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Conserving Honey Bees with Forage Plant Mexican Creeper - *Antigonon leptopus*



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# JOURNAL OF HORTICULTURAL SCIENCES

Volume 15

Number 2

December 2020

## CONTENTS

### ***In this Issue***

i-ii

### ***Review***

- Biodiversity of tropical fruits and their conservation in India** 107-126  
Sankaran M. and Dinesh M.R.
- An overview of canopy management in cashew (*Anacardium occidentale* L.)** 127-135  
Adiga D.J., Veena G.L., Thondaiman V. and Babli M.

### ***Original Research in Papers***

- Phenotypic variability for horticultural and fruit quality attributes in plastic house grown tomato** 136-146  
Adeniji O.T., Tenebe A.V., Ishaka A., Jandong E., Adamu J.T., Adekoya M., Zamzam M.A. and Aremu C.A
- Development and evaluation of novel gladiolus hybrid selections IHRG-7 (IC620379) and IHRG-11 (IC620380) for flower quality and *Fusarium* wilt resistance** 147-152  
Rao T.M., Janakiram T., Negi S.S., Aswath C., Dhananjaya M.V., Kumar R. and Ramachandran N.
- Evaluation of potassium salt of phosphonic acid in Nagpur mandarin with special reference to *Phytophthora* management** 153-160  
Ingle Y.V., Paithankar D.H., Sadawarte A.K. and Bhonde S.R.
- Genetic analysis in mango (*Mangifera indica* L.) based on fruit characteristics of 400 genotypes** 161-172  
Sankaran M., Dinesh M.R., Gowda D.C.S. and Venugopalan R.
- Standardization of nitrogen application for potted *Chrysanthemum morifolium* cv. kikiobiory** 173-176  
Tanya Thakur
- Influence of inorganic nutrients on growth, flowering and quality of *Dendrobium* cv. Singapore white** 177-182  
Sujatha A. Nair, Sankar V., Muralidhara, B.M., Awcharae C.M. and Singh D.R.
- Palynological investigations in *Jasminum* spp.** 183-190  
Ganga M., Lakshmi J., Manivannan N. and Rajamani K.



- Effect of putrescine and benzyl adenine on growth, flowering and post-harvest keeping quality parameters in chrysanthemum (*Chrysanthemum morifolium ramat*)** 191-196  
Taranjit Singh and Madhu Bala
- Studies on bioavailability of iron from fe-fortified commercial edible mushroom *Hypsizygusulmarius* and standardization of its delivery system for human nutrition** 197-206  
Pandey M., Gowda N.K.S., Satisha G.C., Azeez S., Chandrashekara C., Zamil M. and Roy T.K.
- Amino acid profile of eighteen isolate of different edible macrofungal species** 207-220  
Azeez S., Pandey M., Jasmin M.R., Rachitha R., Satisha G.C., Roy T.K.  
Chandrashekara C. and Shivashankara K.S.

### **Short Communications**

- A promising new tamarind selection-lakshamana : Linking biodiversity with livelihood** 221-224  
Kanupriya C., Karunakaran G. and Singh P.
- Mexican creeper, *Antigonon leptopus* Hook. and Arn : An effective bee forage plant to conserve honey bee** 225-228  
Rami Reddy P.V.
- First report on honeydew excretion by the melon thrips, *Thrips palmi* karny (Thysanoptera : Thripidae) and its biochemical analysis** 229-232  
Aravintharaj R., Asokan R. and Roy T.K.
- Influence of potting mixture on growth and economics of stone graft of mango cv. alphonso** 233-237  
Lad O.A., Kulkarni M.M., Ragaji S.G., Gavankar M.S., Burondkar M.M., Gokhale N.B.  
Pawar C.D., Khandekar R.G., Kshirsagar P.J. and Desai V.S.

## ***In this issue...***

### ***Hearty New Year Greetings from our Editorial Team to all the readers of JHS!***

*As the world is slowly coming out of glitches of pandemic, there is no other better way than celebrating 2021 as Year of Fruits and Vegetables as announced by United Nations Assembly to welcome the new year and recognize the importance of nutrition for better health. Fruits and Vegetables ensure the Nutritional Security to humankind. They play key role in addressing the malnutrition that is a major concern. We are proud that JHS creatins awareness of importance of fruits and vegetables by publishing the recent developments in research with respect to these crops.*

*Diversity of fruit crops and genetic resources available with respect to fruit crops are important for developing better fruit crop varieties. **Sankaran and Dinesh** have reviewed the “Biodiveristy of Fruit Crops in India” in a very comprehensive way. There is diversity in Jasmine species. **Ganga et al.** carried out the palynological investigations and recorded the variability in pollen morphology in different species of Jasmine by documenting images using scanning electron microscope. Biodiversity can be linked to livelihood also. One such success story with tamarind selection ‘Lakhamna’ is being reported by **Kanupriya et al.** This tamarind selection has been identified from participatory breeding programme. It has a better pod characters and more preferred by consumers.*

*Protected cultivation has seen greater momentum in last two decades. **Adeniji et al.** identified the best varieties of tomato for polyhouse cultivation in Nigeria. **Rao et al.** selected two gladiolus hybrid selections IIHRG-7 and IIHRG-11 with red purple and red coloured flowers respectively. These hybrids have resistance to Fusarium wilt and suitable for cut flower and flower arrangement purposes. **Sankaran et al.** analysed the variance for 6 quantitative and 30 qualitative traits in mango in 400 genotypes and identified 18 clusters. Selected genotypes from specific clusters can be used in hybridization programme.*

*The production aspects are important in perennial crops. It is crop management that needs to be prioritized for enhanced yield. **Adiga et al.** have reviewed the research work carried in “Canopy Management in Cashew”, providing the wholistic view of cultural operations to have a better crop. Use of soilless medium in nursery industry is gaining importance. Best suited potting mixture for mango stone graft of cv. Alphonso has been identified by **Lad et al.** They found that cocopeat + leaf manure + compost (1:1:2) as pot mixture provided better plant growth.*

*Growing Chrysanthemum in pots is practiced in home and terrace gardens. The cultivar Kikiobiory is well suited for this purpose. **Thakur** has studied the nitrogen requirement for this cultivar and has come out with the recommendation of 300 mg of N per pot applied*



twice in September and October in Punjab for best results. In another study, **Singh and Bala** confirmed that use of benzyl adenine at 200 ppm helped in extended vase life of *Chrysanthemum morifolium* flowers. **Nair et al.** recorded that foliar spray of 30:20:20 NPK at weekly interval recorded more number of flowers of *Dendrobium* cv. Singapore White with significantly longer spikes.

Crop production is directly influenced by pollinators. Decline in honey bee population is a serious concern and to conserve the pollinators community approach through ecosystem services is required. **Rami Reddy** reports the benefits of having ornamental plant Mexican Creeper (*Antigonon leptopus*) as forage plant. This creeper attracted all the four species of honey bees studied. This creeper can be used as bioindicator of honey bee population.

**Aravindaraj et al.** have reported the honey dew secretion by *Thrips palmi* and analysed the composition of it. They had identified different sugars present in the honey dew secretion of *Thrips*. *Thrips* not only cause direct damage but act as vectors of many plant viruses. Management of diseases in perennial crops is a challenge. *Phytophthora* incited root infection in citrus needs concerted efforts. **Ingle et al.** have demonstrated that use of potassium salt of phosphonic acid could help in management of *Phytophthora* root rot in Nagpur Mandarin.

Mushrooms can fill the gaps in nutritional security as they are rich in nutritive value. Iron deficiency is important issue to be addressed. Iron fortified oyster mushroom products have been developed by **Pandey et al.** The bioavailability of iron from Arka Mushroom Fe-Fortified Rasam Powder has been confirmed. In another study, the amino acid profile of 18 isolates of oyster mushroom species belonging to 4 species have been documented by **Azeez et al.** Quantification of essential and non-essential amino acids has been reported. Nutritionally superior isolates can be selected from these isolates.

The editorial team of JHS expresses the sincere efforts of reviewers who really complement the publication processes. All scientists and scholars can utilize the open access of JHS. Recently FAO has made JHS available through AGRIS. It is indexed by Redalyc, CABI\_Hort and Scopus. All subscribers, scientists and scholars are requested to continue their support in publishing quality information in **Journal of Horticultural Sciences**.

**S. Sriram**  
Editor in Chief

**Original Research Paper**

## Evaluation of potassium salt of phosphonic acid in Nagpur mandarin with special reference to *Phytophthora* management

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### ABSTRACT

*Phytophthora parasitica* var. *nicotianae* is a major fungal pathogen that causes foot rot, root rot, crown rot, gummosis, leaf fall and brown rot diseases in Nagpur mandarin in the entire Vidarbha region of Maharashtra. For the efficient management of root rot and gummosis due to *Phytophthora*, potassium salt of phosphonic acid (PSPA) was evaluated under field and laboratory conditions. In field trials, infected plants were treated with different concentration of PSPA by foliar spray and soil drenching. The results revealed that foliar spray + soil drenching of PSPA at 3 ml/liter water was better with respect to the average reduction in no. of lesion with oozing (28.39%), minimum in feeder root index (2.17), increase in canopy volume (11.15%) and higher fruit yield (65.89 kg/ per tree). Effect of PSPA was assayed at three different concentrations against *P. nicotianae* under *in vitro*. PSPA was found most effective in arresting growth of *P. nicotianae* as complete (100%) inhibition observed in tested doses.

**Keywords:** Foot rot, Gummosis, Nagpur mandarin, *Phytophthora* and Potassium salt of phosphonic acid (PSPA)

### INTRODUCTION

Mandarins (*Citrus reticulata* Blanco) occupy a place of prime significance among the major fruit crops of India positioning third after mango and banana. They are a good source of vitamin C, as well as several other vitamins, minerals, and antioxidants. As per third advance estimates 2019-20, total land under orange (Mandarin orange/kinnow) cultivation in is 4.79 lakh hectare with production of 63.97 lakh tonnes (Anon., 2020). Major states engaged in orange cultivation are Madhya Pradesh, Punjab, Maharashtra, Rajasthan and Haryana.

*Phytophthora* spp. infect citrus plants at all stages and may infect most parts of the plant, including roots, stem, branches, twigs, leaves and fruits. Root rot, foot rot (also known as “gummosis”, “trunk gummosis” or “collar rot”), fruit brown rot, twig and leaf dieback (often indicated collectively as “canopy blight”) and rot (better known as “damping off”) of seedlings, all incited by *Phytophthora* spp., may be considered diverse faces of the alike disease (Naqvi, 2000). In citrus, gummosis and foot rot (*Phytophthora*

*parasitica* var. *nicotianae*) is reported as major constraint to sustain optimum production and it reduces yield by 46 per cent annually (Menge, 1993). It is responsible for 10-30 per cent yield loss in citrus cultivation around the world (Timmer *et al.*, 2000). The disease is also reported to pose a serious problem in mandarin grown in on large scale in Vidarbha region of Maharashtra (Naqvi, 2003). The severity of the disease is higher during monsoon season. Integrated disease management package that incorporates fungicides, biocontrol agents and organic amendments is required. Number of workers (Thind *et al.*, 2004; Gade *et al.*, 2005; Kaur *et al.*, 2009; Jagtap *et al.*, 2012; and Singh *et al.*, 2015) used contact and systemic fungicides and bioagents for management of root rot/gummosis disease due to *Phytophthora* in citrus crops. Use of conventional fungicides can moderate the problem up to some level but cannot eliminate it; moreover, there are chances of resistance risk in the pathogen due to the use of systemic chemicals.



Potassium salt of phosphonic acid is chemically known as potassium phosphonate ( $H_3PO_3$ ). The dynamic component of this chemical within plants is phosphonate (phosphate) or phosphonic acid which is the active constituent working against the plant pathogen (Fenn and Coffey, 1987; Dunhill, 1990 and Guest and Grant, 1991). PSPA possess significant symplastic ambimobility or movement in both xylem and phloem (acropetally and basipetally). Translocation in phloem allows the chemical to move from leaf tissues to the crowns and roots (Ouimette and Coffey, 1990). Confirmation from histological and biochemical studies prove that PSPA application increases level of host resistance to pathogen invasion (Jackson *et al.*, 2000 and Daniel and Guest, 2006). Previously in India, effectiveness of PSPA against foot rot of black pepper incited by *Phytophthora capsici* (Lokesh *et al.*, 2012) and nut rot disease in areca nut (*Phytophthora arecaea*) have been evaluated (Hegde, 2015) and was found effective.

**Table 1. Treatment details**

Sl. No.	Treatments	Dose (ml/ L of water)
1	Foliar spray of PSPA	02
2	Foliar spray of PSPA	03
3	Foliar spray of PSPA	04
4	Soil drenching of PSPA	02
5	Soil drenching of PSPA	03
6	Soil drenching of PSPA	04
7	Foliar spray+Soil drenching of PSPA	03 + 03
8	Foliar spray of Fosetyl -Al	02 g
9	Absolute control	-

First foliar spray and soil drenching was given in September and succeeding second application at one-month interval (October)

However, there is lack of information on use of PSPA for management of the *Phytophthora* root rot and gummosis disease in Nagpur mandarin. Therefore, an effort was made to explore the efficacy of PSPA in managing *Phytophthora* root rot and gummosis disease of Nagpur mandarin in the endemic region of Vidarbha in Maharashtra.

## MATERIALS AND METHODS

The research trial was conducted on Nagpur mandarin at Dr. PDKV, Akola in randomized block

design with nine treatments and three replicates. Application of respective potassium salt of phosphonic acid (PSPA) (trade name Sanchar 40) was given in one-month interval during September and October 2018. Fosetyl - Al @ 0.2% was used as standard check and (Table 1). Individual dosages were applied at foliar and basin region of plants. The observations on number were lesions with oozing, canopy volume, feeder root rot rating, number of fruits per tree and phytotoxicity were recorded.

Number of oozing lesions was recorded on experimental plants (main stem/side branches) before the application of PSPA and after second application of PSPA. Reduction in oozing lesion measured by using following formula-

$$= (\text{Initial no. of oozing lesion} - \text{Final no. oozing lesions}) / \text{Initial no. of oozing lesion} \times 100$$

The feeder root rating was recorded before the application and after second application of PSPA. The feeder root rotting using scale (1-5) given by Grimm and Hutchinson (1973) and Gade *et al.* (2005) was followed Root scale (1-5): 1= No visible symptoms, 2= A few roots with symptoms (1-25%), 3= Majority of roots with symptoms (26-50%), 4= All roots infected, cortex sloughed from major roots (51-75% rotted), 5= Majority roots dead or missing (>76% rotted). The canopy volume was as per the formula suggested by Westwood (1993) and increase in plant volume calculated as per the formula given below-

$$\text{Increase in canopy volume (\%)} = (\text{Final canopy volume} - \text{Initial canopy volume}) / \text{Initial canopy volume} \times 100.$$

Observations on phytotoxicity symptoms were recorded for all treatments visually as per the guidelines of Central Insecticide Board, Govt. of India on 0–10 scale, 1-1 to 10%, 2-11 to 20%, 3-21-30%, 4-31-40% 5- 41-50% 6-51 to 60%, 7-61 to 70%, 8-71-80%, 9-81-90% and 10-91-100%. Effect on crop health *viz.*, leaf yellowing, tip necrosis, scorching, epinasty and hyponasty etc., were recorded on 0, 1, 3, 5, 7 and 10 days after application of each spray using the following score and per cent effect was worked out as per the method proposed by Nishantha *et al.* (2009).

*In vitro* study was also conducted to know the inhibition of pathogen by poison food technique (Nene



and Thapliyal, 1993). PSPA was added to cornmeal agar at various concentrations A 6 mm diameter agar disk, taken from an actively growing fungal colony on agar without PSPA, was placed with pathogen side downward at the center of the plate (9 cm diameter). Plates were incubated in the incubator at  $25 \pm 1$  °C for ten days. Radial growth of pathogen recorded and per cent inhibition in each treatment was calculated by using formula of Vincent (1927).

Sample of fruits for residue analysis (harvested 3 months after second application) were sent to Pesticides Residue Analysis Laboratory, National Horticultural Research and Development Foundation, Nasik. Residue of PSPA in fruits samples were quantified by utilizing LCMS technique (Saindrean *et al.*, 1985).

The data collected from the experiments were subjected to analysis of variance for different treatments. Fisher's protected critical difference (CD) test was used to indicate the difference between the treatments at the probability level of  $p < 0.01$  following the procedure described by Gomez and Gomez (1984).

## RESULTS AND DISCUSSION

The number of oozing lesions before the first application of PSPA and after second application of one-month interval and final oozing lesions were counted. There were significant differences in the number of oozing lesions in plates treated with PSPA at different concentration of (Taldiz) and Fosetyl- Al. The results revealed that amongst the different treatments, foliar and soil drenching of PSPA @ 3ml/liter at one-month interval significantly reduced the number of oozing lesions (8.75) on tree trunk with enhanced reduction in number of oozing lesions (28.39%). It was on par treatments (T3, T5, T6, T7). Maximum number of oozing lesions was recorded in absolute control (14.04). This clearly indicates that by the application of PSPA through soil or foliar and combinations will reduce no. with oozing lesions from tree trunk. There was high reduction with T7 compared to other treatments (Table 2).

Subsequent to final application (2<sup>nd</sup> foliar and drenching) feeder root rot index (infected and healthy effective roots) observed from the basin of treated plants and was found in the range of 2.17 to 2.97 (Table 2).

**Table 2. Efficacy of potassium salt of phosphonic acid on oozing lesion and feeder root index**

Sl. No.	Treatments	Dose Product (ml/L of water)	Number of Oozing lesion		Reduction in oozing lesion (%)	Feeder root Index	Feeder root index reduction over control (%)
			Initial	Final			
1	Foliar spray of PSPA	02 ml/L	12.18	9.78	19.68	2.33	21.55
2	Foliar spray of PSPA	03 ml/L	11.73	8.98	21.60	2.30	22.56
3	Foliar spray of PSPA	04 ml/L	11.69	8.87	23.27	2.27	23.57
4	Soil drenching of PSPA	02 m/L	12.25	9.90	19.86	2.23	24.91
5	Soil drenching of PSPA	03 ml/L	11.70	8.87	22.64	2.20	25.92
6	Soil drenching of PSPA	04 ml/L	11.67	8.79	23.93	2.20	25.92
7	Foliar spray + Soil drenching of PSPA	03 ml/L + 03 ml/L	12.25	8.75	28.39	2.17	26.93
8	Foliar spray of Fosetyl -Al @ 02 g/L	02 g/L	12.75	10.37	19.30	2.30	22.56
9	Absolute control	—	11.93	14.04	-	2.97	
	SE (m)±		-	0.43		0.12	
	(CD at 5%)		NS	1.29		0.36	

Maximum extreme feeder root rot (2.97) index was recorded in control treatment. Highest per cent reduction (26.93%) in feeder root rot index over control was observed in treatment T7 (Foliar spray + Soil drenching of PSPA @ 3ml/L each) followed by T6 and T5 (25.92%) and T4 (24.91%). The results indicated that concentrations and application methods were able to reduce roots infections of pathogen.

Maximum canopy volume (10.33 m<sup>3</sup>) with an increase by 11.15% was recorded in treatment T7 (Foliar spray + Soil drenching of PSPA @ 3ml/L). Next best array of treatments was T6, T3, T5, and T2 that recorded higher canopy volume 10.17, 9.83, 9.76 and 8.99 m<sup>3</sup>

with increase in canopy volume 7.96, 6.46, 5.63 and 5.19 respectively (Table 3).

The maximum yield of (65.89 kg/tree) was registered in the plots sprayed with Foliar spray + Soil drenching of PSPA @ 3ml/L (T7), which was par with 62.11 kg/tree in the plots soil drenched with PSPA @ 4ml/L (T6), foliar spray of PSPA @ 4ml/L (T3) 60.78 kg/tree and plots drenched with PSPA @ 3ml/L (T5) 59.78 kg/tree (Table 3). Commonly used fungicides and standard check Fosetyl-Al recorded yield 59.33 kg/tree (T8) which was notably lower in compared to PSPA application. The lower yield of 51.11 kg/tree was recorded in the untreated plots (T9) i.e., absolute control.

**Table 3. Efficacy of potassium salt of phosphonic acid on canopy volume and fruit yield**

Sl. No.	Treatments	Dose Product (ml/L of water)	Canopy volume (m <sup>3</sup> )		Increase in canopy volume (%)	Fruit yield (kg/tree)
			Initial	Final		
1	Foliar spray of PSPA	02 ml/L	8.50	8.91	4.82	57.78
2	Foliar spray of PSPA	03 ml/L	8.55	8.99	5.19	59.56
3	Foliar spray of PSPA	04 ml/L	9.23	9.83	6.46	60.78
4	Soil drenching of PSPA	02 ml/L	8.68	9.12	5.03	58.22
5	Soil drenching of PSPA	03 ml/L	9.24	9.76	5.63	59.78
6	Soil drenching of PSPA	04 ml/L	9.42	10.17	7.96	62.11
7	Foliar spray + Soil drenching of PSPA	03 ml/L+ 03 ml/L	9.29	10.33	11.15	65.89
8	Foliar spray of Fosetyl -Al @ 02 g/L	02 g/L	9.35	9.90	5.92	59.33
9	Absolute control	-	8.51	8.56	0.59	51.11
	SE (m)±		-	0.37		2.25
	(CD at 5%)		NS	1.11		6.38

During the course of investigation phytotoxicity symptoms not observed in any of the treatments at respective days of observation.

Efficacy of PSPA at respective concentration was tested *in-vitro* by following poison food technique for mycelial growth of *Phytophthora nicotianae*. After 10 days of inoculation, PSPA was found most effective in arresting complete growth of *P. nicotianae* as complete (100%) inhibition observed in tested doses i.e., 2, 3, and 4 ml/L.

Radial growth of 20.32 mm was recorded in control plate on 10<sup>th</sup> day (Table 4).

Residue examination of treatment T3 (PSPA foliar shower @ 4ml/L) and T7 (Foliar spray + Soil drenching of PSPA @ 3ml/L) was done (Table 5). Treatment T3 recorded 0.329mg/kg residue content in harvested fruits however in treatment T7 recorded 0.666 mg/kg residue PSPA was observed that were below the recomond of 70g/kg level of MRL (according to EU).

**Table 5. Residue analysis of PSPA**

Sl. No.	Treatments doses	Equipment used	LOQ (mg/kg)	Residue content (mg/kg)	Fruits parts used
1	PSPA foliar spray @ 4ml/L	LCMS	0.010	0.329	Fruits with Peel
2	PSPA foliar spray @ 3 ml/L + Soil drenching @ 3 ml/L	LCMS	0.010	0.666	Fruits with Peel

Results demonstrated that application of PSPA significantly reduced the number of oozing lesions compared to chemical fungicide (Fosetyl -Al) at different concentrations. The results were also consistent with feeder root index, increase in canopy volume and fruit yield. Among the different concentrations and application methods of PSPA, two applications of PSPA @ 3ml/L foliar + soil drenching (one month interval) significantly reduced the gummosis symptoms (28.39%) i.e., reductions in number of oozing lesions, reduced feeder root not index (Phytophthora root rot symptoms) (26.93%), increase in canopy volume (11.15%), and higher yield (65.89 kg/tree).

zone Use of PSPA at foliar plant and root challenge the infection adequately and reduce the gummosis and root rot. This had been observed by Hegde and Mesta (2014) who reported that in cocoa, spraying with PSAP @ 6 ml/L and soil drench @ 4 ml/L had reduced the incidence of pod rot caused by (*Phytophthora theobromae*). Lokesh *et al.* (2012) also reported that application of potassium phosphonate @ 0.3 % as spraying and drenching with soil application of *T. harzianum*, @ 50 g/vine along with neem cake (1 kg/vine) to the black pepper vines against *Phytophthora* foot rot served as best treatment when compared to the farmers practice with use of 1 % Bordeaux mixture as spray. Moreover, current results are in agreement with the report of Hegde (2015) where potassium phosphonate effectively protected areca nut plants against nut rot disease incited by (*P. arecae*). Compared to Fosetyl -Al, potassium phosphonate applied as a foliar spray or soil drench reduced stem infection of *Persea indica* seedlings by *Phytophthora citricola* (Fenn and Coffey, 1987). Numerous reports confirm that PSPA is readily absorbed by leaves and roots (Groussol *et al.*, 1986; Schroetter *et al.*, 2006 and Graham, 2011). After application of PSPA on the plant, the chemical gets translocated upwards in the xylem and downwards in the phloem (Guest and

Grant, 1991). Its translocated in the phloem and its distribution is then subjected to normal source sink relationship in the plants. The translocation of phosphonate to different parts of black pepper plant was demonstrated by using radioactive <sup>32</sup>P Kumar *et al.*, 2009). Graham (2011) also experimentally proved that potassium phosphonate is highly systemic rapidly taken up by leaves and to move to fruit and provide protection against citrus brown rot of fruit caused by *Phytophthora palmivora*. In adding together, PSPA treated plants appear to be capable to create an anti-microbial environment more effectively by disrupting pathogen metabolism and triggering their own defense mechanisms (Daniel and Guest, 2006). Niere *et al.* (1994) proposed that the toxicity of PSPA on oomycetes was due to an increased level of inorganic poly-phosphonate, which is known to inhibit key phosphorylation reactions in them. In addition, PSPA also found to alter the nucleotide pools and pentose phosphate metabolism in *Phytophthora citrophthora* (Barchietto *et al.*, 1992).

In present experiment, phytotoxicity symptoms were not visually observed on treated plants in respective concentrations and on respective days of observations. These results are in line with Pilbeam *et al.* (2000) who did not observe any phytotoxicity symptoms in *Eucalyptus* spp. treated with different concentrations of phosphonate. Guest and Grant (1991) observed that PSPA caused minimal toxicity when used at acute concentrations. Foliar sprays of phosphonate can cause phytotoxicity to citrus leaves and rapidly growing fruit later in the season if applied at high rates, at high temperatures, or if the tree is under drought stress (Le Roux, 2000). During the experimentation, congenial conditions prevailed and no phytotoxicity symptoms was observed.

PSPA effectively inhibited *P. nicotianae*. Anti-fungal chemical effects of the PSPA against *Phytophthora* spp. were reported by Cohen and Coffey (1986); Fenn and Coffey (1984); Bompeix *et al.*, 1989), Grant *et al.*, (1990) and Truong *et al.* (2012). Wong (2004)

documented in his *in vitro* studies that phosphonate suppressed the growth rate of *Phytophthora capsici* by hyphal lysis.

Fruits samples with peel subjected for LCMS/MS for determination of PSPA residue and results confirmed that phosphonic acid present in treated plants. PSPA remarkably persistent in plants. Concentrations of PSPA in the fruits can be well below those MRL level (MRL level is 70g/kg of phosphonic acid as per EU).

Present results indicated that foliar sprays and soil drench of PSPA to Nagpur mandarin could be a practicable method of application for *Phytophthora* root rot and gummosis management.

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## AUTHOR INDEX - VOL. 15 ( 1&2) 2020

Name	Page	Name	Page
<b>A</b>			
Adamu, J.T.	136	Gavankar, M. S.	233
Adekoya, M.	136	Gokhale, N. B.	233
Adeniji, O.T.	136	Gowda D. C. S.	161
Aghora T.S.	62	Gowda, N. K. S.	197
Ahamed N.	17	I	
Aravintharaj, R.	229	Ingle Y. V.	153
Aremu, C.A.	136	Ishaka, A.	136
Ashok Kumar J.	45	J	
Asokan, R.	229	Jadhav S.B.	67
Aswath C.	93	Janakiram, T.	147
Aswath, C.	147	Jandong, E.	136
Awcharae, C. M.	177	Jasmin M. R.	207
Azeez, S.	197, 207	Jessy Mol K.K.	52
<b>B</b>			
Babli, M.	127	K	
Bala, M.	191	Kalaivanan D.	9
Bhatt R.M.	62	Kanupriya, C.	221
Bhonde, S. R.	153	Karunakaran, G.	221
Burondkar, M. M.	233	Katwate S.M.	67
<b>C</b>			
Chandran, N. K.	81	Khandekar, R. G.	233
Chandrashekara C.	197, 207	Kshirsagar, P. J.	233
<b>D</b>			
Desai, V. S.	233	Kulkarni, M. M.	233
Dhananjaya, M. V.	147	Kumar D.	17
Dinakara Adiga, J.	127	Kumar, R.	147
Dinesh, M. R.	107, 161	L	
<b>G</b>			
Ganeshamurthy A.N.	9	Lad, O. A.	233
Ganga, M.	183	Lakshmana Reddy D.C	52
		Lakshmi, J.	183
		Laxman R.H.	35
		M	
		Madhavi Reddy K	52
		Manivannan, N.	183
		Manjunath B.L.,	35





<b>Name</b>	<b>Page</b>	<b>Name</b>	<b>Page</b>
Manoj Y.B.	52	Sankar V	177
Meena H.R.	72	Sankaran, M.	107, 161
Mohan N.	62	Satisha G.C.	197, 207
Muralidhara, B. M	177	Shejal A. Porob	97
<b>N</b>		Shilpa Pandurangaiah,	27
Nair A.K.	35	Shivashankar K.S.	27
Negi, S. S.	147	Shivashankara, K. S.	207
<b>P</b>		Singh D. R.	177
Paithankar, D. H.	153	Singh S.R.	17
Pandey, M.	197, 207	Singh, P.	221
Pawar, C. D.	233	Singh, T.	191
Priya Devi S	45, 97	Somasundaram J.	72
<b>R</b>		Sriram S.	81
Rachitha R.	207	Srivastava K.K.	17
Radha T.K.	72	Sudhakar Rao D.V.	27
Ragaji, S. G.	233	Sujatha A. Nair	177
Raghu B.R.	1	Susmita C.	62
Raghupathi H.B.	9	<b>T</b>	
Rajamani, K.	183	Tanya Thakur	173
Rajiv Kumar	93	Tejaswini Prakash	81
Ramachandran, N.	147	Tenebe, A.V.	136
Ramachandrudu K	45	Thangam M	45, 97
Rami Reddy, P. V.	225	Thondaiman, V.	127
Rao, T. M.,	147	<b>V</b>	
Rashmi I.	72	Veena, G.L.	127
Ravishankar K.V	27	Venugopalan, R.	161
Roy, T. K.	197, 207, 229	Vichare S.V	67
Rupa T.R	9	<b>Y</b>	
<b>S</b>		Yousuf S.	17
Sadashiva A.T.	27	<b>Z</b>	
Sadawarte, A. K.	153	Zamil, M.	207
Safeena S.A.	45	Zamzam, M.A.	136

## SUBJECT INDEX - VOL. 15 (1&2) 2020

<b>Name</b>	<b>Page</b>	<b>Name</b>	<b>Page</b>
<b>A</b>			
Alphonso	233	Foot rot	152
Amino acid score	207	Free amino acids	207
Antigonon	225	Fruit development	97
Anti-senescence compound	191	Fruit trees	9
Apis spp	225	Fruit quality	136
Arka Mushroom Rasam	197	Fruit shape	136
<b>B</b>			
B:C ratio	233	Fruit yield	136
Bee flora	225	Fruits	107
Bioavailability	197	Fusarium wilt	147
Biplot analysis	161	<b>G</b>	
Bound amino acids	207	Garden pea	62
Breeding	62	GCV	161
Bulb	67	Genetic diversity	17
<b>C</b>			
Canopy management	127	Genetic analysis	161
Carotene	27	Genetic divergence	45
Carotenoid	27	Genotype by environment	136
CGMS	52	Gerbera	93
Character correlation	136	Germplasm	1, 107
Chrysanthemum	173, 191	GIS	107
Conservation	107	Gladiolus	147
Copper	72	Goa	97
Correlation coefficient	45	Groundwater depletion	9
Curry leaves	1	Growth	67
Cut flower production	177	Growth parameters	233
Cut-flower	93	Gummosis	152
<b>D</b>			
Delayed flowering	191	<b>H</b>	
Dendrobium	177	Heritability	161
Distribution	1	High temperature	62
Diversity	1	Honey bees	225
Drought	9	Honeydew	229
<b>E</b>			
Early summer	62	Hot pepper	52
Evaluation	93, 147	Hybrid	67
Ex situ	107	Hypsizygus ulmarius	197
<b>F</b>			
Flower	67	<b>I</b>	
Flowering	147	In situ	107
		Iron	72
		Iron fortified	197
		<b>J</b>	
		Jasminum spp	183
		<b>K</b>	
		Kikiobiory	173



<b>Name</b>	<b>Page</b>	<b>Name</b>	<b>Page</b>
<b>L</b>			
LC-MS-MS	229	Pruning	127
Leaf analysis	72	Pulp recovery	221
Lycopene	27	<b>Q</b>	
<b>M</b>			
Manganese	72	Quality	177
Mango	161, 233	Quantitative character	45
Marker Assisted Selection	52	<b>R</b>	
Micronutrient deficiency	72	Resistance Gene Analogues (RGA)	81
Mitochondria	52	Rootstocks	127
Morphotypes	1	Rose	81
Mushrooms	197	<b>S</b>	
<b>N</b>			
Nagpur mandarin	152	Sapota	72
Nitrogen	173	Scheduling irrigation	35
Novel hybrids	93	Selection	221
Nucleotide Binding Site-Leucine	81	Single linkage cluster analysis	17
Rich Repeats (NBS-LRR)		Single type tuberose	67
Nutrients	177	Soil volume wetting	35
Nutrition	207	Soilless media	233
<b>O</b>			
Onion	17	Solanum lycopersicum	136
Orchid	177	Spacing	35
ORF	52	Standardization	173
Ornamental creeper	225	Stress tolerance	62
<b>P</b>			
Palynology	183	Sugars	229
Papaya yield	35	<b>T</b>	
PBZ	127	Tamarind	221
PCV	161	Thrips palmi	229
Peak water	9	Tomato	27
Perennial crops	9	Training	127
Phytophthora	152	Tropical	107
Pink types	97	<b>V</b>	
Planting geometry	127	Variability	136
Podosphaera pannosa	81	Varieties	107
Policy issue	9	Vase life	147, 191
Pollen germination	183	Vegetable cowpea	45
Pollen morphology	183	<b>W</b>	
Polyhouse	93, 136	Water use efficiency	35
Potassium salt of phosphonic acid (PSPA)	152	Wax apple	97
Potted plants	173	White types	97
Powdery mildew	81	Wild species	107
Principal component analysis	17	<b>Y</b>	
		Yield	221
		<b>Z</b>	
		Zinc	72



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