kaolin at 3 %reported a yield of 16.19 kg per plant, showing 25.75 % increase when compared to the control (12.02 kg). However, T_4 - salicylic acid @ 300 ppm, showed statistically on par (14.62 kg) results with kaolin which was followed by T_{11} - SOP @ 0.80 %.

Spraying of kaolin also increased fruit yield as per the similar studies of Ismail *et al.* (2018); Hegazi *et al.* (2014) in pomegranate, Gullo *et al.* (2020) in sweet orange and Saour and Makee (2003) in olive, Ali and Zayat (2019) in orange and Ennab *et al.* (2017) in mandarin. Also, Abd-Allah *et al.* (2013) reported that kaolin at 5 % recorded the highest yield per tree in mango during both the seasons. Ergun (2012) documented that kaolin can minimize the fruit damage caused by sunburn because of its reflective influence to ultraviolet light. Moreover, it minimized the leaf and fruit surface temperatures by reflecting ultraviolet and infrared light without affecting the stomatal or photosynthetic conductance (Colavita *et al.*, 2010), which would increase carbon assimilation and supply of carbohydrates aiding in increasing fruit yield as reported by Glenn (2012).

Marketable fruits. It is evident from the data tabulated in Table 2 that T_6 - kaolin @ 3 % recorded the highest percentage of marketable fruits (86.23 %). The minimum percentage of marketable fruits (68.60 %) was registered in control T_1. In a recent investigation, Al-Saif *et al.* (2022) demonstrated that the percentage of marketable fruits considerably increased with the application of kaolin. Ismail *et al.* (2018) stated that kaolin treated fruits were less prone to sunburn damage and fruit cracking resulting in more percentage of marketable fruits. The present investigation is also supported by the findings of Ennab *et al.* (2017) who documented the decreased percentage of sunburned fruits with the application of kaolin at 3 % in mandarin. Glenn *et al.* (1999) in his studies reported that kaolin treated fruits were reported to have more repellency to the penetration of pests and pathogens than untreated ones. In this respect, Braham *et al.* (2007) reported that, kaolin particle film applications successfully protected fruits from medfly infestations and provided long term control from fruit development until harvest compared to insecticide in orange. These positive results of kaolin application were also confirmed with studies of Hegazi *et al.* (2014); Harhash *et al.* (2019) in pomegranate and Cantore *et al.* (2009) in tomato.

Unmarketable fruits. The maximum (28.06 %) percentage of unmarketable fruits was recorded in T_1 control. Whereas, it was minimum (15.10 %) in T_6 kaolin @ 3 %. The results were in confirmation with Saour and Makee *et al.* (2003) who reported that kaolin treated plants gave better quality fruits in olive due to reduced leaf surface temperature and minimum evaporative losses which helped in maintaining the optimum microclimate within the plant at the time of heat stress. Simlarly, Sharma *et al.* (2018) reported enhanced photosynthesis and formation of plant pigments in favour of enhancing marketable quality of the fruits in pomegranate due to which the untreated fruits exhibited poor quality as they showed less tolerance towards the high temperature and were prone to sunburn damage. Glenn *et al.* (1999) in his experiment proved the potentiality of kaolin in the suppression of pests and pathogens by which we can presume that untreated fruits appeared to be below consumer level acceptance thus increasing the percentage of unmarketable fruits. The present study results were also supported by the findings of Ismail *et al.* (2018); Hegazi *et al.* (2014) in pomegranate, Cantore *et al.* (2009) in tomato and Zaghloul *et al.* (2017) in mandarin.

Table 2: Effect of bio-stimulants and nutrients on fruit physical characteristics and yield attributes of pomegranate cv. Bhagwa.

Treatments	Number of arils per fruit	100 aril weight (g)	Fruit weight (g)	No. of fruits per plant	Yield (kg/ plant)	Marketable fruits (%)	Unmarketable fruits (%)
T_1 - Control	492.67	36.81	270.07	64.33	12.02	68.60	28.06
T_2 - Methyl jasmonate @ 0.5 mM	540.13	40.26	306.40	71.33	13.42	78.81	20.75
T_3 - Methyl jasmonate @ 1 mM	514.67	39.29	297.40	68.67	13.14	75.03	22.47
T_4 -Salicylic acid @ 300 ppm	604.59	42.01	342.90	76.33	14.62	83.78	18.25
T_5 - Salicylic acid @ 500 ppm	551.35	40.89	323.57	72.33	13.55	81.30	20.06
T_6 – Kaolin @ 3 %	615.65	43.89	376.37	78.33	16.19	86.23	15.10
T_7 - Kaolin @ 6 %	562.33	41.36	333.27	72.67	13.72	81.41	19.35
T_8 - Calcium Chloride @ 0.20 %	502.31	38.74	293.53	68.33	12.97	73.03	23.40
T_9 - Calcium Chloride @ 0.40 %	535.87	39.38	301.23	69.67	13.21	76.19	21.10
T_{10} - SOP @ 0.50 %	575.14	41.52	335.57	73.67	13.82	81.92	19.15
T_{11} – SOP @ 0.80 %	586.44	41.87	341.73	74.67	14.11	82.09	18.55
S.Em ±	**2.11**	**0.98**	**1.22**	**0.93**	**0.67**	**2.55**	**1.54**
C.D. @ 5%	**6.22**	**2.89**	**3.59**	**2.74**	**1.98**	**7.53**	**4.53**

CONCLUSION

Based on the above results, it can be concluded that kaolin @ 3 % recorded the maximum number of fruits per plant, yield, fruit weight, fruit length, fruit diameter, fruit volume, rind weight, rind thickness, number of arils per fruit, aril weight per fruit, 100 aril weight per fruit, marketable fruits and the minimum rind-aril ratio, seed weight and unmarketable fruits. Hence, the application of kaolin at 3% at an interval of 30 days after first irrigation was found to be effective in increasing the yield and yield attributes of pomegranate and proved to be promising in fetching a better return for the farmers by enhancing the yield in pomegranate *cv.* Bhagwa under Central Dry Zone of Karnataka.

FUTURE SCOPE

— Since, heat stress is evolving as a major constraint in pomegranate production, commercialization of these bio-stimulants and anti-transpirants and bringing them to the knowledge of a common man has to be done due to their efficacy in fighting against abiotic stresses

— Studies on the scheduling of foliar application of bio-stimulants and nutrients at different growth and fruit development stages could be carried out.

Acknowledgment. I extend my heartfelt gratitude to KSNUAHS, Shivamogga, for providing fellowship under the SRP grants and to the College of Horticulture, Mudigere, for providing the facilities to accomplish the present study.

Conflict of Interest. None.

REFERENCES

Abd-Allah, A. S. E., El-Razek, E. A. and Saleh, M. M. S. (2013). Effect of sun-block materials on preventing sunburn injury of Keitt mango fruits. *Journal of Applied Sciences Research*, *9*(1), 567-571.

Abdel-Sattar, M., Eissa, A. M., El-Shazly, S. M. and Alabd, A. S. (2017). Improving quality of Wonderful pomegranate by using bagging and different agrochemical treatments. *Alexandria Journal of Agricultural Sciences*, *62*(1), 103-109.

Ali, M. S. and Zayat, H. E.E (2019). Effect of some biological stimulants and kaolin particles sprays on fruit retention, productivity and fruit quality of Washington Navel orange trees. *Hortscience Journal of Suez Canal University*, *8*(1), 69-78.

Al-Saif, A. M., Mosa, W. F., Saleh, A. A., Ali, M. M., Sas-Paszt, L., Abada, H. S. and Abdel-Sattar, M. (2022). Yield and Fruit Quality Response of Pomegranate (*Punica granatum*) to Foliar Spray of Potassium, Calcium and Kaolin. *Horticulturae*, *8*(10), 946.

Bonomelli, C. and Ruiz, R. (2010). Effects of foliar and soil calcium application on yield and quality of table grape cv.'Thompson Seedless'. *Journal of plant nutrition*, *33*(3), 299-314.

Braham, M., Pasqualini, E. and Ncira, N. (2007). Efficacy of kaolin, spinosad and malathion against *Ceratitis capitata* in Citrus orchards. *Bulletin of insectology*, *60*(1), 39.

Cantore, V., Pace, B. and Albrizio, R. (2009). Kaolin-based particle film technology affects tomato physiology, yield and quality. *Environmental and Experimental Botany*, *66*(2), 279-288.

Colavita, G. M., Blackhall, V. and Valdez, S. (2010). Effect of kaolin particle films on the temperature and solar injury of pear fruits. In *XI International Pear Symposium 909* (pp. 609-615).

El-Akkad, M. M., Gouda, F. E. Z. M. and Ibrahim, R. A. (2016). Effect of GA_3, calcium chloride and vapor guard spraying on yield and fruit quality of Manfalouty pomegranate trees. *Assiut J. Agric. Sci*, *6*(1), 181-190.

El-Rhman, I. E.A. (2010). Physiological studies on cracking phenomena of pomegranates. *J. Appl. Sci. Res*, *6*(6), 696-703.

Ennab, H. A., El-Sayed, S. A. and El-Enin, M. M. S. (2017). Effect of kaolin applications on fruit sunburn, yield and fruit quality of Balady mandarin (*Citrus reticulata*, Blanco). *Menoufia Journal of Plant Production*, *2*(2), 129-138.

Erez, A. and Glenn, D. M. (2002). The effect of particle film technology on yield and fruit quality. In *XXVI International Horticultural Congress: Key Processes in the Growth and Cropping of Deciduous Fruit and Nut Trees*, *636* (pp. 505-508).

Ergun, M. (2012). Postharvest quality of 'Galaxy' apple fruit in response to kaolin-based particle film application. *Journal of Agricultural Science and Technology*, *14*(3), 599-607.

Ghanbarpour, E., Rezaei, M. and Lawson, S. (2019). Reduction of cracking in pomegranate fruit after foliar application of humic acid, calcium-boron and kaolin during water stress. *Erwerbs-obstbau*, *61*(1), 29-37.

Glenn, D. M. (2012). The mechanisms of plant stress mitigation by kaolin-based particle films and applications in horticultural and agricultural crops. *HortScience*, *47*(6), 710-711.

Glenn, D. M., Puterka, G. J., Vanderzwet, T., Byers, R. E. and Feldhake, C. (1999). Hydrophobic particle films: a new paradigm for suppression of arthropod pests and plant diseases. *Journal of Economic Entomology*, *92*(4), 759-771.

Goud, E. L. and Kumar, P. (2021). Responses of Crops to Foliar Application of Calcium and Potassium. *Biological Forum – An International Journal*, *13*(1), 54-60.

Gullo, G., Dattola, A., Vonella, V. and Zappia, R. (2020). Effects of two reflective materials on gas exchange, yield, and fruit quality of sweet orange tree *Citrus sinensis* (L.) Osb. *European Journal of Agronomy*, *118*, 126071.

Harhash, M. M., Ali, M. A., El-Megeed, A. and Ben Hifaa, A. B. (2019). Effect of some growth regulators, nutrient elements and kaolin on cracking and fruit quality of pomegranate 'Wonderful'cultivar. *Journal of the Advances in Agricultural Researches*, *24*(3), 280-297.

Hegazi, A., Samra, N. R., El-Baz, E. E. T., Khalil, B. M. and Gawish, M. S. (2014). Improving Fruit Quality OfManfaloty And Wonderfull Pomegranates by Using Bagging and some Spray Treatments with Gibberellic Acid, Calcium Chloride and Kaolin. *Journal of Plant Production*, *5*(5), 779-792.

Ismail, M. H., Abd-Alhamid, N., Sewrus, E. S. and Nasr, S. (2018). Improving fruit cracking resistance of wonderful pomegranates. *Arab Universities Journal of Agricultural Sciences*, *26*(2), 445-457.

Jifon, J. L. and Syvertsen, J. P. (2003). Kaolin Particle Film Applications Can Increase Photosynthesis and Water Use Efficiency of 'Ruby Red' Grapefruit Leaves. *Journal of the American Society for Horticultural Science*, *128*(1), 107-112.

Norrie, J. (2015). *Ascophyllum nodosum* extracts: Gifts from Poseidon to TheoiGeorgikoi (the Greek gods of agriculture). In *II World Congress on the Use of Biostimulants in Agriculture 1148* (pp. 1-12).

Prakash, A. B., Reddy, G. S., Vardhan, N. H., Bhattacharyya, S. and Bhati K. (2022). Bio-Stimulants- An Overview. *Biological Forum – An International Journal*, *14*(2): 850-856.

Rosati, A., Metcalf, S. G., Buchner, R. P., Fulton, A. E. and Lampinen, B. D. (2007). Effects of kaolin application on light absorption and distribution, radiation use efficiency and photosynthesis of almond and walnut canopies. *Annals of botany*, *99*(2), 255-263.

Saour, G. and Makee, H. (2003). Effects of kaolin particle film on olive fruit yield, oil content and quality. *Advances in Horticultural Science*, 204-206.

Sharma, N. and Belsare, C. (2011). Effect of plant bio-regulators and nutrients on fruit cracking and quality in pomegranate (*Punica granatum* L.)'G-137' in Himachal Pradesh. *Acta horticulturae*, *890*, 347-352.

Sharma, R. R., Datta, S. C. and Varghese, E. (2018). Effect of Surround WP®, a kaolin-based particle film on sunburn, fruit cracking and postharvest quality of 'Kandhari' pomegranates. *Crop Protection*, *114*, 18-22.

Solhjoo, S., Gharaghani, A. and Fallahi, E. (2017). Calcium and potassium foliar sprays affect fruit skin color, quality attributes, and mineral nutrient concentrations of 'Red delicious' apples. *International Journal of Fruit Science*, *17*(4), 358-373.

Weerakkody, P., Jobling, J., Infante, M. M. V. and Rogers, G. (2010). The effect of maturity, sunburn and the application of sunscreens on the internal and external qualities of pomegranate fruit grown in Australia. *Scientia horticulturae*, *124*(1), 57-61.

Zaghloul, A., Ennab, H., and El-Shemy, M. (2017). Influence of kaolin sprays on fruit quality and storability of Balady mandarin. *Alexandria science exchange journal*, *38*(October-December), 661-670.

How to cite this article: Krithika C.K., Sridhar R., Shivakumar B.S., Kantharaj Y. and Ganapathi M. (2022). Effect of Preharvest Foliar Application of Bio-stimulants and Nutrients on improving Yield of Bhagwa Pomegranate under Central Dry Zone of Karnataka. *Biological Forum – An International Journal*, *14*(4a): 56-61.