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Effect of rooting media influenced by shoot growth of Ber (*Ziziphus mauritiana* Lamk) cv. Apple ber

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Abstract
The present experiment was conducted in Factorial Completely Randomized Design with three factors at unequal levels and replicated thrice. At 120 days second order interactions between media, IBA concentration and method of application (M×C×A), maximum fresh weight of shoot was (12.45 g) recorded with $M_1C_1A_2$. While, minimum fresh weight of shoot (6.06g) observed in $M_1C_3A_1$. Highest dry weight of shoot (4.22g) was exhibited by $M_1C_1A_2$ which was on par with $M_1C_2A_2$ (4.05 g) while lowest dry weight of shoot was in $M_2C_2A_2$ (1.56 g). Maximum root and shoot ratio (0.23) was with $M_1C_1A_2$ followed by $M_3C_1A_2$ (0.19) while minimum root and shoot ratio (0.07) recorded in $M_1C_2A_1$.

Keywords: Apple ber, shoot fresh weight, shoot dry weight and root and shoot ratio

Introduction
India is bestowed with a varied agro-climate, which is highly favourable for growing a large number of horticultural crops. It has large range of varieties of fruits in its basket and accounts for 10 % of world's total fruit production with an area of 6480 thousand hectares and production of 92846 MT (Anonymous, 2017) [1]. In Indian arid regions having high temperature, low and variable precipitations are spread over about 31.7 million hectares limiting the scope for high horticultural productivity. However these conditions greatly favour development of high quality in number of fruits.
The two most important auxins *i.e*, IBA and NAA have been used widely either singly or in combination for inducing rooting in cuttings of various crop species (Thimann, 1935) [12]. Hence, to find out the survival percentage of apple ber cuttings, the cuttings will be treated with different IBA combinations and will be planted in different rooting media mixtures.

Material and methods
The present investigation entitled "Effect of rooting media and IBA on rhizogenesis and growth of terminal cuttings in Ber (*Ziziphus mauritiana* Lamk) cv. Apple Ber″ was carried out during the period from October, 2018 to March, 2019 in mist house at Kadiyadda village, Tadepalligudem mandal of West Godavari District, Andhra Pradesh. The experimental site falls under 'Agro-climatic zone-10 of east coastal plain and hills' (Krishna-Godavari Zone) with an average rainfall of 900 mm and located at an altitude of 34 m above mean sea level. Kadiyadda village is geographically situated at 16º83' North latitude and 81º5' East longitude. The zone experiences with hot and humid summer with mild winter climate.
The meteorological data pertaining to the maximum, minimum temperature and relative humidity were recorded during the period of investigation with monthly averages both in mist chamber and shade net conditions at kadiyadda village.
A slant cut was given at the basal end of the terminal cuttings to expose maximum absorbing surface area for induction of effective rooting. The basal parts (1-2 cm depth) of the terminal cuttings were dipped in IBA solutions (at 1000, 1500 and 2000 ppm) for 5 minutes as per treatments, subsequently the cuttings were air dried for 5 minutes. For another treatment of IBA, the basal part of the terminal cuttings were dipped in the IBA powder formulations (at 1000, 1500 and 2000 ppm) and then just taped the cuttings to remove excess powder on the

cuttings. The treated cuttings were planted in protrays containing respective rooting media *i.e*. coco peat, vermiculite and saw dust up to one node depth. The rooting media was pressed gently around the base of the cutting to hold the cutting in right place, to eliminate air pockets and to make sure that the base of the cutting was in good contact with the moist rooting media. The terminal open ends of cuttings were smeared with blitox paste to avoid fungal infections. The protrays were kept in mist chamber and maintained in the congenial atmosphere for rooting of cuttings.

Fresh weight of shoot (g)

Effect of rooting media, IBA concentration and method of application their interactions recorded significant on fresh weight of shoot at 90 and 120 days after planting and represented in Table 1.1 and Fig. 2.1.

At 60 DAP, the interaction effect of media, IBA and method of application was found non significant for the fresh weight of shoot at 60 days after planting.

At 90 days after planting, In second order interaction, among the interaction effects between media, IBA concentration and method of application (M×C×A), maximum fresh weight of shoot (3.28 g) was recorded in the treatment combination of sawdust media, IBA @ 1500 ppm and cuttings treated with IBA solution for 5 min ($M_3C_2A_2$) which was followed by $M_1C_1A_2$ (2.98 g), while minimum fresh weight of shoot (1.53 g) was recorded in the treatment combination of coco peat media, IBA @ 1500 ppm and cuttings treated with mixture of IBA and talcum powder ($M_1C_2A_1$).

At 120 days after planting, among second order interactions between media, IBA concentration and method of application (M×C×A), maximum fresh weight of shoot (12.45 g) was recorded in the treatment combination of coco peat media, IBA @ 1000 ppm concentration and cuttings treated with IBA solution for 5 min ($M_1C_1A_2$) which was followed by ($M_2C_1A_2$) (11.41 g), while minimum fresh weight of shoot (6.06 g) was recorded in the treatment combination of coco peat media, IBA @ 2000 ppm and cuttings in treated with mixture of IBA and talcum powder ($M_1C_3A_1$).

The terminal cuttings were planted in coco peat gave the maximum fresh weight of shoots per cutting because coco peat increased the aeration, water holding capacity and nutrient retention at an optimum level essential for the early growth of plants (Cresswell, 1997) [5] resulting in increased number of leaves, length and number of shoots which helps in increased fresh weight of shoots. Maximum fresh weight of shoots per cutting was recorded when cuttings were treated with dipping of cuttings in IBA @ 1000 ppm concentration and cuttings treated with IBA solution per 5 min which might be because of an increase in the number of leaves, length and number of shoots per cutting.

The variation in shoot fresh weight per cutting between the shade net conditions could be attributed to the climatic conditions and also due to variation in accumulation of dry matter in shoots. Increase in shoot fresh weight per cutting with IBA @ 1000 ppm treatment could be due to absorption of more amounts of water and nutrients from the soil through formation of more number of adventitious roots per cutting resulted in maximum plant height and number of leaves which lead to overall assimilation and redistribution of photosynthates within the plant and increased the fresh weight (Sandhu and Singh, 1986) [11]. The results are in line with Krishan and Chouhan (2016) [8] in phalsa.

Dry weight of shoot (g)

Effect of rooting media, IBA concentration and method of application their interactions recorded significant dry weight of shoot at 60, 90 and 120 days after planting and represented in Table 1.2 and Fig. 2.2

At 60 days after planting, In second order interactions, among the interaction effects between media, IBA concentration and method of application (M×C×A), maximum dry weight of shoot (0.79 g) was recorded in the treatment combination of sawdust media and IBA @ 1500 ppm concentration and cuttings treated with IBA solution for 5 min ($M_3C_2A_2$) which was followed by $M_1C_1A_2$ (0.70 g), while minimum dry weight of shoot (0.31 g) was recorded in the treatment combination of vermiculite media and IBA @ 1500 ppm concentration and cuttings treated with mixture of IBA and talcum powder ($M_2C_2A_1$) at 60 DAP.

At 90 days after planting, In second order interactions, among the interaction effects between media, IBA concentration and method of application (M×C×A), maximum dry weight of shoot (0.94 g) was recorded in the treatment combination of coco peat media, IBA @ 1000 ppm concentration and cuttings treated with IBA solution for 5 min ($M_1C_1A_2$), which was followed by $M_3C_2A_2$ (0.87 g) while minimum dry weight of shoot (0.38 g) was recorded in the treatment combination of vermiculite media and IBA @ 2000 ppm concentration and cuttings treated with mixture of IBA and talcum powder ($M_2C_3A_1$) at 90 DAP.

At 120 days after planting, in second order interactions, among the interaction effects between media, concentration and methods of application (M×C×A), maximum dry weight of shoot (4.22 g) was recorded in the treatment combination of coco peat media, IBA @ 1000 ppm concentration and cuttings treated with IBA solution for 5 min ($M_1C_1A_2$) which was on par with $M_1C_2A_2$ (4.05 g) while minimum dry weight of shoot (1.56 g) was recorded in the treatment combination of vermiculite media, IBA @ 1500 ppm concentration and cuttings treated with IBA solution for 5 min ($M_2C_2A_2$) .

Among the rooting media, terminal cuttings planted in coco peat recorded the maximum dry weight of shoot. It could be due to increase in number of leaves, length and number of shoots per cutting. Among media, IBA @ 1000 ppm concentration and cutting treated with IBA solution for 5 mins performed the best. This might be due to the reason, that auxins activated shoot growth, could have elongated the stems and leaves through cell division accounting for a higher dry weight of shoot (Abraham, 1996) [2]. As discussed earlier, IBA at 1000 ppm concentration favored many shoot parameters in positive direction and at the same time sustained the root strength to continue the vigor and vitality in taking up the nutrients as well as moisture from the growing media. The integrated effect over root and shoot parameters established the merit of dipping of cutting in IBA solution for 5 min @ 1000 ppm concentration.

Significant difference among the shade net conditions and growth regulator treatment might be due to the congenial climate and increase in the production of the leaves and leaf area which ultimately increased the photosynthesis, relative growth rate and growth of lateral shoots, which finally resulted in an increase in the fresh and dry biomass of the shoots (Deb *et al*., 2009). The results are similar to the observations of Khapare *et al*. (2012) [7] in fig and Seran and Thiresh (2015) in dragon fruit.

Root and shoot ratio (on dry weight basis)

Effect of rooting media, IBA and method of applications and their interactions recorded significant on root and shoot ratio (on dry weight basis) at 60, 90 and 120 days after planting and represented in Table 1.3 and Fig. 2.3.

At 60 days after planting, in second order interactions, among the interaction effects between media, IBA concentration and method of application (M×C×A), maximum root and shoot ratio (0.31) was recorded in the treatment combination of sawdust media, IBA @ 1500 ppm concentration and cuttings treated with mixture of IBA and talcum powder ($M_3C_2A_1$) which was followed by $M_2C_2A_2$ (0.17) while minimum root and shoot ratio (0.03) was recorded in the treatment combination of coco peat media, IBA @ 1500 ppm and cuttings treated with mixture of IBA and talcum powder ($M_1C_2A_1$).

At 90 days after planting, in second order interactions, among the interaction effects between media, concentration and methods of application (M×C×A), maximum root and shoot ratio (1.12) was recorded in the treatment combination of vermiculite media and IBA @ 2000 ppm concentration and cuttings treated with mixture of IBA and talcum powder ($M_2C_3A_1$), which was followed by $M_2C_1A_1$ (0.64), while minimum root and shoot ratio (0.20) was recorded in the treatment combination of sawdust media, IBA @ 2000 ppm and cuttings treated with mixture of IBA and talcum powder ($M_3C_3A_1$).

At 120 days after planting, in second order interactions, among the interaction effects between media, IBA concentration and methods of application (M×C×A), maximum root and shoot ratio (0.23) was recorded in the treatment combination of coco peat media, IBA @ 1000 ppm concentration and cuttings treated with IBA solution for 5 min ($M_1C_1A_2$) which was followed by $M_3C_1A_2$ (0.19) while minimum root and shoot ratio (0.07) was recorded in the treatment combination of coco peat media, IBA @ 1500 ppm concentration and cuttings treated with mixture of IBA and talcum powder ($M_1C_2A_1$) at 120 DAP.

The increased fresh weight of seedling may be due to the enhanced root and shoot length. Thus the increase in root and shoot length and number of leaves have lead to the overall assimilation and redistribution of photosynthates within the plant and resulted in higher fresh weight of seedling and increased dry matter assimilation (Anjanaw *et al*., 2013) [3]. These results are in line with the findings of Sable and Waskar (2009) [10] in khirni and Choudhary and Chakrawar (1982) [4] in Rangpur lime.

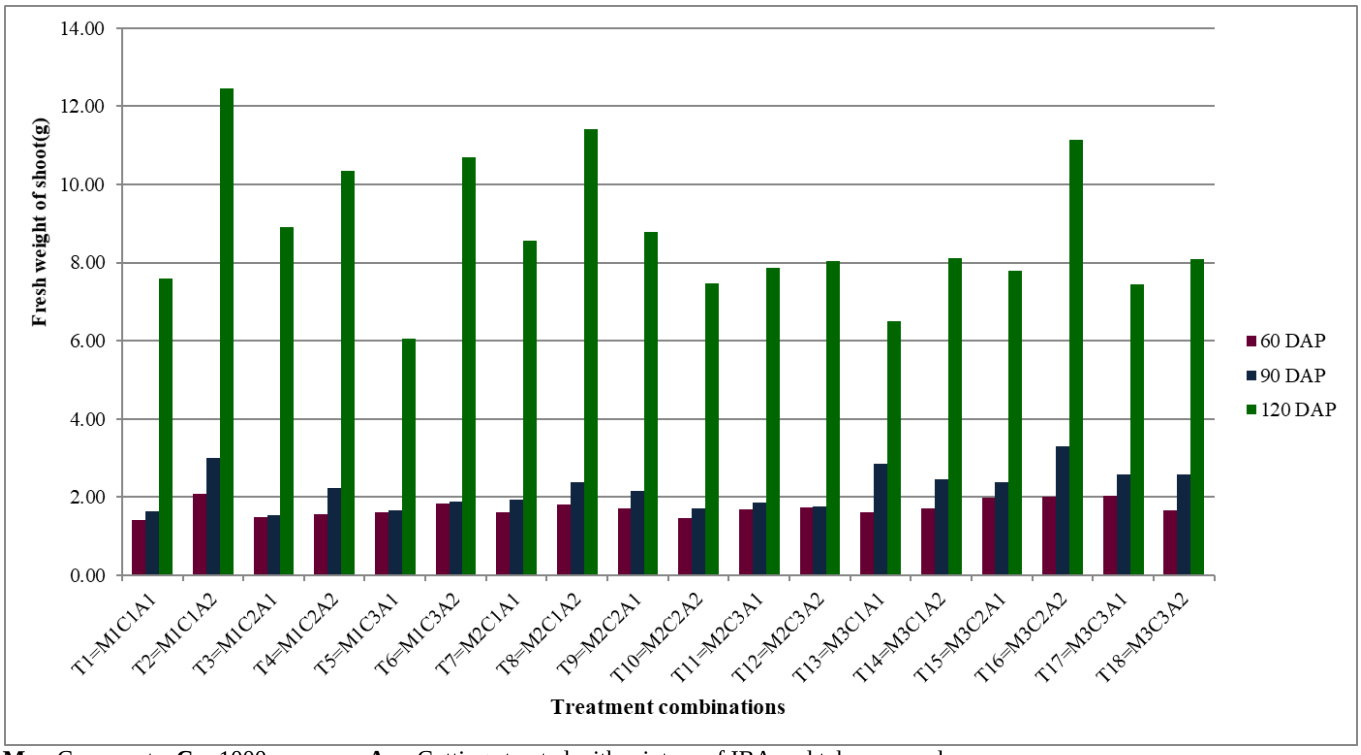
A treatment combination would be more effective when it takes more time to show a reasonable number of shoots per cutting, because it would have triggered more rooting cofactors and diverted more energy for promoting root development during initial stages thus recording lesser number of shoots shortly after planting (Goudappa, 2016) [6].

It is interesting to note that, there might be a reverse trend had the root to shoot ratio could be worked out in the initial stages, but because the roots could not be disturbed in more number of cuttings during the experimentation, the root to shoot ratio could be recorded at all stages which was in association with significantly better treatments in respect of both root and shoot parameters at that stage. The highest root to shoot ratio was recorded in terminal cuttings planted in coco peat might be due to well developed root system relative to shoot system (Ratnakumari, 2014) [9].

Table 1: Effect of rooting media and IBA concentrations on the fresh weight of shoots (g) in terminal cuttings of ber cv. Apple ber

		60 DAP			90 DAP			120 DAP		
		A_1	**A_2**	**Mean MxC**	**A_1**	**A_2**	**Mean MxC**	**A_1**	**A_2**	**Mean MxC**
M_1	C_1	1.39	2.08	1.74	1.63	2.98	2.30	7.59	12.45	10.02
	C_2	1.47	1.55	1.51	1.53	2.21	1.87	8.90	10.34	9.62
	C_3	1.60	1.82	1.71	1.64	1.88	1.76	6.06	10.68	8.37
Mean MxA		1.49	1.82	1.65	1.60	2.36	1.98	7.52	11.16	9.34
M_2	C_1	1.60	1.79	1.70	1.93	2.37	2.15	8.56	11.41	9.99
	C_2	1.70	1.45	1.58	2.16	1.69	1.93	8.78	7.47	8.13
	C_3	1.66	1.73	1.70	1.85	1.75	1.80	7.87	8.03	7.95
Mean MxA		1.65	1.66	1.66	1.98	1.94	1.96	8.40	8.97	8.69
M_3	C_1	1.61	1.70	1.65	2.83	2.44	2.63	6.49	8.10	7.30
	C_2	1.97	2.00	1.98	2.36	3.28	2.82	7.78	11.14	9.64
	C_3	2.03	1.64	1.83	2.57	2.58	2.58	7.43	8.09	7.76
Mean MxA		1.87	1.78	1.82	2.59	2.76	2.68	7.24	9.14	8.17
Mean CxA			Mean C			Mean C		Mean C		
	C_1	1.53	1.86	1.70	2.13	2.60	2.36	7.55	10.66	9.10
	C_2	1.71	1.67	1.69	2.02	2.40	2.21	8.49	9.65	9.07
	C_3	1.76	1.73	1.75	2.02	2.07	2.04	7.12	8.94	8.03
Mean A		1.67	1.75	1.71	2.06	2.35	2.20	7.72	9.75	8.79
Comparing Mean		S Em (±)		CD at 5%	S Em (±)		CD at 5%	S Em (±)		CD at 5%
M		0.048		0.139	0.034		0.097	0.140		0.400
C		0.048		NS	0.034		0.097	0.140		0.400
A		0.040		NS	0.028		0.079	0.114		0.327
MxC		0.084		0.241	0.058		0.167	0.242		0.693
MxA		0.069		0.197	0.048		0.137	0.197		0.566
CxA		0.069		0.197	0.048		0.137	0.197		0.566
MxCxA		0.119		NS	0.083		0.237	0.342		0.980

M_1 = Coco peat **C_1** = 1000 ppm **A_1** = Cuttings treated with mixture of IBA and talcum powder
M_2 = Vermiculite **C_2** = 1500 ppm **A_2** = Cuttings treated with IBA solution for 5 minutes
M_3 = Sawdust **C_3** = 2000 ppm **DAP** = Days after planting **NS** = Non significant



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M_2 =Vermiculite **C_2** =1500ppm **A_2** = Cuttings treated with IBA solution for 5 minutes
M_3 = Sawdust **C_3** = 2000ppm **DAP** = Days after planting

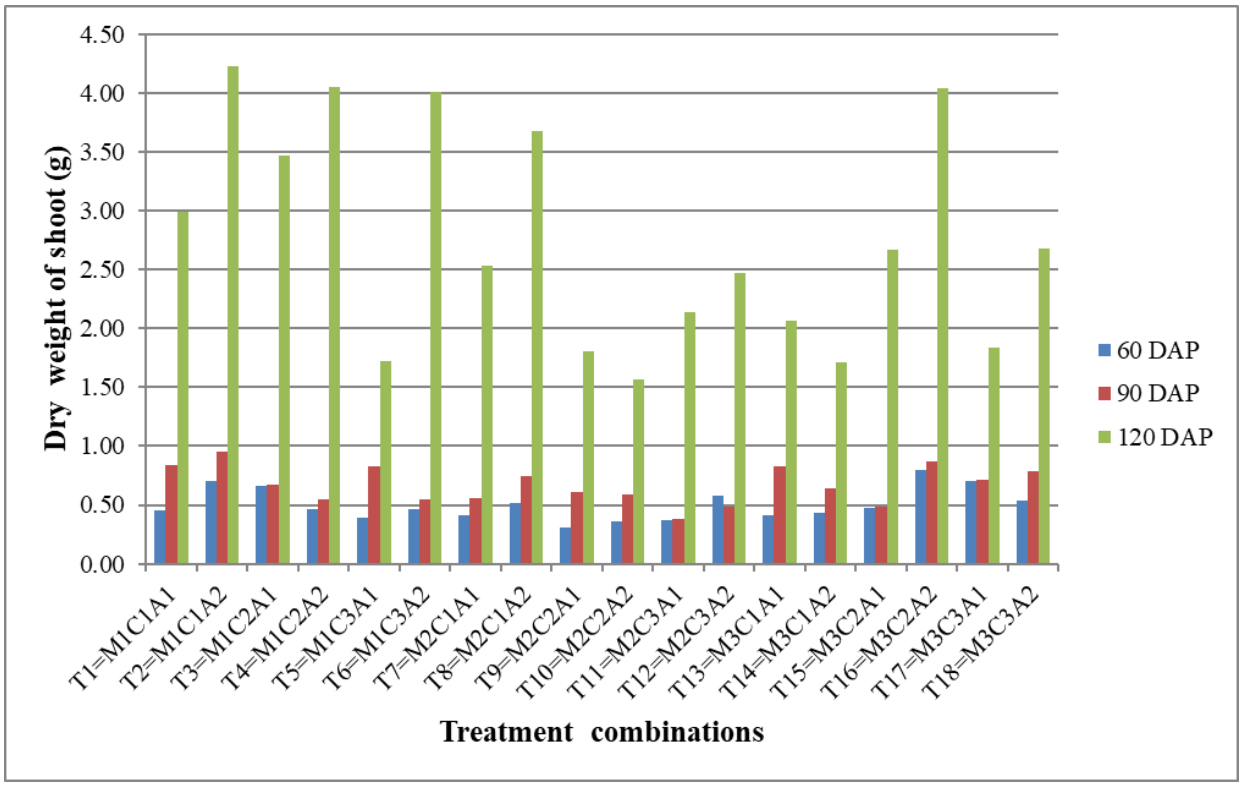
Fig 2: Effect of rooting media and IBA concentration on the fresh weight of shoots (g) in terminal cuttings of ber cv. Apple ber

Table 1: Effect of rooting media and IBA concentration on dry weight of shoots (g) in terminal cuttings of ber cv. Apple ber

		60 DAP			90 DAP			120 DAP		
		A_1	**A_2**	**Mean MxC**	**A_1**	**A_2**	**Mean MxC**	**A_1**	**A_2**	**Mean MxC**
M_1	C_1	0.45	0.70	0.58	0.84	0.94	0.89	2.99	4.22	3.60
	C_2	0.65	0.46	0.56	0.67	0.55	0.61	3.46	4.05	3.75
	C_3	0.39	0.46	0.42	0.82	0.54	0.68	1.72	4.00	2.86
Mean MxA		0.50	0.54	0.52	0.78	0.68	0.73	2.72	4.09	3.41
M_2	C_1	0.40	0.52	0.46	0.56	0.74	0.65	2.53	3.67	3.10
	C_2	0.31	0.36	0.33	0.61	0.59	0.60	1.80	1.56	1.68
	C_3	0.37	0.57	0.47	0.38	0.48	0.43	2.13	2.47	2.30
Mean MxA		0.36	0.48	0.42	0.52	0.60	0.56	2.15	2.57	2.36
M_3	C_1	0.40	0.43	0.42	0.82	0.64	0.73	2.06	1.71	1.89
	C_2	0.47	0.79	0.65	0.48	0.87	0.67	2.66	4.03	3.35
	C_3	0.70	0.54	0.62	0.71	0.78	0.75	1.83	2.67	2.25
Mean MxA		0.52	0.59	0.56	0.67	0.76	0.72	2.19	2.81	2.50
Mean CxA			Mean C		Mean C			Mean C		
	C_1	0.42	0.55	0.48	0.74	0.78	0.76	2.52	3.20	2.86
	C_2	0.48	0.54	0.51	0.58	0.67	0.63	2.64	3.21	2.93
	C_3	0.49	0.52	0.50	0.60	0.60	0.62	1.89	3.05	2.47
Mean A		0.46	0.54	0.50	0.65	0.68	0.67	2.35	3.15	2.75

Comparing Mean	S Em (±)	CD at 5%	S Em (±)	CD at 5%	S Em (±)	CD at 5%
M	0.003	0.008	0.001	0.004	0.024	0.069
C	0.003	0.008	0.001	0.004	0.024	0.069
A	0.002	0.006	0.001	0.003	0.020	0.057
MxC	0.005	0.013	0.002	0.007	0.042	0.120
MxA	0.004	0.011	0.002	0.005	0.034	0.098
CxA	0.004	0.011	0.002	0.005	0.034	0.098
MxCxA	0.007	0.019	0.003	0.009	0.059	0.170

M_1 = Coco peat **C_1** = 1000 ppm **A_1** = Cuttings treated with mixture of IBA and talcum powder
M_2 = Vermiculite **C_2** = 1500 ppm **A_2** = Cuttings treated with IBA solution for 5 minutes
M_3 = Sawdust **C_3** = 2000 ppm **DAP** = Days after planting



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M_2 = Vermiculite **C_2** = 1500ppm **A_2** = Cuttings treated with IBA solution for 5 minutes
M_3 = Sawdust **C_3** = 2000ppm **DAP** = Days after planting

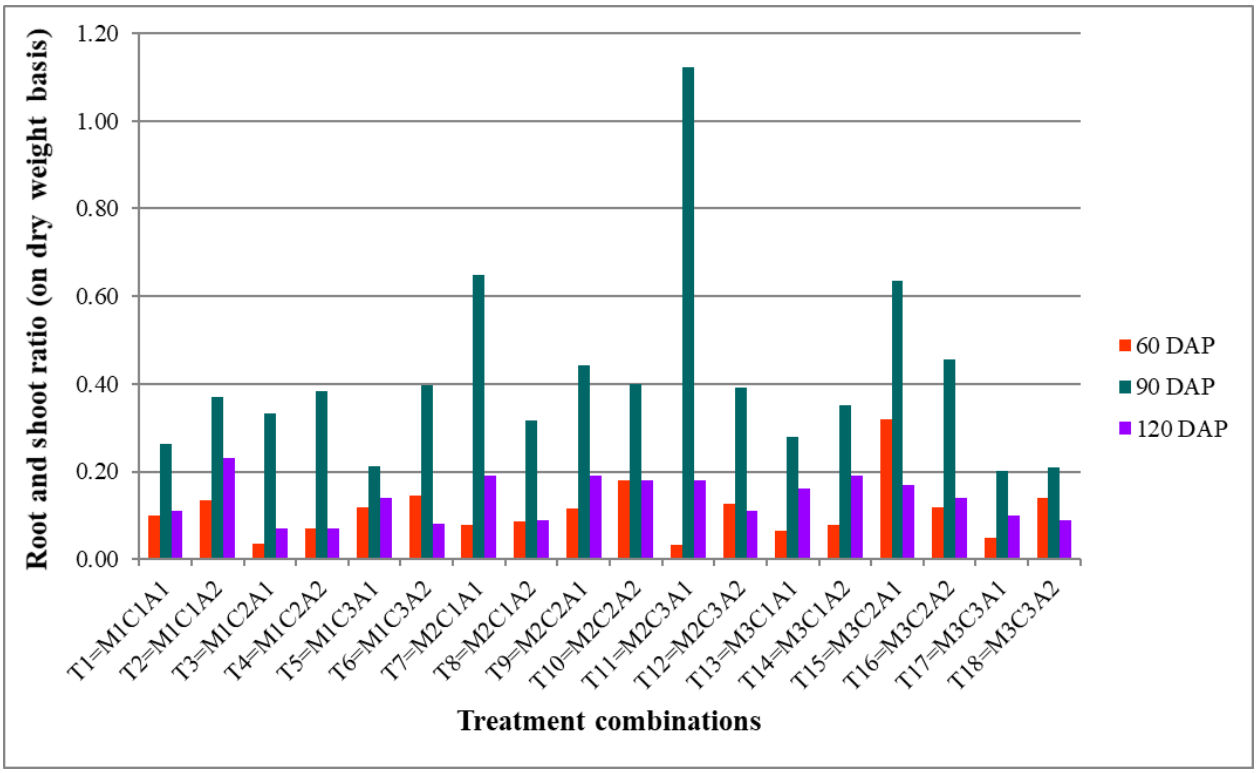
Fig 2: Effect of rooting media and IBA concentration on dry weight of shoots (g) in terminal cuttings of ber cv. Apple ber

Table 3: Effect of rooting media and IBA concentration on growth of root to shoot ratio (on dry weight basis) of terminal cuttings in ber cv. Apple ber

		60 DAP			90 DAP			120 DAP		
		A_1	**A_2**	**Mean MxC**	**A_1**	**A_2**	**Mean MxC**	**A_1**	**A_2**	**Mean MxC**
M_1	C_1	0.10	0.13	0.11	0.26	0.37	0.31	0.11	0.23	0.17
	C_2	0.03	0.07	0.05	0.33	0.38	0.35	0.07	0.07	0.07
	C_3	0.11	0.14	0.13	0.21	0.39	0.30	0.14	0.08	0.11
Mean MxA		0.08	0.11	0.10	0.26	0.38	0.32	0.11	0.13	0.12
M_2	C_1	0.08	0.08	0.08	0.64	0.31	0.48	0.19	0.09	0.14
	C_2	0.11	0.17	0.14	0.44	0.39	0.42	0.19	0.18	0.18
	C_3	0.03	0.12	0.08	1.12	0.39	0.75	0.18	0.11	0.14
Mean MxA		0.07	0.13	0.10	0.73	0.36	0.55	0.18	0.12	0.15
M_3	C_1	0.06	0.07	0.07	0.27	0.35	0.31	0.16	0.19	0.17
	C_2	0.31	0.11	0.21	0.63	0.45	0.54	0.17	0.14	0.15
	C_3	0.05	0.13	0.09	0.20	0.21	0.20	0.10	0.09	0.10
Mean MxA		0.14	0.11	0.12	0.37	0.33	0.35	0.14	0.14	0.14
Mean CxA			Mean C		Mean C			Mean C		
	C_1	0.08	0.10	0.09	0.39	0.34	0.37	0.15	0.17	0.16
	C_2	0.15	0.12	0.14	0.47	0.41	0.44	0.14	0.13	0.14
	C_3	0.06	0.13	0.10	0.51	0.33	0.42	0.14	0.09	0.12
Mean A		0.10	0.12	0.11	0.45	0.36	0.41	0.14	0.13	0.14

Comparing Mean	S Em (±)	CD at 5%	S Em (±)	CD at 5%	S Em (±)	CD at 5%
M	0.005	0.013	0.012	0.036	0.003	0.009
C	0.005	0.013	0.012	0.036	0.003	0.009
A	0.004	0.011	0.01	0.029	0.003	0.008
MxC	0.008	0.022	0.022	0.062	0.006	0.016
MxA	0.006	0.018	0.018	0.051	0.005	0.013
CxA	0.06	0.018	0.018	0.051	0.005	0.013
MxCxA	0.011	0.032	0.031	0.088	0.008	0.023

M_1 = Coco peat **C_1** = 1000 ppm **A_1** = Cuttings treated with mixture of IBA and talcum powder
M_2 = Vermiculite **C_2** = 1500 ppm **A_2** = Cuttings treated with IBA solution for 5 minutes
M_3 = Sawdust **C_3** = 2000 ppm **DAP** = Days after planting



M₁ = Coco peat **C₁** = 1000ppm **A₁**= Cuttings treated with mixture of IBA and talcum powder
M₂ = Vermiculite **C₂** = 1500ppm **A₂** = Cuttings treated with IBA solution for 5 minutes
M₃ = Sawdust **C₃** = 2000ppm **DAP** = Days after planting

Fig 3: Effect of rooting media and IBA concentration on root to shoot ratio (on dry weight basis) of terminal cuttings in ber, cv. Apple ber

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