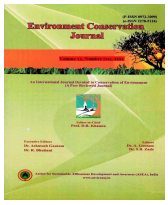
Environment Conservation Journal 24 (3): 116-125, 2023

Journal homepage:https://www.environcj.in/

Environment Conservation Journal

ISSN 0972-3099 (Print) 2278-5124 (Online)



Water stress influence of Rajendrasonia and Pitamber turmeric varieties

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ARTICLE INFO

Received : 18 October 2022
Revised : 17 January 2023
Accepted : 05 February 2023

Available online: 10 April 2023

Key Words:
Pitamber
Rajendrasonia
Water stress

ABSTRACT

Turmeric varieties viz., Rajendrasonia and Pitamber were subjected to water stress by irrigating at different intervals. Impact of water stress on morphological, physiological and yield parameters of both the varieties were investigated. In this study irrigation treatments divided into three groups. Group A, control receives water weekly once. For every two weeks once group B was irrigated and for every three weeks once group C was irrigated. Plants which are under heavy water stress showed gradual reduction in morphological, physiological and yield parameters, i.e. plant height, number of leaves, leaf area, leaf area index, Net Assimilation rate, Relative Growth rate , fresh and dry weight of rhizome. Pitamber and Rajendrasonia growth parameters, physiological and yield parameters were slightly affected in moderate stress compared to control. In heavy stress condition the two varieties severely affected compared to control and moderate stress. Among the two selected varieties Pitamber was less affected in all parameters except in leaves number, tuberous roots length and in dry weight in moderate and heavy stress.

Introduction

Among the oldest spices turmeric is one of them. Increased demand on turmeric use as natural-dye, spice, flavorant led to increase in cultivation and production across the globe. Curcumin , de methoxy curcumin , bis de methoxy curcumin are the important active components present in turmeric. Among these components curcumin is the pivotal component. Curcumin has numerous properties like " anti-inflammatory, anticancer, antitumor, antibacterial, antioxidant, antidiabetic, antiallergic properties". (Singh *et al.*, 2012: Shehzad *et al.*, 2013: Devassy *et al.*, 2015: Deogade and Ghate 2015). Water supply can be considered as the major factor that affects plant growth , it also affects production of second-ary metabolites . (Randhawa *et al.*, 1992, 1996). Lack of water supply to plants leads to drastic changes in growth and in photosynthesis rate . However, some reports confirmed that providing limited water to plants enhances the secondary metabolites biosynthesis, accumulation of solutes and enzyme related activities (Singh-Sangwan *et al.*, 2001). Depletion in leaf area, leaf -senescence & reduced cell development were developed due to water undersupply conditions (Kafi and Damghani, 2001). Metabolic responses and physiological actions are significantly decreased due to lack of moisture (Flevas *et al.*, 2002). Under supply of water may be primarily influence "the primary, secondary metabolites biosynthesis, plant -lipids, plasma- membrane". Fatty-acids components undergo modifications in several crops due to lack of water. Essential- oil biosynthesis is also affected by water stress. (Laribi *et al.*, 2009; Bourgou *et al.*, 2011 Bettaieb *et al.*, 2011, 2012;). The main goal of this study was to analyze the resistance level and productivity of improved varieties of Curcuma plants (Pitamber, Rajendrasonia) under different water stress conditions.

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Doi:https://doi.org/10.36953/ECJ.15482486

Material and Methods

A field study was conducted during the year 2019-20 at the University College of Science, Saifabad, Hyderabad. Arid type of climate was recorded in the Hyderabad. Latitude and longitude of the study area is 17.4074° N, 78.4536° E. Black soil was used for the study and its analysis were conducted by using Digital Soil Testing Mini Lab in Coromandel International Limited located in Center of Excellence (Vegetables and Flowers) Jeedimetla, Hyderabad and the data collected as follows, soil composed of clay (56.5%), silt (23.4%), Fine sand (15.1 %), Coarse sand (4.9 %), pH of the soil was 6.8. Nitrogen content was high in the soil viz., 560.0 kg/ha. Available moisture percentage of the soil was 28.5 mm (0-15 cm depth).The rhizomes of both the categories - control and treatments were planted in pots by using randomized complete block design method with three replications, in order to study the morphological, physiological and yield parameters of turmeric. Two short duration varieties of turmeric, Pitamber, Rajendrasonia were used for the study. The healthy rhizomes of turmeric varieties were collected from Horticulture & Sericulture Department, Nizamabad, Telangana, India. The rhizomes were sterilized by metaloxin mancozeb (150g/150ml concentration) by soaking for 30 minutes. After 30 minutes, the turmeric rhizomes were dried in shade for around one and a half hour and planted in the pots. After 60 days of sowing, the saplings were exogenously treated with 70% thiophanate methyl.

The two treatments provided were treatment A-Moderate water stress giving water in 14 days interval and treatment B-Heavy water stress giving water in 21 days interval, where control includes watering plants weekly once. At each irrigation, 800 ml of water per pot was applied.

Plants for observation were randomly selected from control and treatments to study experimental parameters according to the chapman and pratt method (1978). The parameters choosed for the study is germination percentage where, germination counts were made at 10 days interval upto 90 days after subjecting the rhizomes to the soils of control and treatment categories, when the germination rate becomes almost constant in each pot. However, germination percentage was calculated only at 50 days after sowing, height of the plant where, the main shoot was taken to represent the height of the plant. The plant height was measured in centimeters at 60,120, 180 and 240 days after plantation. The measurement was taken from the soil surface to the shoot apex and the average mean was taken from three plants selected from control and treatment categories randomly, total numbers of thin and tuberous adventitious roots count were made at various growth stages and average mean was taken from three sample plants selected from control and treatment categories randomly at 60,120,180 and 240 days after plantation, number of functional leaves per plant of treatments and control categories were counted at 60,120,180 and 240 days after plantation. Average mean was taken from three sample plants, leaf length, leaf width per plant of treatments and control groups were measured in centimeters at 60,120,180 and 240 days after plantation, Leaf Area was measured by Portable Area Meter (LI-COR) Model LI-3,000 in cm^2. Average mean of leaf area was taken from three plants selected from control and treatment categories respectively at the 60,120,180 and 240 days after plantation.

Net Assimilation Rate measured by Radford method (1967), fresh weight of mother rhizome was measured in grams at 180 and 240 days after plantation by using the electrical balance**,** length of mother rhizome was measured in centimeters at 60,120,180, 240 days after plantation, width of mother Rhizome was measured in centimeters at 240 days after plantation. Dry weight of mother rhizome was measured in grams at 240 days after plantation by using electrical balance. Radford (1967) method was followed to measure the plant Relative Growth Rate at 240 days after plantation. SPSS 16.0 soft ware used to determine the least significant difference ($P \leq 0.05$) and other calculations were carried out using MS Excel 2010.

Results and Discussion

Water stress greatly influences the germination percentage of turmeric. At 50^{th} day after planting Pitamber in the control showed highest germination rate. Rajendrasonia and Pitamber showed 100 percent germination from 70^{th} day onwards in control where water was given 7 days once. In moderate stress condition least germination percentage was recorded in Rajendrasonia than

Pitamber (figure 1 and 2). In the heavy stress condition 0nly 33 percent germination on 50th day was recorded in both varieties. In the heavy stress condition highest germination percentage was recorded in Pitamber compared to Rajendrasonia. Plants are particularly vulnerable to water deficit stress in the course of the key periods of germination of seed and initial development of seedling (Li *et al.*, 2011). The lack of free water availability in the early stages of seeds may be the cause of the reduced seed germination . This would render the hydrolytic enzymes inactive (C. B. Shah *et al.*,1975 , A. Hadas *et al.*, 1976).

Figure 1: Reduction in germination percentage in turmeric varieties

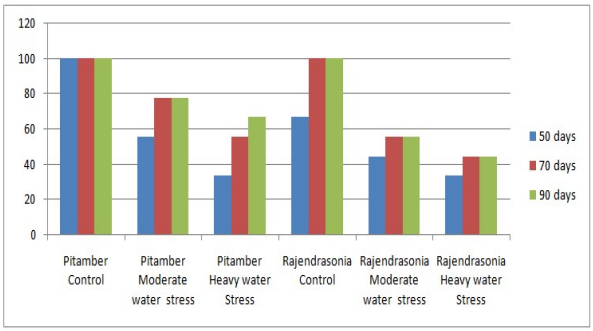

Figure 2: Effect of irrigation intervals on Germination percentage of Mother Rhizome of Rajendrasonia and Pitamber after 50,70,90 days after plantation (mean of sea son 2019 - 2020)

Plant height varied at different stages of growth of turmeric significantly differed among treatments (figure 3). Plant height was noted highest in Pitamber control viz., 110 cm at 240 days after plantation compared to Rajendrasonia(95.4 cm). Pitamber showed highest Plant height (80 cm) than the Rajendrasonia (69.2 cm) in case of moderate water stress condition at 240 days after plantation. Compared to control , plants which exposed to moderate water stress showed reduced plant height. In case of heavy water stress reduced plant height was noted in Rajendrasonia (45.4 cm) compared to Pitamber (50.1 cm).Heavy water stress reduced Plant height. Due to the water deficit condition, mitosis divisions was compromised, and elongation of cell and expansion of cell led to slower plant- growth and development (Hussain *et al.*, 2008).

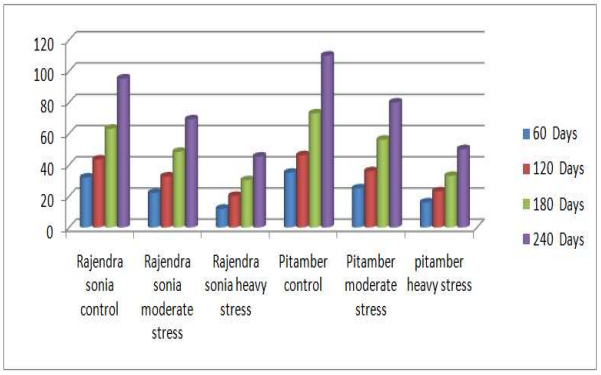

Figure 3: Effect of irrigation intervals on Plant height of Mother Rhizome of selected varieties after 60, 120, 180, 240 days after plantation (mean of season 2019 - 2020)

Number of thin and tuberous adventious roots at different stages of growth of turmeric significantly differed among treatments (figure 4). Highest number of thin and tuberous adventious roots was noted in Pitamber (32) in control at 240 days after plantation compared to Rajendrasonia (30). Pitamber (29) showed maximum number of thin and tuberous adventious roots than the Rajendrasonia(21) in case of moderate water stress condition at 240 days after plantation. Compared to control, the plants which faced moderate stress showed less number of thin and tuberous adventious roots . In case of heavy water stress few number of thin and tuberous adventious roots noted in Rajendrasonia(15) compared to Pitamber (18).Heavy stress reduced number of thin and tuberous adventious roots . According to Dhole and Reddy (2010), as the water potential decreases, the number of roots per plant decreases. Number of leaves per plant at different stages of growth of turmeric significantly differed among treatments (figure 5). The number of leaves slightly reduced in

the plants which were undergone moderate water stress compared to control.

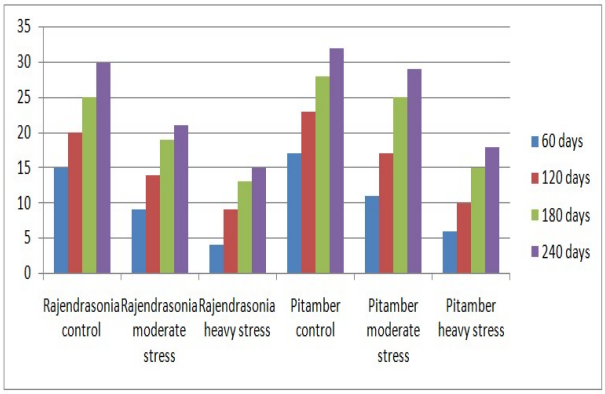

Figure 4: Effect of irrigation intervals on number of thin and tuberous adventious roots of Rajendrasonia and Pitamber after 60,120,180,240 days after plantation (Mean of season 2019 - 2020)

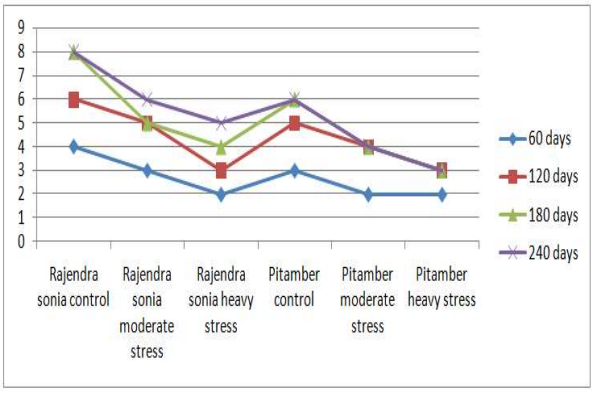

Figure 5: Effect of irrigation intervals on Number of leaves of Mother Rhizome of Rajendrasonia and Pitamber after 60,120,180,240 days after plantation (mean of season 2019 - 2020)

Among the two varieties Rajendrasonia (6) leaves was less affected than Pitamber (4) leaves. 5 leaves were recorded in Rajendrasonia and 3 leaves were recorded in Pitamber at 240 days after plantation in case of heavy water stress condition compared to control. Among the two varieties Rajendrasonia is less affected than Pitamber. Compared to control Pitamber more affected than Rajendrasonia. The number of leaves observed under the severely stressed treatment (CG 80–85% MAD) are in agreement with the findings on the response of water stress on essential oil of oregano by, Said-A l Ahl *et al.*(2009), Auges Gatabazi *et al* . (2019).

Leaf length of mother rhizome (cm) at different stages of growth of turmeric significantly differed among treatments (figure 6) In control maximum leaf Length was noted in Pitamber(45.5 cm) . In moderate water stress condition leaf length was less affected in pitamber (20.5,27.2,35.3,40) than Rajendrasonia (20,26,30,35 cm) at 60, 120,180,240 days after plantation. Compared to control both are slightly reduced. In heavy water stress condition leaf length was more affected in pitamber and Rajendrasonia at 60, 120,180,240 days after plantation, compared to control and moderate stress .Among the two leaf length was less affected in Pitamber(30.5 cm) than Rajendrasonia (25 cm) at 240 days after plantation. Leaf width of mother rhizome (cm) at different stages of growth of turmeric significantly differed among treatments (figure 7) In control maxium leaf width was noted in Pitamber(9.9 cm) at 240 days after plantation .In moderate water stress condition leaf width was less affected in Pitamber than Rajendrasonia at 60, 120,180,240 days after plantation. Compared to control, Pitamber (7.9 cm) and Rajendrasonia (7.7 cm) are slightly reduced at 240 days after plantation. In heavy water stress condition leaf width was more affected in pitamber and Rajendrasonia compared to control and moderate stress .Among the two varieties leaf width was less affected in Pitamber (6.1 cm) than Rajendrasonia (5.9 cm) at 240 days after plantation. Both the total number of leaves and the size of each individual leaf diminish during a drought. The amount that the leaf expands is frequently governed by the turgor pressure and the availability of assimilates. Reduced turgor pressure and a slow rate of photosynthesis, largely restrict leaves from expanding in dry conditions (Rucker *et al.*, 1995)

Leaf Area of mother rhizome plant (cm^2) at different stages of growth of turmeric significantly differed among treatments (figure 8). In control maxium leaf area was noted in Pitamber (150.5 cm^2) at 240 days after plantation .In moderate water stress condition leaf area was less affected in Pitamber than Rajendrasonia at 60, 120,180,240 DAP. Compared to control, Pitamber (124.5 cm^2) and Rajendrasonia (114 cm^2) are slightly reduced. In heavy water stress condition leaf area was more affected in Pitamber and Rajendrasonia compared to control and moderate water stress. Among the

two, leaf area was less affected in Pitamber (79.5 cm ^{2}) than Rajendrasonia (66 cm^2). The results are agreed with the Bittimen.s *et al* (1987).

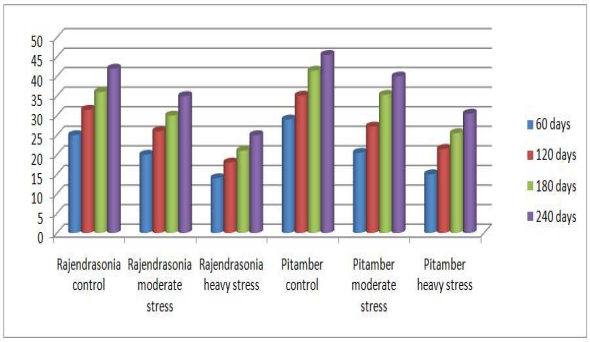

Figure 6: Effect of irrigation intervals on leaf length of mother rhizome in cm of Rajendrasonia and Pitamber after 60,120,180,240 days after plantation (mean of season 2019 - 2020)

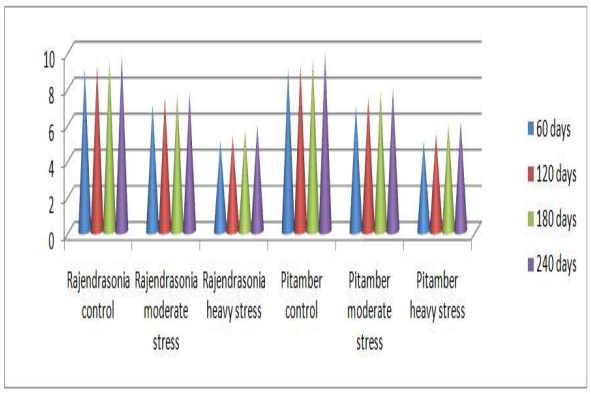

Figure 7: Effect of irrigation intervals on leaf width of mother rhizome in cm of Rajendrasonia and Pitamber after 60,120,180,240 days after plantation (mean of season 2019 - 2020)

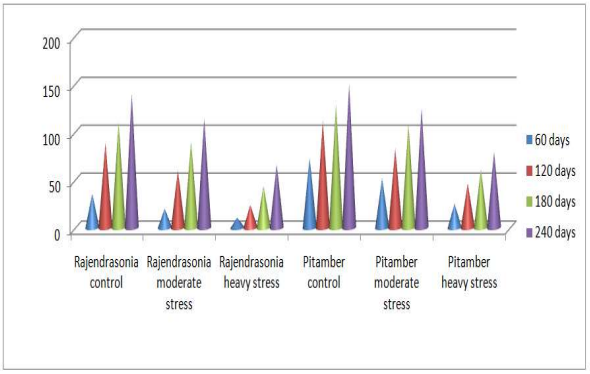

Figure 8: Effect of irrigation intervals on leaf area of mother rhizome in cm^2 of Rajendrasonia and Pitamber after 60,120,180,240 days after plantation (mean of season 2019 - 2020)

Physiological aspects:

Leaf Area Index of mother rhizome plant at different stages of growth of turmeric significantly differed among treatments (figure 9). In control

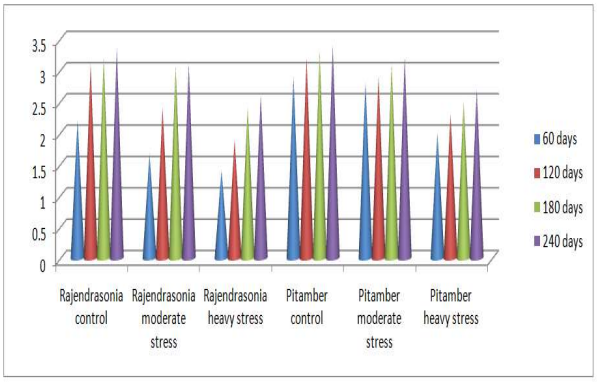

Figure 9: Effect of irrigation intervals on Leaf Area Index of Mother rhizome of Rajendrasonia and Pitamber after 60,120,180,240 days after plantation (mean of season 2019 - 2020)

maxium leaf area index was noted in Pitamber (3.4) .In moderate water stress condition leaf area index was less affected in Pitamber than Rajendrasonia at 60, 120,180,240 DAP. Compared to control both are slightly reduced. In heavy water stress condition leaf area index was more affected in Pitamber(2.7) and Rajendrasonia(2.6) compared to control and moderate stress .Among the two varieties leaf area index was less affected in Pitamber than Rajendrasonia. The reduced leaf area index value under stress is due to fewer and smaller leaves, as well as a well-documented drought response in many crops. The leaf area index responds to physiological activities that are necessary for dry matter generation, such as leaf expansion and photosynthesis (Blum 2005) A prior investigation of *Pelargonium sidoides* growth in response to water and nitrogen levels demonstrated a decrease in leaf area with water stress. Similarly, Acreche et al (2009), found that well-watered commercial ginger had the highest leaf area index when compared to stress given treatments.

Net Assimilation Rate of mother rhizome was measured after 240 DAP. It Was observed that Pitamber (0.0041) net assimilation rate was less affected than Rajendrasonia (0.002)in control (figure 10).In moderate water stress condition net

assimilation rate of mother rhizome were affected more in Pitamber(0.003) and Rajendrasonia (0.001) compared to control. Among the two selected varieties Pitamber performance is good than the variety Rajendrasonia at 240 DAP. In heavy water stress condition net assimilation rate was more affected in Pitamber (0.002) and Rajendrasonia (0.00064) compared to control and moderate stress. Among the two net assimilation rate was less affected in Pitamber than Rajendrasonia. The results are similar with Moradi et al (2008), who discovered that water deficit stress during the vegetative development phase significantly reduced NAR and came to the conclusion that irrigation should be extended throughout all growth stages, particularly during the reproductive phase, to maximise Net Assimilation Rate. Relative Growth Rate of mother rhizome was measured after 240 DAP. It Was observed that Pitamber (0.0194) Relative Growth Rate was less affected than Rajendrasonia (0.01) in control (figure 11).

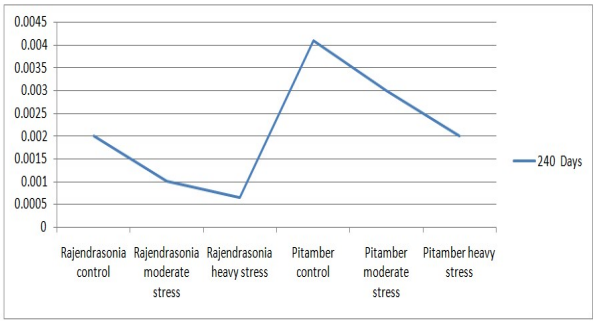

Figure10: Effect of irrigation intervals on Net Assimilation Rate of Mother rhizome of Rajendrasonia and Pitamber after 240 days after plantation (mean of season 2019 - 2020)

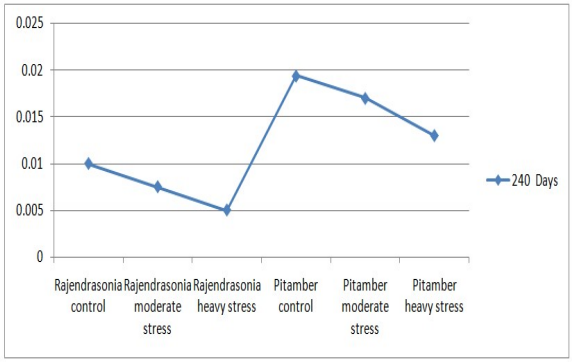

Figure 11: Effect of irrigation intervals on Relative Growth Rate of mother rhizome of Rajendrasonia and Pitamber after 240 days after plantation (mean of season2019 and 2020)

In moderate water stress condition Relative Growth Rate of mother rhizome were affected more in Pitamber (0.017) and Rajendrasonia (0.0075) compared to control. Among the two selected varieties Pitamaber performance is good than the variety Rajendrasonia at 240 DAP. In heavy water stress condition Relative Growth Rate was more affected in Pitamber (0.013) and Rajendrasonia (0.005) compared to control and moderate stress .Among the two Relative Growth Rate was less affected in Pitamber than Rajendrasonia. The results are agreed with Shihab Uddin et al (2013) ,who mentioned lack of water significantly lowers RGR in mung variety.Concerning the combination between irrigation and the two species of *Curcuma* plants it can be noticed that there were no significant effect on the growth and physiological parameters. The results obtained are agreed with the results of Leithy *et al.* 2006 on rosemary and El-Mekawy (2013) on Achillea santolina. Under supply of water had modified the rosemary plants morphology, i.e declined height of the plant and the shoot development according to Nicola´s *et al.* (2008).According to L. El-Tahir *et al.* (2011), this may be due to the vital functions of water supply at adequate amount of diverse physiological processes such as photosynthesis, respiration, transpiration, translocation, enzyme reaction, and cell turgidity occurring concurrently. Furthermore, rising levels of water stress impair growth and yield due to decreased photosynthesis due to decreased stomata and mesophyll conductivity. Studies on *Catharanthus roseus* seedlings by Amirjani (2013) reported that subjecting seedlings to four varied water- treatments i.e irrigating once in every week, every two weeks and once in three weeks, where plants in control were given water daily. The activity of photosynthesis and rate of transpiration were significantly declined with drought level enhancement.

Yield aspects

Fresh weight of mother rhizome (gms) at different stages of growth of turmeric significantly differed among treatments (figure 12). In control maxium fresh weight was noted in Pitamber (60.2 grams) at 240 days after plantation .In moderate water stress condition fresh weight was less affected in

Pitamber (22,42 grams) than Rajendrasonia (19,28 grams) at 180,240 days after plantation. Compared to control both are slightly reduced. In heavy water stress condition fresh weight was more affected in Pitamber and Rajendrasonia compared to control and moderate stress .Among the two fresh weight was less affected in Pitamber (28 grams) than Rajendrasonia (19.8 grams). The results similar with Auges Gatabazi *et al.*, 2019, who found that fresh weight of commercial ginger was more negatively impacted by extreme water stress than that of African ginger. Length of mother rhizome in cms at different stages of growth of turmeric significantly differed among treatments (figure 13).

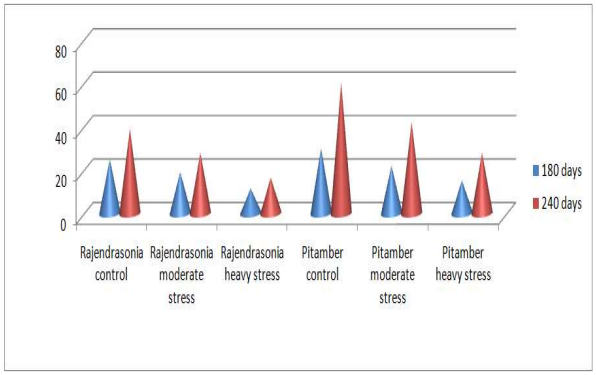

Figure 12: Effect of irrigation intervals on Fresh weight of Mother rhizome in grams of Rajendrasonia and Pitamber after 180,240 days after plantation (mean of season 2019 - 2020).

In control maximum length of mother rhizome was noted in Pitamber(6.9 cm) .In moderate water stress condition length of mother rhizome was less affected in Pitamber (4.9,5.2,5.7,5.9 cm) than Rajendrasonia (4.1,4.4,4.7,4.9 cm) at 60, 120,180,240 days after plantation. Compared to control both are slightly reduced. In heavy water stress condition length of mother rhizome was more affected in Pitamber and Rajendrasonia compared to control and moderate stress .Among the two length of mother rhizome was less affected in Pitamber (5.1 cm) than Rajendrasonia (4.6 cm) at 240 days after plantation. The differences between the irrigation intervals were significant in most cases. Width of mother rhizome in cms at different stages of growth of turmeric significantly differed among treatments (figure 14). In control maxium Width of mother rhizome was noted in Pitamber (4.3 cm) .In moderate water stress condition Width of mother rhizome was less affected in Pitamber (3.3 cm) than Rajendrasonia (2.2 cm) at 240 days after plantation.

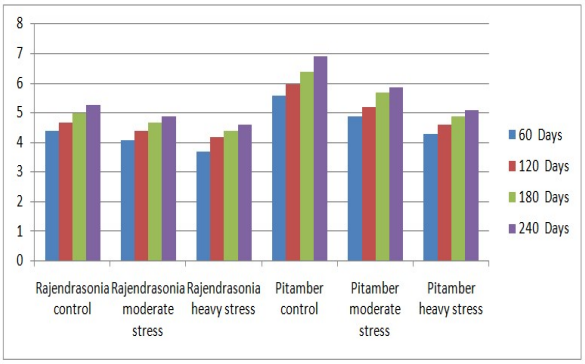

Figure13: Effect of irrigation intervals on length of Mother rhizome in cm of Rajendrasonia and Pitamber after 60,120,180,240 days after plantation (mean of season 2019 - 2020)

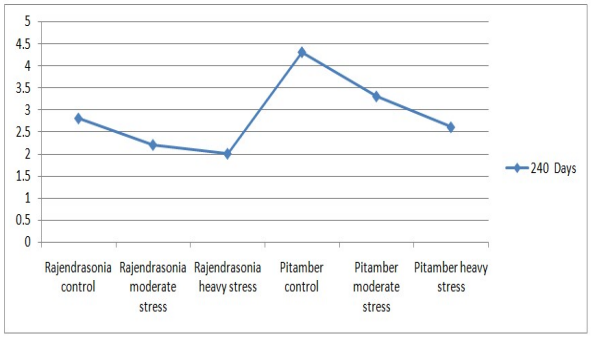

Figure 14: Effect of irrigation intervals on width of mother rhizome in cms of Rajendrasonia and Pitamber after 240 days after plantation (mean of season 2019 and 2020)

Compared to control both are slightly reduced. In heavy water stress condition Width of mother rhizome was more affected in Pitamber and Rajendrasonia compared to control and moderate stress .Among the two Width of mother rhizome was less affected in Pitamber (2.6 cm) than Rajendrasonia (2 cm). Dry weight of mother rhizome(gms) at different stages of growth of turmeric significantly differed among treatments (figure 15). In control maximum dryweight was noted in Rajendrasonia (8.0 grams). In moderate water stress condition dry weight was maximum in Rajendrasonia than Pitamber at 180,240 days after plantation. Compared to control both are slightly reduced. In heavy water stress condition dryweight

was more affected in Pitamber and Rajendrasonia compared to control and moderate stress .

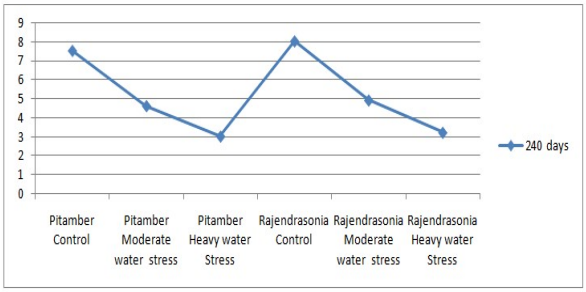

Figure 15: Effect of irrigation intervals on Dry weight of mother rhizome in gms of Rajendrasonia and Pitamber after 240 days after plantation (mean of season 2019 and 2020)

Among the two dry weight was maximum noted in Rajendrasonia (3.2 grams) than Pitamber (3.0 grams) at 240 days after plantation. According to earlier findings, when there is a water deficit, the dry weight reduces due to a decrease in chlorophyll concentration, which lowers the effectiveness of photosynthesis, as noted by Khalid (2006). The results were similar with this.

Mean of weight of whole rhizome in kgs per plant of selected varieties after 240 Days After Plantation (DAP) were recorded. It Was observed that Pitamber rhizome (0.123 kg) whole weight was maximum than Rajendrasonia (0.079 kg) in control (figure 16). In moderate stress condition weight of whole rhizome were affected more in Pitamber and Rajendrasonia compared to control.

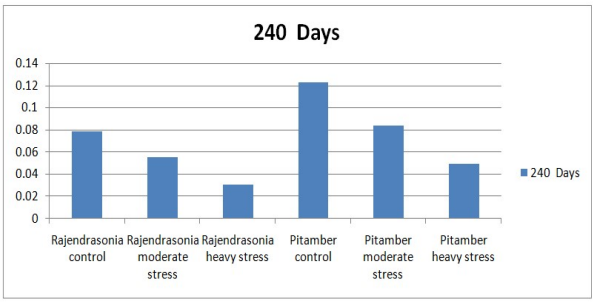

Figure 16: Effect of irrigation intervals on weight of whole rhizome of Rajendrasonia and Pitamber after 240 days after plantation (mean of season 2019 and 2020).

Among the two selected varieties Pitamber rhizome (0.084 kg) weight was maximum than the variety Rajendrasonia (0.056 kg) at 240 days after plantation. In heavy stress condition rhizome whole weight was more affected in Pitamber and Rajendrasonia compared to control and moderate stress .Among the two whole rhizome weight was less affected in Pitamber (0.050 kg) than Rajendrasonia (0.031 kg). The results are agreed with the findings mentioned.Water plays a crucial role in plant growth and its production of several crops & medicinal plants was prooved by several researchers. Nutrients absorption drastically reduced as a result of reduction in vegetative development of plants as per Pascale *et al.* (2001). A study of several irrigation regimes on potato development and production found that total fresh and marketable tuber output improved with increasing irrigation (Yuan, B.Z. *et al.*,2003).Total plant fresh weight, Total dry weight of plant "*Satureja hortensis*" (summer savory) was awfully reduced under soil water debt conditions. (Baher *et al.*, 2002).A Study on "*Eragrostis curvula"* plant cultivated under water stress showed that plant number, stem number, dry weight was affected adversely (Colom and Vazzana, 2002). Dry weight of the plant was reduced drastically because of decrease in the content of chlorophyll as reports mentioned under deficit water condition satisfied with the data of Khalid (2006). The results mentioned are satisfied with the results obtained by Farooq (2009) who mentioned that morphological parameters and yield parameters of plant was severely reduced by drought stress, which mainly affects biochemical functions and physiological aspects i.e photosynthesis, trans-location, respiration, uptake of ions, carbohydrates, nutrient- metabolism and promoters of growth. Reduced plant biomass recorded in *Salvia officinalis* (Bettaieb, I *et al.*, 2009) Jyotsna et al (2012) found similar results in ginger, reporting that water stress reduced growth and yield. Mulu et al (2012) conducted studies on onion crop and found that well-watered treatments given better yields than stressed ones.

Conclusion

Pitamber showed good germination percentage, highest number of thin and tuberous roots, maximum leaf length, leaf area, leaf area index, plant height, plant fresh weight and also resulted in highest relative growth rate, net assimilation rate in control than Rajendrasonia. In moderate stress these parameters

was slightly reduced in Pitamber and Rajendrasonia compared to control. Among the two Pitamber was less affected at 60, 120,180,240 DAP. In heavy water stress condition, where water given 21 days once showed more impact on all the parameters of pitamber and Rajendrasonia compared to control and moderate water stress. Among the two, pitamber was less affected than Rajendrasonia. Rajendrasonia leaves number, leaf width, dry weight was maximum in control than Pitamber and its leaves number, leaf width, dry weight were less affected in moderate and in heavy
stress condition than Pitamber. Irrigating turmeric two weeks once showed minor impact on plants than irrigating those three weeks once. In heavy water stress, plants were affected in all morphological, physiological and yield parameters. Thus, irrigation intervals every one week improved growth characteristics and yield of selected *Curcuma* varieties. Pitamber produced the higher values as compared to Rajendrasonia.

Conflict of interest

The authors declare that they have no conflict of interest.

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