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Effect of different concentrations of IAA, BAP and $ZnSO_4$ on the success percentage of veneer grafting in mango cv. Banganapalli

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Abstract
The present investigation entitled "Effect of different concentrations of IAA, BAP and $ZnSO_4$ on the success percentage of veneer grafting in mango cv. Banganapalli" was conducted at College of Horticulture, Dr. Y.S.R. Horticultural University, Venkataramannagudem, West Godavari District, Andhra Pradesh during 2022-23. There are totally twelve treatments which are replicated thrice Among them, T_{11} (BAP 20 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}) had showed the best results in terms of graft success parameters, including minimum days required for first sprouting (7.00 days), highest number of grafts sprouted (22.00, 23.33, 23.33 and 23.33), graft sprouting (%) (88.00%, 93.33%, 93.33% and 93.33%) and graft success rate (%) (86.67%, 85.33%, 84.00% and 82.67%), survival percentage of graft (86.67%, 85.33%, 84.00% and 82.67%) at 30, 60, 90 and 120 days after grafting respectively compared to other treatments.

Keywords: Banganapalli, veneer grafting, scion dip, IAA, BAP, $ZnSO_4$, days after grafting

Introduction
Mango (*Mangifera indica* L.) belongs to the family Anacardiaceae with chromosome number (2n=40) is considered as the most popular fruit crop in India and it was originated in Indo-Burma region (Mukherjee and Litz, 2009) [9].
Banganapalli is the leading commercial variety of Andhra Pradesh and G.I. Tag given to the Banganapalli variety. The variety possess unique characteristics *i.e.*, when the fruit is fully ripe, the peel has a gleaming golden yellow colour with prominent lenticels and without any blemishes or marks. Pulp is so sweet and firm and has a pleasant and delightful flavour (Rajan and Mishra, 2021) [10]. It is also known as Baneshan in South India and Safeda in North India.
The effect of growth regulators acts as a potential candidate which are involved in grafting process has been well acknowledged. Auxin and cytokinin that plays vital role in vascular system formation during root development and differentiation of vasculature in callus. Cytokinin accumulates in the rootstock and auxins accumulate in the scion portion due to the cutting process that consequently activates the genes associates with wound response and vascular development (Melnyk and Meyerowitz, 2015) [8].
Plant growth regulator (PGR) *i.e.*, Benzyl Amino Purine (BAP) and chemical $ZnSO_4$, applied to the graft union at the time of grafting and pre-treated root stock and scion led to earlier callus development and graft union. (Ikeuchi *et al*. 2013) [5]. Zinc, an important element helpful in maintenance and accumulation of IAA in higher quantity and thereby leading to the formation of xylem in graft union after phloem formation (Masev and Kutacek, 1966) [7].

Material and Methods
The experimental site was located at College of Horticulture, Dr. Y.S.R. Horticultural University, Venkataramannagudem, West Godavari District, Andhra Pradesh. The experiment was laid out in a randomized block design (RBD) comprising of twelve treatment which are replicated thrice *viz.*, T_1: IAA 750 mgl^{-1}, T_2: BAP 10 mgl^{-1}, T_3: BAP 20 mgl^{-1}, T_4: $ZnSO_4$ 500 mgl^{-1}, T_5: $ZnSO_4$ 750 mgl^{-1}, T_6: IAA 750 mgl^{-1} + $ZnSO_4$ 500 mgl^{-1}, T_7: IAA 750 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}, T_8: BAP 10 mgl^{-1} + $ZnSO_4$ 500 mgl^{-1}, T_9: BAP 10 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}, T_{10}: BAP 20 mgl^{-1} + $ZnSO_4$ 500 mgl^{-1}, T_{11}: BAP 20 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}, T_{12}: Control (Without any growth regulator and chemical treatment). The extracted stones were sown immediately in the filled polybags as mango stones loses viability quickly.

The seedlings were allowed to grow till they form pencil size thickness stems and were ready for grafting. Mango var. Banganapalli is selected for scion grafting. Scion was selected from healthy mother trees should possess following characteristics *i.e.,* healthy, mature terminal shoots of more than three months old with plumpy buds. About 12-15 cm long, straight and pencil size bud woods were served as scion from mother trees, leaves were tipped off seven days prior to detachment. The veneer grafting operation were done in fortnight of October at, under shade net (50 per cent).

The cut portion of scion was dipped in a beaker containing freshly prepared solution for few seconds and then it was grafted *i.e.,* 25 grafts per treatment which were kept under shade net (50 per cent). The data on days required for first sprouting, number of grafts sprouted, graft sprouting (%), graft success rate (%) at 30, 60, 90, 120 days after grafting were recorded. The data on various parameters studied during the course of investigation was analysed statistically by applying the procedures of analysis of variance as outlined by Sukhatme and Amble (1985) [11].

Results and Discussion

Days required for first sprouting

The significant differences among the treatments were observed for minimum days required for first sprouting (7.00 days) was recorded in BAP 20 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1} (T_{11}), while, the maximum number of days required for first sprouting (14.59 days) was found in control (without any growth regulator and chemical treatment) (T_{12}) (Table 1).

This might be due to the activation of bud caused by the ample supply of carbohydrates, other food material and defoliation and based on the principle *i.e.,* when photosynthetic unit of shoots are removed, a sink is created in defoliated shoots and the reserved food material from the adjoining shoots get mobilized to the defoliated shoots and they are in position to sprout early (Zimmermann, 1958) [13]. Hartmann (1978) [4] earlier stated that the scion dipped with cytokinin and zinc sulphate produced a sink for carbohydrates which induces the translocation of sugars to the union area. This sink was observed only after callus formation, since accumulation takes place against a concentration gradient as direct action of cytokinin. Zinc plays an important role in metabolism of carbohydrates through sucrose loading and synthase activity (Brown *et al*., 1993) [2]. Hence minimum number of days are needed for first sprouting with increase in concentration of cytokinin and zinc sulphate combination.

Number of grafts sprouted

Among the treatments, significant difference was noticed for the highest number of grafts sprouted (22.00, 23.33, 23.33 and 23.33) was observed in treatment BAP 20 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1} (T_{11}), While, the lowest number of grafts sprouted (16.00, 17.00, 17.00 and 17.00) was observed in control (Without any growth regulator and chemical treatment) (T_{12}) at 30, 60, 90 and 120 days after grafting (Table 2).

Graft sprouting (%)

When scions were treated with BAP 20 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1} (T_{11}) showed highest graft sprouting percentage (88.00%, 93.33%, 93.33% and 93.33%) and lowest graft sprouting percentage (64.00%, 68.00%, 68.00% and 68.00%) was observed in control (T_{12}) at 30, 60, 90 and 120 days after grafting respectively (Table 3).

The number of grafts sprouted and percentage of graft sprouting was more in T_{11} treatment might be due to that fact that application of plant growth regulators and chemicals, which has maintained the balance between sugar and growth substances and also promoted callus formation which ultimately resulted in highest number of grafts sprouted and percentage of graft sprouting.

Graft success rate (%)

The data presented in Table 4 showed that there was a significant difference were noticed in the graft success rate (%). When scions were treated with (T_{11}) (BAP 20 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}) showed maximum graft success rate percentage (86.67%, 85.33%, 84.00% and 82.67%) and minimum graft success rate percentage (62.67%, 61.33%, 60.00% and 60.00%) at 30, 60, 90 and 120 days after grafting respectively was observed in control (T_{12}).

This might be due to cytokinin plays a major role in the differentiation of fibres, vessels and sieve tubes as a limiting and controlling factor for the developmental signalling of the root. Cytokinin stimulates early stages of vascular differentiation and many cell divisions in the differentiating tissue in the presence of auxin (Aloni *et al*., 1990) [1]. The element zinc plays a key role in tryptophan synthesis and leading to increase in the IAA production and also helpful in maintenance and accumulation of IAA in higher quantity and thereby leading to the formation of xylem in graft union after phloem formation (Masev and Kutacek, 1966; LaMotte and Jacobs, 1963; Thompson and Jacobs, 1966) [7, 6, 12].

Survival percentage of graft

When scions were treated with (T_{11}) (BAP 20 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}) showed maximum survival percentage of graft (86.67%, 85.33%, 84.00% and 82.67%) and minimum survival percentage of graft (62.67%, 61.33%, 60.00% and 60.00%) was observed in control (T_{12}) at 30, 60, 90 and 120 days after grafting respectively (Table 5).

This might be due to the vascular connections between the scions-rootstock which was permitted by the production of new xylem and phloem. It is essential that this stage should be accomplished before much leaf development arises from buds on the scion. Otherwise, due to little or no water to offset, the enlarged leaf surfaces on the scion shoots will quickly become desiccated and dies because of transpiration loss. Resulted in low survival rate (Hartmann *et al*., 2002) [3]. Aloni *et al*. (1990) [1] was earlier reported that the high level cytokinin produces quick phloem in presence of low concentration of auxin. Then element zinc plays a key role in increasing tryptophan synthesis and also in maintenance and higher accumulation of IAaA, thereby leading to formation of xylem in graft union after phloem formation (Masev and Kutacek, 1966) [7].

Table 1: Effect of different concentrations of IAA, BAP and $ZnSO_4$ on days required for first sprouting of veneer grafting in mango cv. Banganapalli.

Treatments	Days required for first sprouting
T_1: IAA 750 mgl^{-1}	10.40
T_2: BAP 10 mgl^{-1}	11.73
T_3: BAP 20 mgl^{-1}	9.67
T_4: $ZnSO_4$ 500 mgl^{-1}	8.33
T_5: $ZnSO_4$ 750 mgl^{-1}	7.93
T_6: IAA 750 mgl^{-1} + $ZnSO_4$ 500 mgl^{-1}	11.67
T_7: IAA 750 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}	10.67
T_8: BAP 10 mgl^{-1} + $ZnSO_4$ 500 mgl^{-1}	11.67
T_9: BAP 10 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}	11.17
T_{10}: BAP 20 mgl^{-1} + $ZnSO_4$ 500 mgl^{-1}	7.40
T_{11}: BAP 20 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}	7.00
T_{12}: Control (Without any growth regulator and chemical treatment)	14.59
Mean	10.19
SEm±	1.17
CD at 5%	3.44

Table 2: Effect of different concentrations of IAA, BAP and $ZnSO_4$ on the number of grafts sprouted on veneer grafting in mango cv. Banganapalli.

Treatments	Number of Grafts sprouted			
	30 DAG	60 DAG	90 DAG	120 AG
T_1: IAA 750 mgl^{-1}	20.19 (4.60)	20.67 (4.65)	20.67 (4.65)	20.67 (4.65)
T_2: BAP 10 mgl^{-1}	18.00 (4.36)	20.00 (4.58)	20.00 (4.58)	20.00 (4.58)
T_3: BAP 20 mgl^{-1}	19.67 (4.55)	20.33 (4.62)	20.33 (4.62)	20.33 (4.62)
T_4: $ZnSO_4$ 500 mgl^{-1}	18.67 (4.43)	20.00 (4.58)	20.00 (4.58)	20.00 (4.58)
T_5: $ZnSO_4$ 750 mgl^{-1}	20.00 (4.58)	20.33 (4.62)	20.33 (4.62)	20.33 (4.62)
T_6: IAA 750 mgl^{-1} + $ZnSO_4$ 500 mgl^{-1}	18.00 (4.36)	19.67 (4.55)	19.67 (4.55)	19.67 (4.55)
T_7: IAA 750 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}	19.00 (4.47)	20.33 (4.62)	20.33 (4.62)	20.33 (4.62)
T_8: BAP 10 mgl^{-1} + $ZnSO_4$ 500 mgl^{-1}	20.33 (4.62)	21.00 (4.69)	21.00 (4.69)	21.00 (4.69)
T_9: BAP 10 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}	20.67 (4.65)	21.67 (4.76)	21.67 (4.76)	21.67 (4.76)
T_{10}: BAP 20 mgl^{-1} + $ZnSO_4$ 500 mgl^{-1}	21.33 (4.73)	22.00 (4.80)	22.00 (4.80)	22.00 (4.80)
T_{11}: BAP 20 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}	22.00 (4.80)	23.33 (4.93)	23.33 (4.93)	23.33 (4.93)
T_{12}: Control (Without any growth regulator and chemical treatment)	16.00 (4.12)	17.00 (4.24)	17.00 (4.24)	17.00 (4.24)
Mean	19.49 (4.52)	20.53 (4.64)	20.53 (4.64)	20.53 (4.64)
SEm±	0.06	0.05	0.05	0.05
CD at 5%	0.19	0.14	0.14	0.14

Square root transformation values are mentioned in brackets

Table 3: Effect of different concentrations of IAA, BAP and $ZnSO_4$ on graft sprouting (%) of veneer grafting in mango cv. Banganapalli.

Treatments	Graft sprouting (%)			
	30 DAG	60 DAG	90 DAG	120 DAG
T_1: IAA 750 mgl^{-1}	81.33 (64.48)	82.67 (65.40)	82.67 (65.40)	82.67 (65.40)
T_2: BAP 10 mgl^{-1}	72.00 (58.03)	80.00 (63.41)	80.00 (63.41)	80.00 (63.41)
T_3: BAP 20 mgl^{-1}	78.67 (62.49)	81.33 (64.41)	81.33 (64.41)	81.33 (64.41)
T_4: $ZnSO_4$ 500 mgl^{-1}	74.67 (59.86)	80.00 (63.41)	80.00 (63.41)	80.00 (63.41)
T_5: $ZnSO_4$ 750 mgl^{-1}	80.00 (63.48)	81.33 (64.41)	81.33 (64.41)	81.33 (64.41)
T_6: IAA 750 mgl^{-1} + $ZnSO_4$ 500 mgl^{-1}	72.00 (58.03)	78.67 (62.49)	78.67 (62.49)	78.67 (62.49)
T_7: IAA 750 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}	76.00 (60.64)	81.33 (64.41)	81.33 (64.41)	81.33 (64.41)
T_8: BAP 10 mgl^{-1} + $ZnSO_4$ 500 mgl^{-1}	81.33 (64.41)	84.00 (66.40)	84.00 (66.40)	84.00 (66.40)
T_9: BAP 10 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}	82.67 (65.40)	86.67 (68.60)	86.67 (68.60)	86.67 (68.60)
T_{10}: BAP 20 mgl^{-1} + $ZnSO_4$ 500 mgl^{-1}	85.33 (67.50)	88.00 (69.88)	88.00 (69.88)	88.00 (69.88)
T_{11}: BAP 20 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}	88.00 (69.88)	93.33 (75.17)	93.33 (75.17)	93.33 (75.17)
T_{12}: Control (Without any growth regulator and chemical treatment)	64.00 (53.19)	68.00 (55.62)	68.00 (55.62)	68.00 (55.62)
Mean	78.00 (62.28)	82.11 (65.30)	82.11 (65.30)	82.11 (65.30)
SEm±	1.55	1.31	1.31	1.31
CD at 5%	4.58	3.88	3.88	3.88

Angular transformation values are mentioned in brackets

Table 4: Effect of different concentrations of IAA, BAP and $ZnSO_4$ on graft success rate (%) of veneer grafting in mango cv. Banganapalli.

Treatments	Graft success rate (%)			
	30 DAG	60 DAG	90 DAG	120 DAG
T_1: IAA 750 mgl^{-1}	80.00 (63.48)	78.67 (62.61)	78.67 (62.61)	78.67 (62.61)
T_2: BAP 10 mgl^{-1}	70.67 (57.20)	70.67 (57.20)	69.33 (56.39)	69.33 (56.39)
T_3: BAP 20 mgl^{-1}	77.33 (61.62)	76.00 (60.69)	76.00 (60.69)	76.00 (60.69)
T_4: $ZnSO_4$ 500 mgl^{-1}	73.33 (58.94)	73.33 (58.94)	73.33 (58.94)	73.33 (58.94)
T_5: $ZnSO_4$ 750 mgl^{-1}	78.67 (62.61)	77.33 (61.69)	77.33 (61.69)	77.33 (61.69)
T_6: IAA 750 mgl^{-1} + $ZnSO_4$ 500 mgl^{-1}	70.67 (57.20)	69.33 (56.39)	68.00 (55.56)	68.00 (55.56)
T_7: IAA 750 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}	74.67 (59.77)	73.33 (58.94)	73.33 (58.94)	73.33 (58.94)
T_8: BAP 10 mgl^{-1} + $ZnSO_4$ 500 mgl^{-1}	80.00 (63.48)	78.67 (62.61)	78.67 (62.61)	78.67 (62.61)
T_9: BAP 10 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}	81.33 (64.48)	80.00 (63.48)	80.00 (63.48)	78.67 (62.61)
T_{10}: BAP 20 mgl^{-1} + $ZnSO_4$ 500 mgl^{-1}	84.00 (66.50)	82.67 (65.51)	81.33 (64.59)	80.00 (63.71)
T_{11}: BAP 20 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}	86.67 (68.89)	85.33 (67.96)	84.00 (66.86)	82.67 (65.99)
T_{12}: Control (Without any growth regulator and chemical treatment)	62.67 (52.35)	61.33 (51.57)	60.00 (50.79)	60.00 (50.79)
Mean	76.67 (61.38)	75.56 (60.63)	75.00 (60.26)	74.67 (60.04)
SEm±	1.83	2.15	2.20	2.44
CD at 5%	5.42	6.34	6.51	7.20

Angular transformation values are mentioned in brackets

Table 5. Effect of different concentrations of IAA, BAP and $ZnSO_4$ on the survival percentage of graft of veneer grafting in mango cv. Banganapalli.

Treatments	Survival percentage of graft			
	30 DAG	60 DAG	90 DAG	120 DAG
T_1: IAA 750 mgl^{-1}	80.00 (63.48)	78.67 (62.61)	78.67 (62.61)	78.67 (62.61)
T_2: BAP 10 mgl^{-1}	70.67 (57.20)	70.67 (57.20)	69.33 (56.39)	69.33 (56.39)
T_3: BAP 20 mgl^{-1}	77.33 (61.62)	76.00 (60.69)	76.00 (60.69)	76.00 (60.69)
T_4: $ZnSO_4$ 500 mgl^{-1}	73.33 (58.94)	73.33 (58.94)	73.33 (58.94)	73.33 (58.94)
T_5: $ZnSO_4$ 750 mgl^{-1}	78.67 (62.61)	77.33 (61.69)	77.33 (61.69)	77.33 (61.69)
T_6: IAA 750 mgl^{-1} + $ZnSO_4$ 500 mgl^{-1}	70.67 (57.20)	69.33 (56.39)	68.00 (55.56)	68.00 (55.56)
T_7: IAA 750 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}	74.67 (59.77)	73.33 (58.94)	73.33 (58.94)	73.33 (58.94)
T_8: BAP 10 mgl^{-1} + $ZnSO_4$ 500 mgl^{-1}	80.00 (63.48)	78.67 (62.61)	78.67 (62.61)	78.67 (62.61)
T_9: BAP 10 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}	81.33 (64.48)	80.00 (63.48)	80.00 (63.48)	78.67 (62.61)
T_{10}: BAP 20 mgl^{-1} + $ZnSO_4$ 500 mgl^{-1}	84.00 (66.50)	82.67 (65.51)	81.33 (64.59)	80.00 (63.71)
T_{11}: BAP 20 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1}	86.67 (68.89)	85.33 (67.96)	84.00 (66.86)	82.67 (65.99)
T_{12}: Control (Without any growth regulator and chemical treatment)	62.67 (52.35)	61.33 (51.57)	60.00 (50.79)	60.00 (50.79)
Mean	76.67 (61.38)	75.56 (60.63)	75.00 (60.26)	74.67 (60.04)
SEm±	1.83	2.15	2.20	2.44
CD at 5%	5.42	6.34	6.51	7.20

Angular transformation values are mentioned in brackets

Conclusion

Based on the results obtained in the above investigation it can be concluded that among the treatments, scions were treated with BAP 20 mgl^{-1} + $ZnSO_4$ 750 mgl^{-1} showed the best treatment for minimum days required for first sprouting, number of grafts sprouted, graft sprouting (%), graft success rate (%) and survival percentage of graft.

The $ZnSO_4$ can be used either alone or in combination with BAP to produce healthy and vigorous veneer grafts that have a high success rate in mango.

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