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Effect of *Pseudomonas fluorescens* (PBAP-27) and Ferrous Sulphate on Growth and Leaves Nutrient Status of Peach cv. Flordaprince

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Abstract: An experiment was conducted to examine the effect of *Pseudomonas fluorescens* (PBAP-27) and foliar spray of ferrous sulphate on tree height, tree spread, trunk diameter, extension of shoot growth, diameter of shoot and Mn content in leaves of peach cv. Flordaprince. It was laid in a split plot design and the treatments comprised no inoculation (I_0) and inoculation (I_1) of *Pseudomonas fluorescens* (PBAP-27) as main plot along with four levels of foliar spray of ferrous sulphate 0.5%, i.e., F_0 (no spray: water spray), F_1 (single spray), F_2 (two spray), F_3 (three spray) as sub plot treatments. The results obtained from the investigation showed that the inoculation of *Pseudomonas fluorescens* (PBAP-27) and foliar spray of ferrous sulphate significantly increased tree height and canopy spread.

1 Introduction

Peach [*Prunus persica* (L.) Batsch] is one of the major temperate fruit crops of India, and it cultivated in 18.00 thousand ha area with the production of 107.00 thousand tons [1]. Flordaprince is a low chill cultivar requires about 150 hrs. of chilling at or below 7.2 °C [2]. It is one of the most popular peach cultivars in Uttrakhand. Due to continuous growing of crops without Fe replenishment, it is resulting in depletion of available iron levels in soils [3]. Peach suffered to loss of yield and quality of fruit due to iron deficiency [4]. Microbial siderophore helps in enhancing iron availability to plant root [5,6]. Experimental results by Radzki *et al*. (2013) [7] proved the effectiveness of siderophore in providing iron to plants of tomato. The higher fruit yield in pomegranate has reported in pomegranate with the exogenous application of iron [8]. The present investigation were, therefore, undertaken to assess the effect of the inoculation of *Pseudomonas fluorescens* (PBAP-27) and foliar spray of ferrous sulphate on growth and leaves nutrient status of peach cv. Flordaprince.

2 Results

Tree height

The perusal of data contained in table 1 indicated that tree height was significantly affected by inoculation of *Pseudomonas fluorescence* and foliar spray of $FeSO_4.7H_2O$. The interaction between inoculation of *Pseudomonas fluorescence* and foliar spray of $FeSO_4.7H_2O$ also showed significant change in tree height. The inoculation of *Pseudomonas fluorescence* (I_1) resulted a significantly higher increase in plant height (18.50%) over increase observed with no inoculation of the *Pseudomonas fluorescence* (I_0) (14.69%). Foliar spray of $FeSO_4.7H_2O$ showed effect on per cent increase in plant height. The maximum increase in plant height (19.32%) was recorded with three (F_3) foliar spray of $FeSO_4.7H_2O$ 0.5% which was significantly superior over rest other treatments. The minimum increase in plant height (14.30%) was recorded with water spray (F_0). The interaction between inoculation of *Pseudomonas fluorescence* and foliar spray of $FeSO_4.7H_2O$ had a significant effect on per cent increasing in tree height. The highest increase in tree height (22.29%) was recorded with inoculation of *Pseudomonas fluorescence* (I_1) along with three (F_3) foliar spray of $FeSO_4.7H_2O$ 0.5%. The minimum increases in plant height (13.16%) was recorded in the treatment receiving combination of no inoculation of *Pseudomonas fluorescence* (I_0) and water spray (F_0).

Iron is recognized with a specific role in the formation of chlorophyll molecule in plants. This subsequently promotes a higher photosynthetic efficiency and mobilization of nutrients for better growth. Sharma and Johri [10] reported that bacterization of maize seeds with strains GRP3A and PRS9 showed significant increase in plant growth. The increase in growth of chickpea with inoculation of *Pseudomonas fluorescence* has been reported by Rokhzadi *et al*. (2008) [11]. Abadia, 1956 [12] found a close correlation with catalase activity and chlorophyll synthesis when chlorotic pear trees were treated with ferrous sulphate.

Tree spread

Data regarding the tree spread are given in table 1. Tree spread was significantly affected by inoculation of *Pseudomonas fluorescence* and foliar spray of $FeSO_4.7H_2O$. But, the interaction between inoculation of *Pseudomonas fluorescence* and foliar spray of $FeSO_4.7H_2O$ fail to exert significant change in the tree spread. The inoculation of *Pseudomonas fluorescence* (I_1) resulted a significantly higher increase in tree spread (25.23%) over increase observed with no inoculation of the *Pseudomonas fluorescence* (I_0) (19.60%). Among the foliar spray of $FeSO_4.7H_2O$, maximum increase in tree spread (24.21%) was recorded with three (F_3) foliar spray of $FeSO_4.7H_2O$ 0.5% which was *at par* with two (F_2) foliar spray of $FeSO_4.7H_2O$ 0.5% (23.02). The minimum increase in tree spread (20.46%) was recorded with water spray (F_0). A critical observation of data (table 1) revealed that plant spread was significantly influenced by different levels of treatments. Bacterial strain may be modify a plant's hormonal balance, which may affect root growth patterns and, therefore, improve nutrient absorption by increasing absorption area [13]. Radzki *et al*. (2013) [7] found that tomato plant treated with bacterial siderphore showed better growth.

Increase in trunk diameter (%)

The data presented in table 2 indicated that % increase in trunk diameter did not significantly influenced by the inoculation of *Pseudomonas fluorescence* and foliar spray of $FeSO_4.7H_2O$. The interaction between inoculation of *Pseudomonas fluorescence* and foliar spray of $FeSO_4.7H_2O$ also showed non-significant change in trunk diameter during both the years and pooled analysis over the years under investigation. The higher increase in trunk diameter *i.e.,* 3.53% was recorded with no inoculation of *Pseudomonas fluorescence* (I_0). The lower increase in trunk diameter *i.e.,* 3.52% was recorded with the inoculation of *Pseudomonas fluorescence* (I_1). Among the foliar spray of $FeSO_4.7H_2O$ treatments, trunk diameter did not varied significantly during both the years and also in pooled analysis. The maximum increase in trunk diameter (3.88%) with three (F_3) foliar spray of $FeSO_4.7H_2O$ 0.5% were recorded. The minimum increase in trunk diameter *i.e.*, 3.29% was recorded under water spray (F_0).

It is evident from the data that trunk diameter did not significantly influence by inoculation of *Pseudomonas fluorescence* and spray of ferrous sulphate. This might be due to either trunk diameter may be least susceptible to iron deficiency or a sink of photosynthats situated far away from the source *viz.* leaves. As a result the treatment of iron may not able to transfer extra food material to the trunk for increasing more growth.

Extension of shoot growth

Data presented in table 2 indicated that the inoculation of *Pseudomonas fluorescence* (I_1) resulted a significantly higher increase in shoot growth (37.83 cm) over increase observed with no inoculation of the *Pseudomonas fluorescence* (I_0) *i.e.,* (34.02 cm). Data presented in table 2 indicated that foliar spray of $FeSO_4.7H_2O$ showed a significant effect on shoot growth. The maximum increase in shoot growth (39.26 cm) was recorded with three (F_3) foliar spray of $FeSO_4.7H_2O$ 0.5% and minimum increase in shoot growth recorded with water spray *i.e.,* 33.21. It is evident from the data (table 2) that shoot growth increased with the inoculation of *Pseudomonas florescence* and foliar iron spray. Fluorescent pseudomonads strains had significant effect on growth factors [14]. Sharma and Johri (2003) [10] found that maize seeds with GRP3A and PRS9 strains of bacteria showed significant increase in plant growth. Maximum shoot and root length and dry weight were also observed with 10µM Fe^{3+} along with inoculation of bacterial strains. The increase in internal iron content subsequently brought about corresponding increase in chlorophyll contents as well as in the percentage of nitrogen of leaves.

Diameter of shoot (cm)

Data in respect of diameter of shoot presented in table 3 did not significantly influenced by inoculation of *Pseudomonas fluorescence* and foliar spray of $FeSO_4.7H_2O$. The interaction between inoculation of *Pseudomonas fluorescence* and foliar spray of $FeSO_4.7H_2O$ also fail to exert significant change in the diameter of shoot. Diameter of shoots varied from 0.30 to 0.31 cm with microbial inoculation. Among the foliar spray of $FeSO_4.7H_2O$ treatments diameter of shoot did not varied significantly. The maximum diameter of shoot was observed with three (F_3) foliar spray of $FeSO_4.7H_2O$ 0.5% (0.32 cm). This might be due to increase only in shoot length during early age of growth of shoot.

Mn (mg kg^{-1} DW)

Data presented in table 3 indicated that inoculation of *Pseudomonas fluorescence* and foliar spray of $FeSO_4.7H_2O$ significantly affect on manganese content of leaves. The interaction between *Pseudomonas fluorescence* application and foliar spray of $FeSO_4.7H_2O$ was non-significant for manganese content of leaves. The content of manganese decreased with inoculation of *Pseudomonas fluorescence* (I_0). The higher content of manganese (33.70 mg kg^{-1} DW) was recorded with treatment devoid of *Pseudomonas fluorescence* (I_0) over the content recorded with the inoculation of *Pseudomonas fluorescence* (I_1). Foliar application of iron also showed a significant effect on manganese content of leaves. The maximum (35.25 mg kg^{-1} DW) was recorded with foliar spray of water (F_0) whereas, the minimum (28.45 mg kg^{-1} DW) manganese content of leaves was recorded with three (F_3) foliar spray of $FeSO_4.7H_2O$ 0.5%. Iron fertilization resulted noticeable decrease in leaf manganese contents [15].

3 Future Prospects

In future, we would like to broadly focus on study of effects of Pseudomonas florescence on mitigation of peach iron chlorosis.

4 Conclusion

Inoculation of *Pseudomonas fluorescens* (PBAP-27) and foliar spray of ferrous sulphate significantly increased tree height and canopy spread. The application of *Pseudomonas* along with ferrous sulphate is one of the effective solutions to eliminate Fe chlorosis in peach.

5 References

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Table 1 Effect of the inoculation of *Pseudomonas fluorescens* (PBAP-27) and foliar spray of ferrous sulphate on per cent increase in tree height and tree sprea

Foliar spray of Ferrous sulphate (F)	**Inoculation (I)**					
	Per cent increase in tree height			**Per cent increase in tree spread**		
	No inoculation (I_0)	Inoculation of *Pseudomonas fluorescens* (PBAP-27) (I_1)	Mean	No inoculation (I_0)	Inoculation of *Pseudomonas fluorescens* (PBAP-27) (I_1)	Mean
No iron spray (water spray) (F_0)	13.16	15.44	14.30	18.13	22.78	20.46
Foliar spray of Ferrous sulphate (0.5%) once (F_1)	14.07	17.07	15.57	19.32	24.60	21.96
Foliar spray of Ferrous sulphate (0.5%) twice (F_2)	15.19	19.22	17.21	19.50	26.54	23.02
Foliar spray of Ferrous sulphate (0.5%) thrice (F_3)	16.35	22.29	19.32	21.43	27.00	24.21
Mean	14.69	18.50		19.60	25.23	
	S.Em.±	CD at 5%		S.Em.±	CD at 5%	
To compare two I mean	0.33	1.48		0.25	1.14	
To compare two F mean	0.40	1.20		0.39	1.16	
To compare two F mean at a given I	0.56	1.70		0.54	NS	
To compare two I mean, either at a given F or at different F	0.58	2.05		0.52	NS	

Table 2 Effect of the inoculation of *Pseudomonas fluorescens* (PBAP-27) and foliar spray of ferrous sulphate on trunk diameter and extension of shoot growth.

Foliar spray of Ferrous sulphate (F)	Inoculation (I)					
	Per cent increase in trunk diameter			Extension of shoot growth on 20 April		
	No inoculation (I_0)	Inoculation of *Pseudomonas fluorescens* (PBAP-27) (I_1)	Mean	No inoculation (I_0)	Inoculation of *Pseudomonas fluorescens* (PBAP-27) (I_1)	Mean
No iron spray (water spray) (F_0)	3.15	3.42	3.29	32.22	34.20	33.21
Foliar spray of Ferrous sulphate (0.5%) once (F_1)	3.75	3.29	3.52	33.33	37.13	35.23
Foliar spray of Ferrous sulphate (0.5%) twice (F_2)	3.15	3.71	3.43	33.83	38.18	36.00
Foliar spray of Ferrous sulphate (0.5%) thrice (F_3)	4.08	3.67	3.88	36.71	41.80	39.26
Mean	3.53	3.52		34.02	37.83	
	S.Em.±		CD at 5%	S.Em.±		CD at 5%
To compare two I mean	0.07		NS	0.28		1.25
To compare two F mean	0.15		NS	1.23		3.65
To compare two F mean at a given I	0.15		NS	1.70		NS
To compare two I mean, either at a given F or at different F	0.20		NS	1.50		NS

Table 3 Effect of the inoculation of *Pseudomonas fluorescens* (PBAP-27) and foliar spray of ferrous sulphate on diameter of shoot and Mn content in leaves.

Foliar spray of Ferrous sulphate (F)	Inoculation (I)					
	Diameter of shoot (cm)			Mn (mg^{-1} kg DW)		
	No inoculation (I_0)	Inoculation of *Pseudomonas fluorescens* (PBAP-27) (I_1)	Mean	No inoculation (I_0)	Inoculation of *Pseudomonas fluorescens* (PBAP-27) (I_1)	Mean
No iron spray (water spray) (F_0)	0.30	0.31	0.30	36.61	33.88	35.25
Foliar spray of Ferrous sulphate (0.5%) once (F_1)	0.30	0.30	0.30	35.49	30.44	32.97
Foliar spray of Ferrous sulphate (0.5%) twice (F_2)	0.29	0.32	0.30	33.17	28.71	30.94
Foliar spray of Ferrous sulphate (0.5%) thrice (F_3)	0.32	0.32	0.32	29.54	27.37	28.45
Mean	0.30	0.31		33.70	30.10	
	S.Em.±		CD at 5%	S.Em.±		CD at 5%
To compare two I mean	0.004		NS	0.37		1.68
To compare two F mean	0.010		NS	0.49		1.46
To compare two F mean at a given I	0.013		NS	0.68		NS
To compare two I mean, either at a given F or at different F	0.012		NS	0.69		NS