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STUDIES ON EFFECT OF INDUCED MOISTURE STRESS ON ROOTSTOCK GROWTH PARAMETERS OF MANGO (*MANGIFERA INDICA* L.) IN THE EASTERN ZONE OF KARNATAKA

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ABSTRACT

The present study was conducted to evaluate mango (*Mangifera indica* L.) moisture stress induced rootstocks and their response in the success of grafts. About 16 treatments with five replications and 10 plants in each replication were used for the experiment. Six months old rootstocks of Alphonso, Dashehari, Neelum and Totapuri were treated with four different stress levels (100% of FC- Control; 80% of FC- moderate stress; 60 % of FC- mild stress and 40 % of FC- severe stress). During stress induced period plant height, number of leaves, plant biomass, was recorded maximum in treatment I_1(100% of FC) and minimum was recorded in moderate stress (60% of FC) and severe stress (40% of FC) treatment while, maximum stem diameter, soil moisture content was recorded highest in mild stress treatment (80% of FC) and minimum was recorded in moderate stress (60% of FC) and severe stress (40% of FC) treatment. Maximum plant height, stem diameter, plant biomass, was recorded maximum in the rootstock Alphonso. Maximum number of leaves, was found in rootstock Totapuri whereas, All the rootstocks with 100 per cent irrigation and 80 per cent irrigation combination comes up well in all the growth parameters, under moderate stressed and severe stressed treatment, rootstock Totapuri and Alphonso contributed better by adapting various morphological, physiological and biochemical traits. The rootstock Totapuri followed by Alphonso clearly shows the survivable strategies under severe stressed period by reducing its plant height, stem diameter, leaf number.

Key words: Moisture stress, Mango rootstocks, field capacity, growth parameters

1.Introduction

Mango (*Mangifera indica* L.) is an economically important fruit crop of India, belongs to the family Anacardiaceae. There are more than one thousand varieties and the crop was cultivated in Indian sub-continent since 4000 years Abourayya *et al* (2012). It was known in India from very early times, as is evident from the reference to it in the early Sanskrit literature as Amra. In the Hindu mythology and religious observances it occupies an important place. The Mughal Emperor Babar called it the choicest fruit of Hindustan. It is the national fruit of India and acknowledged as "King of Fruits". The mango fruit is an excellent source of vitamin A and potassium (Sanjay kumar (2011)). 100g fruit is said to provide 4800 IU of vitamin A, 156 mg of potassium with just 2 mg of sodium. The mango is very nutritious having greater health benefits both, when eaten raw and as a ripened. The fruit (ripe and unripe), seed, bark, leaves, root and even the smoke of burning leaves have healing properties Hada and Singh (2017). It is known to be a very good source of vitamins such as, vitamin-C, riboflavin, thiamine, niacin and ß-carotene. Mango contains numerous polyphenolic and phyto-nutrients compounds that have been shown to exhibit antioxidant properties. Mangoes can be considered as a good source of dietary antioxidant, such as ascorbic acid, carotenoids and phenolic compounds (Ribeiro et al., 2007). ß-carotene is the most abundant carotenoid in several cultivars. Apart from the use of ripe mango, young and unripe fruits are utilized for culinary purposes as well as for preparing pickles, chutneys and amchur.

Moisture stress is one of the most significant abiotic stress factor limiting global production. Plants exhibit number of physiological (Ammar *et al* 2020) and biochemical responses at cellular and whole organism level on account of water stress environment (Amrita 2019). Moisture stress is characterized by decrease in water content, diminished leaf water potential and turgor loss, closure of stomata and reduced cell enlargement and growth. Water stress situation may result in the arrest of photosynthesis, interruption of metabolism and finally the death of plant (Jaleel et al., 2008). Reducing canopy leaf area, stomatal conductance, deeper penetration of roots, higher relative water content and enhanced osmotic adjustment are some of the mechanism that plant employ to overcome plant stress. Agriculture is a main user of water resources in various region of the world. With increase in aridity and population, water will become a scare in the near future. A better understanding of the effects of moisture on plants is vital for improved management practices and for predicting the fate of natural vegetation under climate change.

Mangoes are usually drought resistant to some extent but will not achieve optimum growth if they do not receive sufficient rainfall. An average annual rainfall of 663 mm and especially its even distribution throughout the year are considered to be the most important factors for economic mango production. Mango production in the year 2018 was 14 lakh tonnes and it was dipped to about 3-4 lakh tonnes in the year 2019 due to drought and unseasonal rain. Today the concern is with improving cultural practices and crop genotypes for drought-prone areas. The main aim of this research was to evaluate mango (*Mangifera indica* L.) moisture stress induced rootstocks and their response in the success of grafts.

2. Material and Methods

The Present experiment was conducted at Horticulture research and extension centre (HREC), Hogalagere, Kolar, Karnataka (India) during December 2019 to September 2020 . It is located at an altitude of 849 meters above MSL 13.13° N latitude and 78.13° E longitude in a Factorial Completely Randomized Block Design (FCRD). There were 16 treatments with five replications and 10 plants in each replication. Six month old rootstocks of Alphonso, Dashehari, Neelum and Totapuri were treated with four different stress levels (100% of FC- Control; 80% of FC- moderate stress; 60% of FC- mild stress and 40% of FC- severe stress). Stress was imposed by withholding watering for 15 days and on 16th day plants were irrigated up to 100 per cent of FC and again stress was created for another 15 days. Six such serial stress cycles were given to study the variations among the rootstocks under the stress period (1st January to April 4th). Later on seedlings were allowed to recover by irrigating daily (100% of FC) in the month of April (recovery period). Observations were recorded at monthly interval and pooled data were subjected to statistical analysis and the treatment means were compared by critical difference values computed at 5% level of significance.

3. Results and discussion

3.1. Effect of moisture stress and rootstocks on plant height

In case of different water stress level, there was a significant variation in plant height at different stages of growth. During stress induced period and at recovery period, irrigation treatment I_1 (100% of FC) recorded maximum plant height and I_3 (60% of FC) recorded minimum plant height.In control (100% of FC) and mild stress (80 % of FC) treatment, there was a steady increase in plant height but at moderate (60 % of FC) and severe (40% of FC) stress condition, there was no much rise in plant height till re-watering. Thereafter, at recovery period there was a gradual rise in plant height. This is due to stress condition which slows down the plant growth by impaired mitosis, cell expansion and cell enlargement thus resulted in reduced plant height. Similarly, in case of Kent mango, reduced irrigation treatments significantly reduce the vegetative growth in comparison to the control (Pavel et al., 2004). The reduced plant height is usually associated with a decline in the cell enlargement under water deficit which is greatly hampered because of low moisture content (Bhatt and Rao, 2005).In case of different rootstocks, there was a significant variation in plant height among different treatments. The rootstock V_1 (Alphonso) showed maximum plant height during stress induction period and at recovery period while, minimum height was noticed in rootstock V_3 (Neelum) during stress period and at recovery period. Differences in plant height among the varieties might have resulted from genotypic variability of the varieties. This was supported by Singh and Suryanarayan

(1996). They found that maximum plant height was found in Langra (4.08 m) and minimum plant height was observed in Neelum (2.23 m).

3.2. Interaction effect between water stress and rootstocks on plant height

The water stress level and rootstocks interaction effect on plant height was statistically significant. During stress induction period and at recovery period, treatment interaction I_1V_1 (100 % of FC + Alphonso) recorded maximum plant height and least plant height was recorded in I_4V_4 (40 % of FC + Totapuri).Bhatt and Rao (2005) Mandal et al (2012) inferred that the decline in plant height might be due to lack of ample moisture in root zone of the plant. The findings of the decline in plant height during water stress condition are in conformity with Luvaha et al. (2007) in mango.

3.3. Effect of water stress and rootstocks on stem diameter

There was a significant variation in stem diameter among different stress level. During stress induced period, highest stem diameter was observed in irrigation I_2 (80% of FC) while, minimum was observed in I_3 (60% of FC) and at recovery period, stem diameter was observed in irrigation I_4 (40 % of FC) while, minimum was observed in I_3 (60% of FC).A steady increase in stem diameter was observed in control and mild stress treatment, whereas there was no increase in stem diameter in case of water stress condition (Luvaha et al., 2011). A study on vegetative growth of banana as influenced by deficit irrigation was conducted by Olivieret al. (2019). Stem girth was recorded highest in 100 per cent irrigation with 19.5 per cent followed by 90 per cent irrigation and 80 per cent irrigation with 18.7 cm and 17.5 cm. Significant variation was found in stem diameter among different rootstocks. Maximum stem diameter was noticed in rootstock V_1 (Alphonso) during water stress level and at recovery period while, minimum stem diameter was recorded in rootstock V_2 (Dashehari) during stress induced period and at recovery period. All the four rootstocks differed significantly for stem diameter. This was due to genetic divergence of mango rootstocks. Similar result was also found by Sanjaykumar et al. (2010) for ten mango rootstocks. Under adverse hot condition of the site, stem girth was recorded highest in Kesar cultivar with 2.9 cm followed by Langra with 2.6 cm and least stem girth was recorded in DC-51 with 1.13 cm.

3.4. Interaction effect between water stress and rootstocks on stem diameter

The interaction effect between water stress level and rootstocks on stem diameter of different treatment combinations was statistically significant. During stress induction I_4V_1 combination (40 % of FC + Alphonso) recorded maximum stem diameter while, I_3V_2 (60 % of FC + Dashehari) recoded maximum stem diameter at recovery period. Minimum stem diameter was observed in I_3V_2 (60 % of FC + Dashehari) in case of during stress period and I_3V_2 (60 % of FC + Dashehari) in case of recovery period. As there was increase in the water stress the diameter of stem was decreased to reduce the water loss from the plant. Under water stress, declination in stem diameter was due to the loss of cell turgor which suppresses cell expansion and enlargement thereby, inhibiting the growth of shoot (Bhatt and Rao, 2005).

3.5. Effect of water stress and rootstocks on leaf number

There was a significant variation in number of leaves among different stress level. During stress induced period and at recovery period, I_1 (100% of FC) treatments recorded maximum and I_3 (60 % of FC) recorded minimum number of leaves. There was a general increase in number of leaves except in severe stressed condition (40% of FC). During water stress, depending on their intensity and duration plants tends to minimize transpirational water loss by reducing their number of leaves. At irrigation level below 40 per cent, oldest leaves become chloratic and eventually abscised. At the recovery period, younger leaves recovered within a couple of days whereas older leaves continued to fall. These results are found similar with Singh (1985), and highest number of leaves (9.68) was recorded at -20 K Pa and least (6.25) was recorded in non-irrigation treatment. Among different rootstocks, there was a significant variation in number of leaves. During stress induced period and at recovery period, rootstock V_4 (Totapuri) recorded maximum andV_3 (Neelum) minimum number of leaves. All the four rootstocks differed significantly for leaf number under all three stages of observation. This was due to genetic divergence of mango rootstocks. This result was supported by Abourayya et al. (2012) and Ram et al (2012) They found that maximum number of leaves was found in Tommy Atkins with 10.16 and 10.32 in 2007 and 2008 respectively while, minimum leaves was recorded in Keitt mango cultivar with 9.10 and 9.46 during 2007 and 2008 respectively.

3.6. Interaction effect between water stress and rootstocks on number of leaves

The interaction effect between water stress level and rootstocks on number of leaves of different treatment combinations was statistically significant. During stress induction and at recovery period, I_1V_4 combination (100 % of FC + Totapuri) recorded maximum number of leaves while, minimum number of leaves was observed in I_4V_4 (40% of FC + Totapuri) during stress period and I_4V_3 (40 % of FC + Neelum) at recovery period. In this experiment, minimum number of leaves was maintained by Totapuri rootstock followed by Alphonso under severe stress condition. During water stress, depending on their intensity and duration plants tends to minimize transpirational water loss by reducing their number of leaves. Hence rootstock Totapuri and Alphonso found to be stress tolerance compared to other rootstocks (Neelum and Dashehari which found to be susceptible under water stress).The findings in this experiment are supported by Kadam et al. (2001),Cruz et al *(*2012), and Kulakarni et al (2010) Highest number of leaves per shoot was observed in variety 1103-P at 0.3 bar irrigation level and lowest was recorded in SO4 at 0.7 bar irrigation level. Minimum per cent reduction in total number of leaves was observed in 1103-P found to be more tolerant rootstocks followed by Dogridge.

3.7. Effect of moisture stress and rootstocks on plant biomass

In case of different water stress level, there was a significant variation in plant biomass. During stress induction and at recovery period, irrigation treatment I_1 (100 % of FC) showed maximum plant biomass while, minimum plant biomass was recorded in I_4 (40 % of FC) during stress period and at recovery period. Treatments with full irrigation were observed higher plant biomass, and it was decrease with increase in stress level. After three months of stress period, plant biomass decreased under all treatment. Water stress suppresses leaf expansion, photosynthesis and leaf area. All these factors are responsible for a reduction in biomass accumulation. Naik et al. (2019) and Islam and Rafikul, (2013) estimated the predicted total biomass which was varied from 0.53 to 10.5 Mg/ha with mean annual increment of 0.26 to 1.05 Mg/ha in 2-10 yr old mango orchard. Maximum plant biomass was found (28.068 kg/ha) and least was found (0.278 kg/ha).There was a significant variation in plant biomass among different rootstocks. During stress induction and at recovery period, rootstock V_1 (Alphonso) showed maximum plant biomass while, minimum plant biomass was recorded in V_4 (Totapuri).These findings are in conformity with Sakalauskaite et al. (2006) and Gadekar *et al* (2010). They reported that 50 per cent decrease in fresh and dry weights following five weeks of drought treatments in apple rootstocks.

3.8.Interaction effect between water stress and rootstocks on plant biomass

The interaction effect between water stress level and rootstocks on plant biomass of different treatment combinations was statistically significant. During stress induction and at recovery period, I_1V_1 combination (100 % of FC + Alphonso) recorded maximum plant biomass and I_2V_4 (80 % of FC +Totapuri) combination recorded minimum plant biomass. Under water stress condition, there is a trend of decrease in plant vegetative growth, number of leaves and plant biomass.

4. Conclusion

During stress induced period plant height, number of leaves, plant biomass was recorded maximum in treatment 100% of FC and minimum was recorded in treatment 60% of FC and 40% of FC while, maximum stem diameter, soil moisture content was recorded highest in treatment 80% of FC and minimum was recorded in 60% of FC and 40% of FC treatment. Maximum plant height, stem diameter, plant biomass was recorded in the rootstock Alphonso. Maximum number of leaves was found in rootstock Totapuri.

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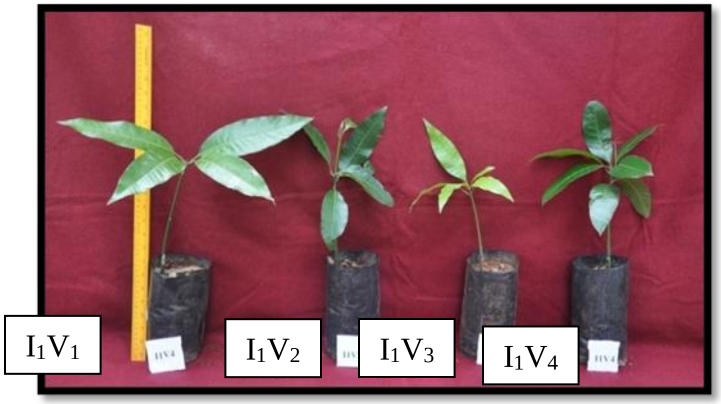
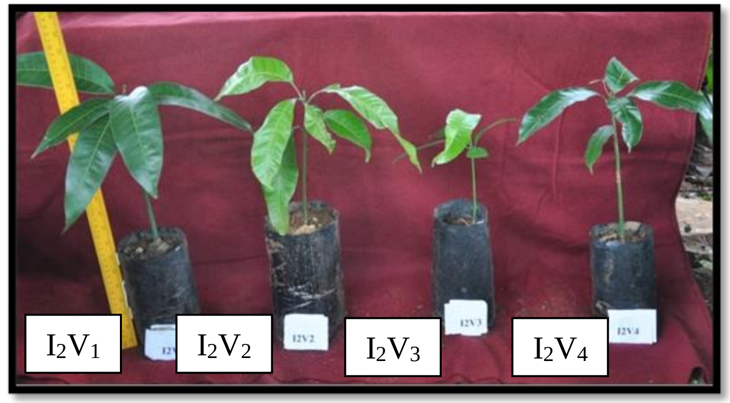
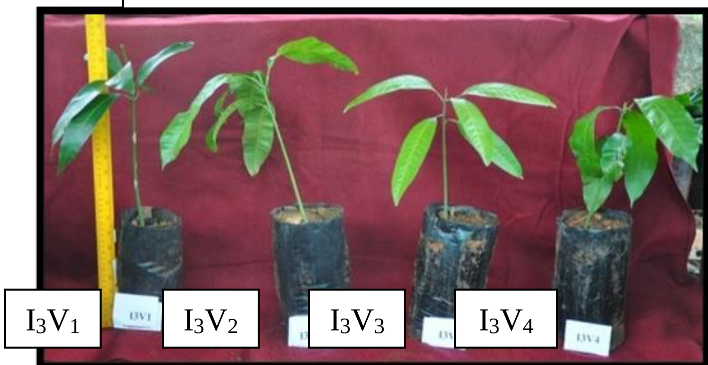


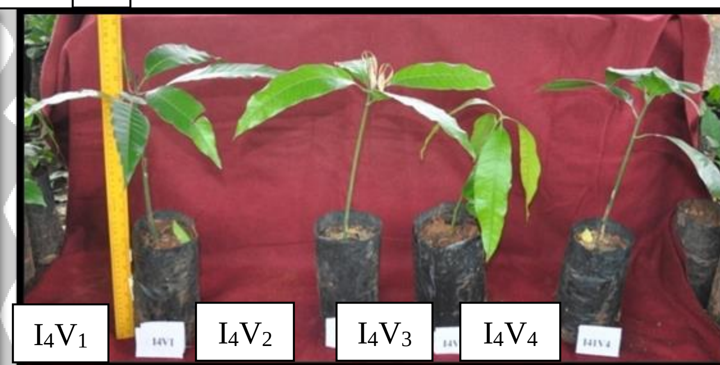
(a) Irrigation treatments upto 100 per cent of FC



(b) Irrigation treatments upto 80 per cent of FC



(c) Irrigation treatments upto 60 per cent of FC



(d) Irrigation treatments upto 40 per cent of FC

Plate 6. Rootstocks of different treatments at before stress induction period

I_1 (100% of FC); I_2 (80% of FC); I_3 (60% of FC); I_4 (40% of FC); V_1(Alphonso); V_2(Dashehari); V_3(Neelum); V_1(Totapuri)

Table 1. Effect of induced moisture stress on plant height (cm), Stem diameter (cm), No. of leaves and Plant biomass (g) at various stages of growth in mango rootstocks

	Plant Height (cm)		Stem diameter (cm)		No. of leaves		Plant biomass (g)	
Treat ments	*** Stress period**	**Recovery period**	*** Stress period**	**Recovery period**	*** Stress period**	**Recovery period**	*** Stress period**	**Recovery period**
Factor 1 (Water stress levels)								
I_1	25.60	26.86	1.33	1.42	7.75	9.25	104.93	106.17
I_2	25.14	26.30	1.36	1.41	7.75	8.58	102.28	102.92
I_3	23.93	24.55	1.27	1.37	5.00	4.92	99.22	100.50
I_4	24.10	25.26	1.35	1.38	5.42	6.00	97.66	100.10
S.Em±	0.095	0.080	0.01	0.02	0.35	0.36	0.02	0.11
CD at 5 %	0.275	0.230	0.02	0.04	1.03	1.03	0.044	0.32
Factor 2 (Rootstocks)								
V_1	25.75	26.66	1.43	1.48	6.58	7.17	104.94	106.40
V_2	24.38	25.45	1.16	1.23	6.08	7.08	101.83	102.85
V_3	23.55	24.69	1.35	1.41	5.67	6.33	99.31	101.19
V_4	25.11	26.17	1.38	1.44	7.58	8.17	98.02	99.26
S.Em±	0.09	0.080	0.01	0.02	0.35	0.36	0.02	0.11
CD at 5 %	0.275	0.230	0.02	0.04	1.02	1.03	0.04	0.32
Interaction effects								
I_1V_1	27.39	28.27	1.47	1.54	7.00	7.67	110.21	112.33
I_1V_2	25.10	26.37	1.17	1.22	6.67	8.67	106.91	106.97
I_1V_3	24.02	25.43	1.39	1.39	7.67	10.00	101.41	102.63
I_1V_4	25.90	27.37	1.36	1.40	9.67	10.67	101.21	102.73
I_2V_1	26.26	27.69	1.46	1.50	8.33	8.33	105.81	105.87
I_2V_2	24.80	25.61	1.27	1.31	6.67	8.67	105.91	106.07
I_2V_3	24.10	25.39	1.30	1.34	7.33	7.667	101.11	102.83
I_2V_4	25.39	26.51	1.42	1.47	8.67	9.67	96.31	96.91
I_3V_1	24.80	25.17	1.37	1.42	4.67	5.00	103.14	104.30
I_3V_2	24.43	25.46	1.04	1.21	5.00	4.33	97.27	98.60
I_3V_3	24.52	25.51	1.33	1.41	4.00	4.67	98.34	99.90
I_3V_4	23.85	24.18	1.35	1.44	6.33	6.67	98.18	99.20
I_4V_1	25.30	25.63	1.41	1.46	3.67	4.00	100.63	103.11
I_4V_2	23.18	24.34	1.14	1.19	6.00	8.67	97.27	99.71
I_4V_3	23.42	24.55	1.40	1.48	6.33	4.83	96.38	99.41
I_4V_4	22.65	23.40	1.11	1.44	3.47	4.67	96.44	98.21
S.Em±	0.190	0.159	0.01	0.03	0.71	0.71	0.03	0.22
CD at 5%	0.055	0.461	0.04	0.09	2.04	2.06	0.09	0.64

I_1 (100 % of FC); I_2 (80 % of FC); I_3 (60 % of FC); I_4 (40 % of FC)

V_1(Alphonso); V_2(Dashehari); V_3(Neelum); V_1(Totapuri)

*Stress period: Stress imposed at 15 days interval up to three months