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Influence of Fertigation Levels and Drip Irrigation on Yield and Quality of Summer Watermelon under with Mulch and without Mulch Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field trial was carried out during summer season at Water Technology Center fields, College Farm, PJTSAU, Hyderabad, Telangana to study the individual and combined effect of fertigation levels, mulch and drip irrigation levels on performance of watermelon for two consecutive years 2020-21 & 2021-22. The experiment consisted of 12 treatment combinations of three fertigation levels (F_{75}, F_{100} & F_{125}) & two drip irrigation levels ($I_{0.8}$ & $I_{1.0}$) imposed under factorial combination of with mulch (M_1) and no mulch (M_0). Among the fertigation levels, The F_{125} has recorded the highest fresh fruit yield (48.52 t ha^{-1}), TSS (11.55 %) and lycopene content (0.68 mg 100 g^{-1} of sample) over F_{100} & F_{75} in the pooled data. Mulch has shown significant influence on fresh fruit yield and quality of watermelon. The M_1 has registered higher fresh fruit yield (59.04 t ha^{-1}), TSS (12.10 %) and lycopene content (0.76 mg 100 g^{-1} of sample) as compared to non-mulching treatment. On another hand drip irrigation levels did not shows significant effect on yield and quality of the watermelon during both the year (2020-21 and 2021-22).

Keywords: Fertigation levels; mulch; drip irrigation; watermelon fruit yield; TSS; lycopene.

1. INTRODUCTION

Watermelon (*Citrullus lanatus*) belongs to the family of Cucurbitaceae and genus of *Citrullus*. It is originated from South Africa and growth is favoured by long period of warm and dry weather. Watermelon is cultivated throughout the world, it's consumption and acreage has been increased in the past years. Globally, the share of watermelon in total fruit production decreased from 13 to 11 between 2000 and 2021 (FAO STAT-2022). In India it is cultivated in many states like Uttar Pradesh, Andhra Pradesh, Maharashtra, Gujarat, etc. In India it is cultivated in the area of 120 thousand ha, with production of 3504.9 thousand MT and productivity is about 28.2 MT ha^{-1} (Indiastat-2021-22). In Telangana, watermelon production is about 64.66 thousand MT which shares about 2 % of India's total production.

Watermelon contains several mineral (K, P & Mg), vitamin C, antioxidants (lycopene) and citrulline. Growth, yield and quality of watermelon are considerably influenced by the nutrient and water availability to the crop (Nisha et al., 2020). Fertilization is important manageable factor which determine the plant production but addition extra amounts of fertilizers produces many ecological problems. Other than that excess application of fertilizers results in adverse effects on the fruit yield and quality. Conventional application of fertilizers may not meet the demand of desirable yield per unit land hence fertigation is opted to improve the production along with nutrient user efficiency (Shubham, 2020). It helps in reducing the nutrient losses when it coupled with mulch.

In present context climate change, it's variability has tremendous influence on arid and semi-arid agricultural production. Climate change directly or indirectly influencing many factors of fruit crop production including soil fertility, water availability, production cycle and pest population (Yesim et al., 2021). Cultivation of horticultural crops experiences the extreme heat and high rain fall patterns. Specific climatic condition like rain fall pattern, higher CO_2 and temperature can impact the physiological responses of summer grown watermelon (Rao et al., 2017) which can have detrimental effect on yield and quality hence practising mulch may beneficial for fruit production. The utmost benefit of drip irrigation coupled with mulch is that soil temperature is reduced during hotter days and raised during cooler days, which promotes the faster crop growth and early maturity (Dadheech et al., 2018). In addition to this mulches made more availability available nutrients which resulted in higher yield and quality of fruits. Information on fertigation levels, mulch and irrigation levels in relation to watermelon performance is very less in Telangana and more research needed of this region.

2. MATERIALS AND METHODS

The present experiment was carried out at Water Technology Center fields, College Farm, College of Agriculture, Rajendranagar, Hyderabad during summer season of 2020-21 and 2021-22. The field experiment was laid out in randomised block design, wherein three fertigation levels (F_{75}, F_{100} & F_{125}) & two drip irrigation levels ($I_{0.8}$ & $I_{1.0}$) imposed under factorial combination of with mulch (M_1) and no mulch (M_0). Thus, the experiment consisted of total 12 treatment combinations which were replicated thrice. Silver-black mulch (30 µ) sheet was laid on the field as per the treatments. Robust seeds of watermelon hybrid (super queen) used as test crop and seeds were sown in paired row method at spacing 40 / 40 cm x 80 cm. Equal amount of irrigation was given up to 10 DAS to get better establishment after that irrigation was scheduled at 2 days interval based on daily evaporation data (0.8 Epan & 1.0 Epan) recorded from USWB class 'A' pan evaporimeter in agro-meteorological station, ARI Farm, Rajendranagar, Hyderabad. The irrigation duration was based on the number of laterals, emitter spacing and emitter discharge for a given design area. To calculate the application rate and irrigation time of the drip system following formulae was used:

Application rate (mm h^{-1}) = Q / D_L x D_E

Where,

Q = Dripper discharge (L h^{-1})
D_L= Distance between laterals (m)
D_E = Distance between drippers (m)

Irrigation time (minutes) = Epan X 60 / Application rate (mm h^{-1})

The fertigation was carried out through ventury system on every 4th day at 190splits as per the treatments. The yield data was recorded at each picking and mean data statistically analysed. The TSS reading was measured immediately after harvesting of the fresh fruits by using refractometer expressed in %. Lycopene content estimated from 5 g of watermelon pulp with acetone in a pestle and mortar till residues became colourless. Lycopene was transferred into petroleum ether phase by diluting acetone extract in a separating funnel, passed through sodium sulfate, volume was made to 50 ml and absorbance was measured at 503 nm using UV visible spectrophotometer. Lycopene content was calculated by using the formula (Sadasivam, S and Manickam, A 2005):

Lycopene (mg 100 g^{-1} sample) = Absorbance at 503 nm X 31.206 / Wt. of the sample (g)

3. RESULTS AND DISCUSSION

3.1 Yield (t ha^{-1})

Yield is a complex phenomenon and partitioning of dry matter between vegetative and reproductive parts is an important process that causes variations in yield. Yield potential of watermelon is dependent on the cultivar chosen and management practices adopted. Thus it is important to measure variation among imposed fertigation levels, mulch and drip irrigation levels on each picking of watermelon.

The scrutinized data on total fresh fruit yield of watermelon during I, II years and pooled data is presented in Table.1 and illustrated in Fig. 1. There was significant variation found among the fertigation levels during I year, II year and in pooled data. During I year (2020-21), the F_{125} has recorded higher total fresh fruit yield (42.37 kg ha^{-1}) followed by F_{100} (38.05 t ha^{-1}) and the lowest was registered in F_{75} (35.38 t ha^{-1}). Likewise during II year (2021-22), F_{125} (54.67 kg ha^{-1}) has recorded higher total fresh fruit yield over F_{100} (51.95 t ha^{-1}) and F_{75} (44.05 t ha^{-1}). In pooled data, the highest total fresh fruit yield was recorded in F_{125} (48.52 t ha^{-1}) and which was comparable with F_{100} (44.99 t ha^{-1}) and significantly higher over F_{75} (39.72 t ha^{-1}). From the data it was clearly observed that linear increased yield was observed with increasing nutrient levels from F_{75} to F_{125} during both the years. The F_{125} treatment has recorded 11.41 %, 5.23 % & 7.85 % increase in total fresh fruit yield over F_{100} during I, II year and in pooled data respectively. Whereas F_{100} treatment has recorded 19.75% and 24.12 % increase in total fresh fruit yield over F_{75} during I & II year respectively. In pooled data F_{100} treatment has resulted in 22.17 % increase in total fresh fruit yield as compared to F_{75}.

Mulching (M_1) of watermelon crop was found to significantly increase the total fresh fruit yield during both the years. With mulching, during I year, it has recorded 51.72 t ha^{-1} which was 2.03 times higher over non-mulching (M_0) (25.47 t ha^{-1}). Similarly during II year also the crop has recorded total fresh fruit yield (66.35 t ha^{-1}) which was 1.95 times higher over non-mulching (34.10 t ha^{-1}). In pooled data the mulching treatment has recorded 59.04 t ha^{-1} total fresh fruit yield which was 1.98 times higher as compared to non-mulch (29.78 t ha^{-1}).

There was no significant variation found between irrigation levels on total fresh fruit yield of watermelon during both the years. Relatively higher fresh fruit yield was noticed in $I_{1.0}$ Epan as compared $I_{0.8.}$ With $I_{1.0}$ level, the total fresh fruit yield recorded was 38.97, 51.12 & 45.05 t ha^{-1} during I year, II year & pooled data respectively.

Whereas the data recorded in $I_{0.8}$ was about 38.22, 49.32 & 43.77 t ha^{-1} during I, II year & pooled data respectively. It is interesting to observe differential response of watermelon crop to different irrigation levels i.e., $I_{1.0}$ & $I_{0.8}$ under mulched (M_1) & non-mulch (M_0) conditions.

Output analysis variance revealed that interaction between fertigation and drip irrigation resulted in higher total fruit yield during 2020-21 (I year) and presented in Table 2. The treatment F_{125} + $I_{0.8}$ has recorded the highest total fresh fruit yield of watermelon (43.25 t ha^{-1}) and it was on par with F_{125}+$I_{1.0}$ (42.37 t ha^{-1}), F_{100} + $I_{0.8}$ (38.70 t ha^{-1}), F_{100} + $I_{1.0}$ (37.37 t ha^{-1}) F_{75}+$I_{1.0}$ (38.04 t ha^{-1}) and F_{75}+ $I_{0.8}$ (32.73 t ha^{-1}). During II year fertigation levels coupled with mulch treatments were found to be significant. The highest total fresh fruit yield was recorded by F_{125} + M_1 (72.49 t ha^{-1}) which was comparable with F_{125} + M_1 (70.30 t ha^{-1}) and significantly lower fresh fruit yield was recorded in F_{75} + M_0 (31.84 t ha^{-1}). In pooled data, none of the interactions showed any significant influence on total fresh fruit yield of watermelon. Relatively the highest fresh fruit yield was recorded in F_{125} + $I_{0.8}$ + M_1 (69.09 t ha^{-1}) closely followed by F_{100} + $I_{0.8}$ + M_1 (61.88 t ha^{-1}) and F_{125} + $I_{1.0}$ + M_1 (59.80 t ha^{-1}).

Table 1. Effect of fertigation and irrigation levels under mulch and non-mulch conditions on total fresh fruit yield (t ha^{-1}) of watermelon during 2020-21 (I year), 2021-21 (II year) and in pooled data during summer season

2020-21 (I Year)- Total Yield (t ha^{-1})							
Treatments	**No mulch**		**Mean**	**Mulch**		**Mean**	**Overall Mean**
	$I_{0.8}$	**$I_{1.0}$**		**$I_{0.8}$**	**$I_{1.0}$**		
F_{75}	20.24	25.79	23.02	45.21	50.29	47.75	35.38
F_{100}	23.87	26.23	25.05	53.53	48.51	51.02	38.03
F_{125}	26.14	30.53	28.34	60.36	52.45	56.40	42.37
Mean	23.42	27.52	25.47	53.03	50.42	51.72	
	Mean of $I_{0.8}$		**38.22**	**Mean of $I_{1.0}$**		**38.97**	
Treatments	**SEm(±)**	**CD *(P=0.05)***	**Interactions**			**SEm(±)**	**CD *(P=0.05)***
Mulch (M)	2.42	7.10	I X M			3.42	NS
Irrigation (I)	2.42	NS	F x M			4.19	NS
Fertigation (F)	0.86	2.51	F x I			4.19	12.29
			F x M x I			5.93	NS
2021-22 (II Year)-Total Yield (t ha^{-1})							
F_{75}	29.97	33.70	31.84	53.88	58.64	56.26	44.05
F_{100}	31.56	35.63	33.60	70.22	70.37	70.30	51.95
F_{125}	32.45	41.26	36.85	77.83	67.15	72.49	54.67
Mean	31.33	36.87	34.10	67.31	65.38	66.35	
	Mean of $I_{0.8}$		**49.32**	**Mean of $I_{1.0}$**		**51.12**	
Treatments	**SEm(±)**	**CD *(P=0.05)***	**Interactions**			**SEm(±)**	**CD *(P=0.05)***
Mulch (M)	2.87	8.41	I X M			4.05	NS
Irrigation (I)	2.87	NS	F x M			4.96	14.56
Fertigation (F)	1.01	2.97	F x I			4.96	NS
			F x M x I			7.02	NS
Mean of two years (pooled data)- Total Yield (t ha^{-1})							
F_{75}	25.11	29.75	27.43	49.54	54.46	52.00	39.72
F_{100}	27.71	30.93	29.32	61.88	59.44	60.66	44.99
F_{125}	29.29	35.90	32.60	69.09	59.80	64.45	48.52
Mean	27.37	32.19	29.78	60.17	57.90	59.04	
	Mean of $I_{0.8}$		**43.77**	**Mean of $I_{1.0}$**		**45.05**	
Treatments	**SEm(±)**	**CD (P=0.05)**	**Interactions**			**SEm(±)**	**CD (P=0.05)**
Mulch (M)	3.48	10.20	I X M			4.92	NS
Irrigation (I)	3.48	NS	F x M			6.02	NS
Fertigation (F)	1.23	3.61	F x I			6.02	NS
			F x M x I			8.52	NS

F_{75}= 75-75-45 kg N-P_2O_5-K_2O ha^{-1}; F_{100}= 100-100-60 kg N-P_2O_5-K_2O ha^{-1}; F_{125}= 125-125-75 kg N-P_2O_5-K_2O ha^{-1}; $I_{0.8}$-0.8 Epan and $I_{1.0}$-1.0 Epan

Table 2. Interaction effect between fertigation levels and irrigation levels on total fresh fruit yield of watermelon crop during 2020-21 (I year) during summer season

2020-21 (I Year)- Total Yield (t ha^{-1})							
Treatments	**$I_{0.8}$**		**Mean**	**$I_{1.0}$**		**Mean**	**Overall Mean**
	No Mulch	**Mulch**		**No Mulch**	**Mulch**		
F_{75}	20.24	45.21	32.73	25.79	50.29	38.04	35.38
F_{100}	23.87	53.53	38.70	26.23	48.51	37.37	38.03
F_{125}	26.14	60.36	43.25	30.53	52.45	41.49	42.37
Mean	23.42	53.03	38.22	27.52	50.42	38.97	
	No Mulch		**25.47**	**Mulch**		**51.72**	
Treatments	**SEm(±)**	**CD (P=0.05)**	**Interactions**			**SEm(±)**	**CD (P=0.05)**
Mulch (M)	2.42	7.10	I X M			3.42	NS
Irrigation (I)	2.42	NS	F x M			4.19	NS
Fertigation (F)	0.86	2.51	F x I			4.19	12.29
			F x M x I			5.93	NS

F_{75}= 75-75-45 kg N-P_2O_5-K_2O ha^{-1}; F_{100}= 100-100-60 kg N-P_2O_5-K_2O ha^{-1}; F_{125}= 125-125-75 kg N-P_2O_5-K_2O ha^{-1}; $I_{0.8}$-0.8 Epan and $I_{1.0}$-1.0 Epan

From pooled data under no mulch conditions, at F_{125} & F_{100} levels, $I_{1.0}$ has recorded 22.55 % & 11.61 % higher yield than $I_{0.8}$ respectively. Whereas F_{75} + $I_{1.0}$ has recorded 4.64 t ha^{-1} higher yield over $I_{0.8}$ and higher response was noticed in F_{125} & F_{100} levels for $I_{1.0}$ over $I_{0.8}$. Thus it is clear that under no mulch condition irrespective of fertigation levels, irrigation level @ $I_{1.0}$ required for watermelon if mulching is done for lower fertigation levels (F_{75}) we need to go for $I_{1.0}$ but at higher fertigation levels (F_{125} & F_{100}), $I_{0.8}$ was enough to meet the crop need.

Relatively higher total fruit yield was recorded in treatment combination of F_{125} + $I_{0.8}$ + M_1. It might be due to higher number of leaves translated to sound chlorophyll development and more stomatal conductance leading to more photosynthetes were translocated to sink causing early maturity and enhanced fruit yield which was positively correlated with yield attributing parameters. Water along with fertilizers were applied frequently and periodically in small amounts in each irrigation interval according to crop requirement to ensure adequate supply of water and nutrients in the root zone and it could be attributed to the stimulation effect of fertigation for the root system by enhancing the efficiency of nutrient absorption (Asad et al., 2019). These findings were in conformity with the findings of Deshmukh, (2005). Nisha et al. (2020) reported that treatment combination of 0.8 Epan + 100% NPK fertilization increased fruit yield of watermelon and it could be due to the linear increase of NPK increased leaf area index and increase in the period for which the crop remained green under mulch which resulted in increased capture of radiation energy and consequently more assimilation rate lead to higher number of fruits and fruit yield.

3.2 Quality Parameters

In any production system, the chief goal is to achieve maximum fruit yield per unit area without affecting the fruit quality. In watermelon, quality is mainly judged by total soluble solids (TSS) and colour of the pulp (lycopene content) in the fruits. Application of nutrients under mulch through fertigation has made a remarkable effect on fruit quality.

3.3 Total Soluble Solids (%)

The total soluble solid (%) content of the watermelon expressed as ºBrix. It is equivalent to percentage of reference sugar solution. The TSS is mainly composed of sugars like fructose. The data regarding to TSS (%) of watermelon is presented in Table 3. TSS values were increased with increment in fertigation levels from F_{75} to F_{125}. Irrespective to the treatments, TSS values were significantly influenced by fertigation levels and mulch treatments during both the years and in pooled data. One hand drip irrigation levels did not significantly influence the TSS and another hand interaction of fertigation levels, mulch and drip irrigation levels shows insignificant effect on TSS values.

Table 3. Effect of fertigation and irrigation levels under mulch and non-mulch conditions on TSS (%) of watermelon during 2020-21 (I year), 2021-21 (II year) and in pooled data during summer season

2020-21 (I Year)- TSS (%)							
Treatments	**No mulch**		**Mean**	**Mulch**		**Mean**	**Overall Mean**
	$I_{0.8}$	**$I_{1.0}$**		**$I_{0.8}$**	**$I_{1.0}$**		
F_{75}	9.40	8.97	9.18	10.87	9.93	10.40	9.79
F_{100}	9.57	8.73	9.15	11.93	11.17	11.55	10.35
F_{125}	9.63	9.17	9.40	12.53	11.40	11.97	10.68
Mean	9.53	8.96	9.24	11.78	10.83	11.31	
Mean of $I_{0.8}$			**10.66**	**Mean of $I_{1.0}$**		**9.89**	
Treatments	**SEm(±)**	**CD (*P=0.05*)**	**Interactions**			**SEm(±)**	**CD (*P=0.05*)**
Mulch (M)	0.38	1.11	I X M			0.53	NS
Irrigation (I)	0.38	NS	F x M			0.65	NS
Fertigation (F)	0.13	0.39	F x I			0.65	NS
			F x M x I			0.93	NS
2021-22 (II Year)-TSS (%)							
F_{75}	9.50	9.68	9.59	12.77	12.53	12.65	11.12
F_{100}	11.83	9.80	10.82	13.27	12.60	12.93	11.88
F_{125}	11.90	11.57	11.73	13.47	12.73	13.10	12.42
Mean	11.08	10.35	10.71	13.17	12.62	12.89	
Mean of $I_{0.8}$			**12.12**	**Mean of $I_{1.0}$**		**11.49**	
Treatments	**SEm(±)**	**CD (*P=0.05*)**	**Interactions**			**SEm(±)**	**CD (*P=0.05*)**
Mulch (M)	0.46	1.34	I X M			0.64	NS
Irrigation (I)	0.46	NS	F x M			0.79	NS
Fertigation (F)	0.16	0.47	F x I			0.79	NS
			F x M x I			1.12	NS
Mean of two years (pooled data)- TSS (%)							
F_{75}	9.45	9.33	9.39	11.82	11.23	11.53	10.46
F_{100}	10.70	9.27	9.98	12.60	11.88	12.24	11.11
F_{125}	10.77	10.37	10.57	13.00	12.07	12.53	11.55
Mean	10.31	9.65	9.98	12.47	11.73	12.10	
Mean of $I_{0.8}$			**11.39**	**Mean of $I_{1.0}$**		**10.69**	
Treatments	**SEm(±)**	**CD (*P=0.05*)**	**Interactions**			**SEm(±)**	**CD (*P=0.05*)**
Mulch (M)	0.45	1.31	I X M			0.63	NS
Irrigation (I)	0.45	NS	F x M			0.77	NS
Fertigation (F)	0.16	0.46	F x I			0.77	NS
			F x M x I			1.09	NS

F_{75}= 75-75-45 kg N-P_2O_5-K_2O ha^{-1}; F_{100}= 100-100-60 kg N-P_2O_5-K_2O ha^{-1}; F_{125}= 125-125-75 kg N-P_2O_5-K_2O ha^{-1}; $I_{0.8}$-0.8 Epan and $I_{1.0}$-1.0 Epan.

In general TSS values were ranged from 9.40 % to 12.53 % during I year, from 9.50 % to 13.47 % during II year and it was ranged from 9.45 % to 13.00 % in pooled data. Among the fertigation levels, the highest TSS value was observed with F_{125} which was 3.22 % higher over F_{100} (10.35 %). The F_{100} and F_{125} treatments are on par to each other. Significantly lower TSS value was noticed in F_{75} (9.79 %) during I year. Similarly higher TSS reading was observed with F_{125} and which was 4.56 % & 11.65 % higher over F_{100} and F_{75} respectively. Significantly lower TSS value was noticed in F_{75} (11.12 %) during II year. In pooled data, the F_{125} has recorded the highest TSS value (11.55 %) and was on par to the F_{100} (11.11 %) and the lower value was recorded in F_{75} (10.46 %). With mulching of the watermelon crop, the M_1 has recorded 22.30 %, 20.35 % & 21.25 % higher TSS value over M_0 (9.24, 10.71 & 9.98 %, respectively) during I, II year and in pooled data. There was insignificant variation found between $I_{0.8}$ & $I_{1.0}$ irrigation levels during both the years. The average TSS readings ranged from 9.89 to 10.66 %, 11.49 to 12.12 % & 10.69 to 11.39 %, respectively during I, II and in pooled data. The interaction effect among fertigation levels, mulch and drip irrigation levels found to be non-significant. Relatively higher

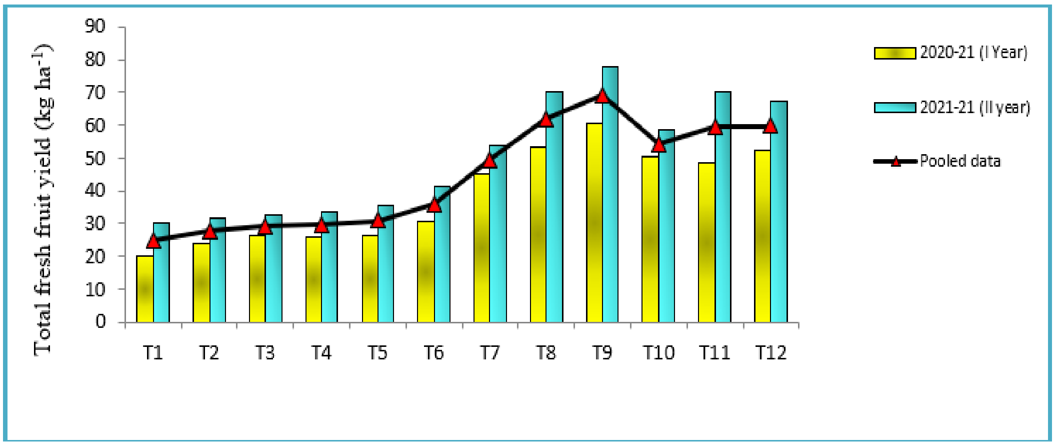

Fig. 1. Effect of fertigation levels, mulch and irrigation levels on total fresh fruit yield of watermelon during I year, II year and in pooled data

T_1=F_{75}+$I_{0.8}$+M_0, T_2=F_{100}+$I_{0.8}$+M_0, T_3=F_{125}+$I_{0.8}$+M_0, T_4=F_{75}+$I_{1.0}$+M_0, T_5=F_{100}+$I_{1.0}$+M_0, T_6=F_{125}+$I_{1.0}$+M_0, T_7=F_{75}+$I_{0.8}$+M_1, T_8=F_{100}+$I_{0.8}$+M_1, T_9=F_{125}+$I_{0.8}$+M_1, T_{10}=F_{75}+$I_{1.0}$+M_1, T_{11}=F_{100}+$I_{1.0}$+M_1, T_{12}=F_{125}+$I_{1.0}$+M_1,.F_{75}= 225- 45-90 kg N-P_2O_5-K_2O ha^{-1}; F_{100}= 300-60-120 kg N-P_2O_5-K_2O ha^{-1}; F_{125}= 375-75-150 kg N-P_2O_5-K_2O ha^{-1}, $I_{0.8}$= 0.8 Epan & $I_{1.0}$=1.0 Epan. M_0=Non Mulching condition & M_1= Mulching condition.

content was observed in F_{125}+$I_{0.8}$+M_1 (13.00 %) closely followed by F_{100}+$I_{0.8}$+M_1 (12.60 %) and F_{125}+$I_{1.0}$+M_1 (12.07 %) while F_{75}+$I_{1.0}$+M_0 (9.33 %) recorded the lowest value for TSS value.

There was positive correlation observed between yield and mean TSS content. The determination coefficient (R^2) (Fig. 2 was 0.729, 0.624 and 0.846 in I, II year and pooled data respectively which showed a linear increase in TSS value observed with total fresh yield.

Increased TSS values were observed with increment in the nutrient levels which could be due to application of nutrients at higher doses linearly increases the TSS content in the fruit as higher levels of nitrogen helps in starch formation furthermore converted in sugar at maturity of fruits (Sajitha, 2013). Another reason might be due to right dose of NP improve the leaf growth, photosynthesis and sugar synthesis. Potassium plays key role in the transport of sugars to fruit from leaves therefore K essential to build up higher sugar content in watermelon fruits (Nisha et al., 2020). Mulch retains more moisture and manages the temperature around the plant which directly affects the fruit quality by controlling several metabolic processes like sugar synthesis (Mehmet simsek et al., 2004). Under higher moisture conditions the activity of acid invertase was more which was enhances in synthesis of sugars and resulted in production of more sucrose and fructose levels in watermelon (Aung Kyaw Moe et al., 2018).

3.4 Lycopene Content (mg 100 g^{-1} Sample)

Lycopene is a carotenoid pigment, a secondary metabolite and found in fruits, vegetable, bacteria, fungi and algae. Watermelon is rich natural source of lycopene, synthesis of this mainly depends on temperature, solar radiation, stage of ripen fruit and fertilization. The data pertaining to lycopene presented in Table 4. There was significant difference observed between the mulch and non-mulch treatments for lycopene content during both the year. During II year, fertigation levels were significantly influence the lycopene content but not during I year and in pooled data. Drip irrigation levels did not significantly the lycopene content during both the year. During I year and in pooled data, interaction of fertigation levels and irrigation levels found to be significant for lycopene content but not during II year.

The lycopene content ranged from 0.38 to 0.77 mg 100 g^{-1} sample during I year, from 0.55 to 0.88 mg 100 g^{-1} sample during II year and it was ranged from 0.47 to 0.82 mg 100 g^{-1} sample in pooled data. With respect to the fertigation levels, during II year, F_{125} recorded the higher lycopene content (0.77 mg 100 g^{-1}) which was comparable to the F_{100} (0.75 mg 100 g^{-1}) and the lowest lycopene content was registered in F_{75} (0.68 mg 100 g^{-1}). During I year and in pooled data fertigation levels did not shows variation for lycopene content though the F_{125} recorded the higher content (0.60 & 0.68 mg 100 g^{-1}). The mulch (M_1) treatment was observed 56.44 %, 31.76 % & 41.95 % higher content when compared to the no mulch treatment (0.44, 0.63 & 0.54 mg 100 g^{-1}, respectively) during I, II year and in pooled data. With respect to irrigation levels, there was non-significant effect was observed between $I_{1.0}$ & $I_{0.8}$ levels. The average lycopene content ranged from 0.55 to 0.59 mg 100 g^{-1} during I year, from 0.72 to 0.75 mg 100 g^{-1} during II year and in pooled data it was ranged from 0.65 to 0.65 mg 100 g^{-1}. Among the interactions (Table 4) there was significant effect was noticed among the combinations of fertigation levels and irrigation levels. The higher lycopene content was observed with F_{125}+ $I_{0.8}$ (0.65 & 0.71 mg 100 g^{-1}) and was on par with all other treatments F_{100} + $I_{0.8}$ (0.59 & 0.67 mg 100 g^{-1}), F_{75} + $I_{1.0}$ (0.59 & 0.66 mg 100 g^{-1}), F_{125} + $I_{1.0}$ (0.54 & 0.65 mg 100 g^{-1}), F_{100} + $I_{1.0}$ (0.53 & 0.64 mg 100 g^{-1}) and F_{75}+ $I_{0.8}$ (0.52 & 0.58 mg 100 g^{-1}).

Table 4. Effect of fertigation and irrigation levels under mulch and non-mulch conditions on lycopene content of watermelon during 2020-21 (I year), 2021-21 (II year) and in pooled data during summer season

2020-21 (I Year)- lycopene content (mg 100 g^{-1} sample)							
Treatments	**No mulch**		**Mean**	**Mulch**		**Mean**	**Overall Mean**
	$I_{0.8}$	**$I_{1.0}$**		**$I_{0.8}$**	**$I_{1.0}$**		
F_{75}	0.38	0.45	0.42	0.66	0.73	0.69	0.55
F_{100}	0.45	0.39	0.42	0.73	0.66	0.70	0.56
F_{125}	0.53	0.47	0.50	0.77	0.62	0.69	0.60
Mean	0.45	0.43	0.44	0.72	51.75	0.69	
	Mean of I $_{0.8}$		**0.59**	**Mean of I $_{1.0}$**		**0.55**	
Treatments	**SEm(±)**	**CD (P=0.05)**	**Interactions**			**SEm(±)**	**CD (P=0.05)**
Mulch (M)	0.04	0.11	I X M			0.05	NS
Irrigation (I)	0.04	NS	F x M			0.07	NS
Fertigation (F)	0.01	NS	F x I			0.07	0.20
			F x M x I			0.09	NS
2021-22 (II Year)- lycopene content (mg 100 g^{-1} sample)							
F_{75}	0.55	0.62	0.59	0.72	0.83	0.78	0.68
F_{100}	0.63	0.65	0.64	0.86	0.85	0.85	0.75
F_{125}	0.67	0.67	0.67	0.88	0.86	0.87	0.77
Mean	0.62	0.65	0.63	0.82	0.85	0.83	
	Mean of I $_{0.8}$		**0.72**	**Mean of I $_{1.0}$**		**0.75**	
Treatments	**SEm(±)**	**CD (P=0.05)**	**Interactions**			**SEm(±)**	**CD (P=0.05)**
Mulch (M)	0.04	0.11	I X M			0.05	NS
Irrigation (I)	0.04	NS	F x M			0.07	NS
Fertigation (F)	0.01	0.04	F x I			0.07	NS
			F x M x I			0.09	NS
Mean of two years (pooled data)- lycopene content (mg 100 g^{-1} sample)							
F_{75}	0.47	0.53	0.50	0.69	0.78	0.73	0.62
F_{100}	0.54	0.52	0.53	0.79	0.76	0.77	0.65
F_{125}	0.60	0.57	0.58	0.82	0.74	0.78	0.68
Mean	0.54	0.54	0.54	0.77	0.76	0.76	
	Mean of I $_{0.8}$		**0.65**	**Mean of I $_{1.0}$**		**0.65**	
Treatments	**SEm(±)**	**CD (P=0.05)**	**Interactions**			**SEm(±)**	**CD (P=0.05)**
Mulch (M)	0.03	0.09	I X M			0.04	NS
Irrigation (I)	0.03	NS	F x M			0.05	NS
Fertigation (F)	0.01	NS	F x I			0.05	0.16
			F x M x I			0.08	NS

F_{75}= 75-75-45 kg N-P_2O_5-K_2O ha^{-1}; F_{100}= 100-100-60 kg N-P_2O_5-K_2O ha^{-1}; F_{125}= 125-125-75 kg N-P_2O_5-K_2O ha^{-1}; $I_{0.8}$-0.8 Epan and $I_{1.0}$-1.0 Epan.

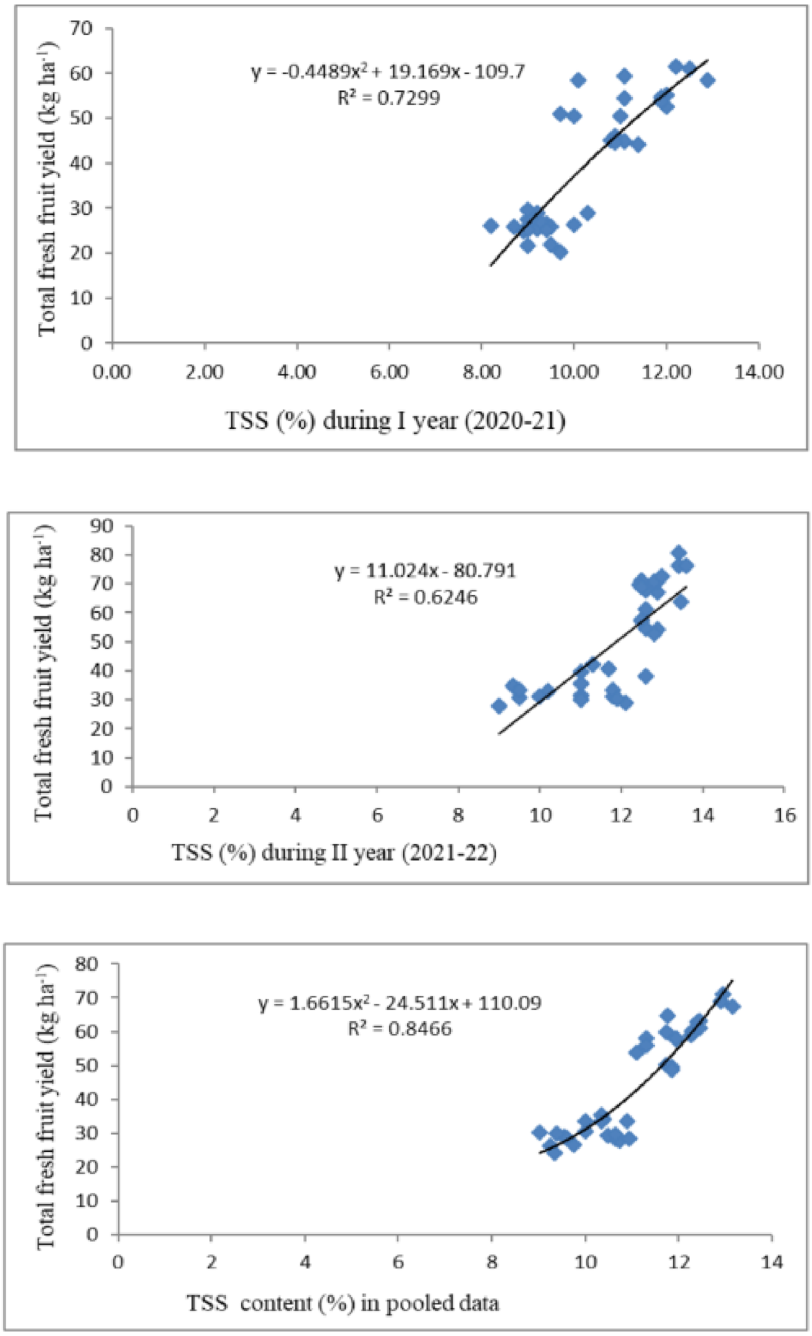

Fig. 2. Regression of watermelon fruit yield (t ha-1) with mean TSS during I, II year and in pooled data mean of watermelon

The data on correlation between yield and mean lycopene content (Fig. 3) revealed that there was significant positive correlation observed for lycopene content (0.691, 0.424 & 0.608) in I, II year and in pooled data respectively.

Different secondary metabolites produced by plants depending on plant and environmental conditions under which they are produced. It imparts the yellowish orange colour to the fruit. Increasing lycopene content with increased nutrient levels observed by De Pascale et al. (2008) in tomato due to as availability of N enhanced the activity of enzymes involved in isoprenoid pathway which is the main pathway for synthesis of lycopene. Sajitha (2013) reported that maximum lycopene content with the application of 125 % RDF. Nisha et al. (2020) stated that early fruit formation lead to improves the quality of fruits like sugar content, TSS & lycopene with 100% RDF. Mulch directly not influence the synthesis of lycopene but it favours the early maturity of the fruit by providing optimum temperature near the root zone (Aung Kyaw Moe et al., 2018).

Biosynthesis of lycopene is affected by atmospheric temperature of the fruits, ideal temperature for the lycopene production is 12-35ºC. During summer season plants provided with mulched conditions could be helped in production of more vegetative growth which inturn helped decrease in the temperature ultimately more lycopene synthesis. These results were inconformity with Dadheech et al. (2018); Quamruzzaman et al. (2021). Moderate irrigation coupled with higher NPK levels enhances the nutritional values of watermelon (Sajitha. 2013). Potassium plays key role in the synthesis of lycopene as well as NP involved in chlomoplasts functioning where carotenoids synthesis and storage takes place (Prabhakar et al., 2013, Erdem et al. 2005)).

Table 5. Interaction effect between fertigation levels and irrigation levels on lycopene content of watermelon during 2020-21 (I year) and in pooled data during summer season

2020-21 (I Year)- lycopene content (mg 100 g^{-1} sample)							
Treatments	**$I_{0.8}$**		**Mean**	**$I_{1.0}$**		**Mean**	**Overall Mean**
	No Mulch	**Mulch**		**No Mulch**	**Mulch**		
F_{75}	0.38	0.66	0.52	0.45	0.73	0.59	0.55
F_{100}	0.45	0.73	0.59	0.39	0.66	0.53	0.56
F_{125}	0.53	0.77	0.65	0.47	0.62	0.54	0.60
Mean	0.45	0.72	0.59	0.43	0.67	0.55	
	No Mulch		**0.44**	**Mulch**		**0.69**	
Treatments	**SEm(±)**	**CD (P=0.05)**	**Interactions**			**SEm(±)**	**CD (P=0.05)**
Mulch (M)	0.04	0.11	I X M			0.05	NS
Irrigation (I)	0.04	NS	F x M			0.07	NS
Fertigation (F)	0.01	NS	F x I			0.07	0.20
			F x M x I			0.09	NS
Mean of two years (pooled data)- lycopene content (mg 100 g^{-1} sample)							
Treatments	**$I_{0.8}$**		**Mean**	**$I_{1.0}$**		**Mean**	**Overall Mean**
	No Mulch	**Mulch**		**No Mulch**	**Mulch**		
F_{75}	0.47	0.69	**0.58**	0.53	0.78	**0.66**	**0.62**
F_{100}	0.54	0.79	**0.67**	0.52	0.76	**0.64**	**0.65**
F_{125}	0.60	0.82	**0.71**	0.57	0.74	**0.65**	**0.68**
Mean	0.54	0.77	0.65	0.54	0.76	0.65	
	No Mulch		**0.54**	**Mulch**		**0.76**	
Treatments	**SEm(±)**	**CD (P=0.05)**	**Interactions**			**SEm(±)**	**CD (P=0.05)**
Mulch (M)	0.03	0.09	I X M			0.04	NS
Irrigation (I)	0.03	NS	F x M			0.05	NS
Fertigation (F)	0.01	NS	F x I			0.05	0.16
			F x M x I			0.08	NS

F_{75}= 75-75-45 kg N-P_2O_5-K_2O ha^{-1}; F_{100}= 100-100-60 kg N-P_2O_5-K_2O ha^{-1}; F_{125}= 125-125-75 kg N-P_2O_5-K_2O ha^{-1}; $I_{0.8}$-0.8 Epan and $I_{1.0}$-1.0 Epan.

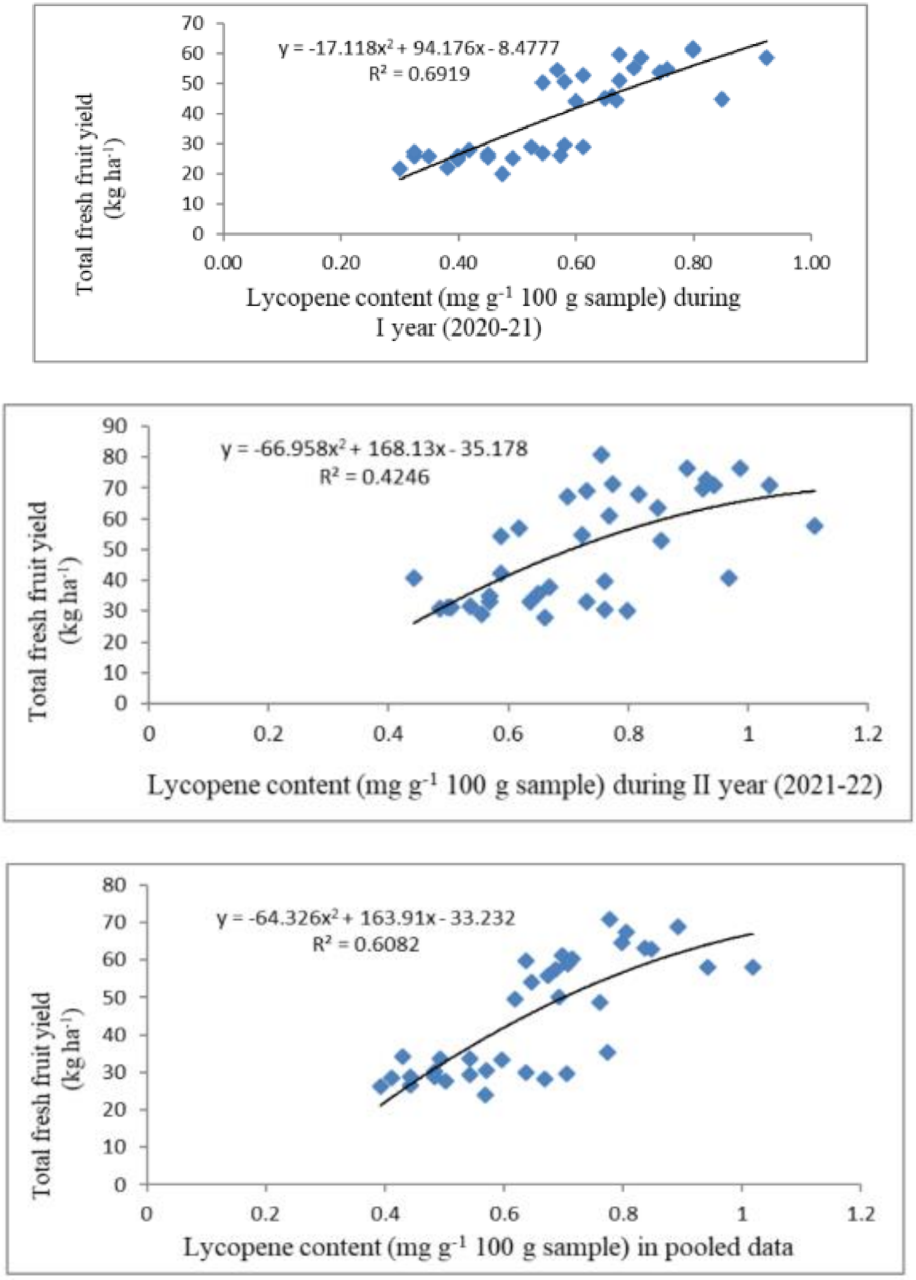

Fig. 3. Regression of watermelon fruit yield (t ha-1) with mean Lycopene content (mg g-1 100 g sample) during I, II year and in pooled data mean of watermelon

4. CONCLUSION

From the current study, it can be concluded that application of 125 % RDF along with I0.8 + mulch resulted in better quality & yield. It might be recommended to commercial farmers for achieving higher yield and economic stability.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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