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Effects of clay mineral application on soil moisture status, physiological traits and yield of rainfed tomato under semi-arid alfisols

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ABSTRACT

The effects of application of farm yard manure (FYM) and clay mineral (CM) on soil and plant characteristics like soil moisture at field capacity, permanent wilting point, leaf area, leaf nitrogen, relative water content, yield of tomato were examined based on field experiments conducted in a semi-arid alfisol at Hyderabad during 1998 –99 and 1999-2000. Two levels of FYM and three levels of CM (fullers earth) were applied in the filed. The Analysis of Variance indicated that application of 16 t/ha of CM together with 10 t/ha of FYM retained a significantly higher soil moisture as measured by pressure outflow and gravimetric methods. The per cent survival, leaf area and relative water content was also significantly higher. On the other hand, application of 8 t/ha of CM together with 10 t/ha of FYM helped to achieve maximum leaf N, higher marketable yield, fruit firmness, total soluble solids, total soluble solids-acidity ratio in tomato under semi-arid alfisols.

Key words : Soil moisture, plant traits, correlation, regression, prediction

INTRODUCTION

The growth and productivity of vegetable crops can be greatly enhanced by improving moisture retention capacity of soils by making water available to plants for longer periods in post-rainy season. Many methods such as microsite improvement, development of micro-catchment areas and mulching are adopted to conserve moisture for a longer time in the root zone of the plant under dryland farming systems. The inherent capacity of soil for retention of water could also be improved with the addition of organic matter and tank silt. Singh and Singh (1988) found that bentonite was useful in reducing percolation losses in round gourd (*Citrullus vulgaris*) in rainfed sandy soils.

Based on information available, it was felt that the addition of clay minerals with high water holding capacity and cation exchange capacity can be attempted specifically in the case of alfisols to improve establishment and yields of vegetable crops. Information is lacking on the use of fullers earth on vegetable crops grown on alfisols under semi-arid conditions in Telangana region of Andhra Pradesh. The present study was therefore conducted on the use of clay mineral (fullers earth) for establishment, growth and yield parameters of tomato under semi-arid alfisols.

MATERIAL AND METHODS

Field experiments were conducted on rainfed tomato with 'Pusa Ruby' variety during 1998-99 and 1999-2000 cropping seasons in a semi-arid alfisol at Central Research Institute for Dryland Agriculture, Hyderabad. The study was conducted with the objective of assessing the influence of farm yard manure (FYM) and clay minerals (CM) on the growth and yield of tomato under rainfed conditions. Two levels of FYM @ 0 and 10 t/ha and 3 levels of CM @ 0, 8 and 16 t/ha were tested in the field experiments. The experiments were conducted in a plot size of 5 x 4 m with 4 replications in a Randomized Block Design. The treatments were randomized and superimposed to plots under each of the 4 replications. The plots receiving FYM treatment were given @ 10 t / ha. The quantities of CM as per treatments were spread in each plot and mixed thoroughly to a depth of 30 cm with spades and the plots were kept ready for transplanting of tomato.

Nursery was raised near a farm pond at the research farm by using harvested water. Healthy, 25 day – old seedlings were used for transplanting. Transplanting was taken up during 1st week of July in 1998–99 and 1999–2000 seasons immediately after the receipt of first rains in which the soil was fully saturated with moisture. The recommended fertilizer dose of 120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha was applied in all the field experiments. Nitrogen was applied in 3 split doses as and when it rained. Planting was done on flat beds of the experimental plots having raised edges on sides at a spacing of 50 x 50 cm. Earthing up was done 15 days after planting so as to form ridges and furrows enabling *in-situ* water harvesting. The plants received regular plant protection sprays to control pests and diseases.

Observations were recorded on soil moisture at field capacity (33 Kpa) and permanent wilting point (1500 Kpa) by pressure outflow method (Laryea and Katyal, 1995). Observations on soil moisture were also recorded based on gravimetric method (Laryea and Katyal, 1995) in two depths viz., 0-15 and 15-30 cm on three different dates during the dry period. Leaf area (cm^2) was measured using L1-3100 Area Meter (Licor inc., Lincoln, Nebraska, USA). Relative water content was determined following Rachna Narang *et al* (1999) and leaf nitrogen (%) was measured by procedure of Jackson (1967). Among fruit quality characters, total soluble solids (°Brix), acidity (%) and fruit firmness (kg/cm^2) were measured as discussed by Ranganna (1986). Apart from soil moisture and plant traits, marketable and unmarketable yield (kg/ha) were recorded in each of the 24 plots.

The Analysis of Variance of effects of FYM, CM and their interaction was carried out based on F–test (Kempthorne, 1952).

RESULTS AND DISCUSSION

Effect of FYM and CM on soil moisture

The effects of FYM and CM on soil moisture (%) in 0–15 and 15–30 cm soil depth at field capacity (33 Kpa) and permanent wilting point (1500 Kpa) based on 'pressure outflow' method were tested for significance. Soil moisture increased with an increase in levels of CM and FYM at both field capacity and permanent wilting points.The main and interaction effects of treatments on soil moisture and their significance for different treatment combinations under 0–15 and 15–30 cm depths measured at field capacity and permanent wilting point are given in Table 1.

The available moisture was maximum at 17.2% with the application of FYM @ 10 t/ha together with CM @ 16 t/ha, while it was minimum at 9.58% with the application of only FYM @ 10 t/ha at field capacity under 0–15 cm of depth. In case of permanent wilting point, a maximum moisture of 11.48% was observed at 0-15cm depth with application of FYM @ 10 t/ha together with clay mineral @ 16 t/ha, while a minimum of 6.49% was obtained under control. FYM had a significant interaction with CM in influencing soil moisture. The mean moisture at field capacity was 12.39% with a c.v of 26.4%, while the moisture at permanent wilting point in 0–15 cm depth was 8.44% with a c.v of 22.4%.

The soil moisture determined under 33 Kpa and 1500 Kpa pressures indicated that in 0–15 cm soil depth showed a maximum difference of 6.07% with the application of FYM @ 10 t/ha together with CM @ 8 t/ha, while a minimum of 2.64% occurred with the application of only FYM @ 10 t/ha. A mean difference of 3.92% in moisture was observed with a variation of 39.4% among treatments of FYM and CM tested.

A maximum soil moisture of 20.99% was observed in 15–30 cm depth with the application of FYM @ 10 t/ha together with CM @ 16 t/ha, while a minimum of 8.66% was observed in control under field capacity. The corresponding values of permanent wilting point for the above treatments were 11.61% and 5.47%, respectively. F–test indicated that both FYM and CM significantly influenced moisture in 15–30 cm depth. There was no significant interaction of FYM and CM in influencing sub–soil moisture. A mean moisture of 14.21% was attained with 26.4% variation for field capacity as compared to 8.72% with 22.4% variation for permanent wilting point in 15–30 cm depth using pressure outflow method.

In 15–30 cm depth, a maximum difference of 9.38% between soil moisture measured under 33 Kpa and 1500 Kpa categories was found with an application of FYM @ 10 t/ha together with CM @ 16 t/ha, while a minimum difference of 3.19% occurred under control. The treatments had a mean moisture difference of 5.49% with a variation of 44.4%.

The soil moisture (%) based on pressure outflow method showed an increase with an increase of CM and FYM application at both field capacity and permanent wilting point especially in 15–30 cm depth. At 0–15 cm depth, although soil moisture (%) increased with CM application at 33 and 1500 Kpa, the available moisture content did not show much variation. However, there was a substantial increase in moisture when CM were applied along with FYM. The influence of CM on available moisture was greater at 15–30 cm depth, especially when it was applied along with FYM. The transformation of added FYM into organic colloids increased the water holding capacity of soil along with CM.

Table 1. Effect of FYM and clay minerals on moisture based on 'pressure outflow' method

FYM (t/ha)	CM (t/ha)	Soil moisture (%) at field capacity (33 Kpa) and permanent wilting point (1500 Kpa) in different depths					
		0–15 cm			15–30 cm		
		FC	PWP	Difference	FC	PWP	Difference
0	0	9.65	6.49	3.16	8.66	5.47	3.19
0	8	10.21	7.33	2.88	10.46	6.63	3.83
0	16	11.97	8.93	3.04	14.77	9.38	5.39
10	0	9.58	6.94	2.64	12.97	9.21	3.76
10	8	15.55	9.48	6.07	17.41	10.04	7.37
10	16	17.20	11.48	5.72	20.99	11.61	9.38
Mean		12.39	8.44	3.92	14.21	8.72	5.49
CV (%)		26.40	22.40	39.40	31.90	26.00	44.40
F–test	FYM	**	**	**	**	**	**
	CM	**	**	**	**	**	**
	FYM x CM	**	**	NS	NS	NS	NS
LSD	FYM	0.73	0.57	0.80	0.88	0.56	0.80
	CM	0.89	0.70	0.95	1.07	0.68	1.15
	FYM x CM	1.26	0.99	NS	NS	NS	NS

** indicates significance at 1% level CV : Coefficient of variation (%)
FC : Field capacity PWP : Permanent wilting point CM : Clay mineral
NS : Not significant LSD : Least significant difference

Unger (1975) reported that at lower depths of soil, the influence of clay species on water retention at 33 Kpa becomes more evident. In this experiment also, the influence of CM along with FYM on soil moisture retention at 33 Kpa was more evident at 15–30 cm depth. Brown (1977) suggested that at a potential of 33 Kpa, the water retention by soils is directly associated with clay content. Prasad and Pillai (1995) studied moisture retention characteristics of red soils and reported that in most of the pedons, the available water and moisture retained at field capacity were low in surface soils than in lower horizons and they attributed it to lesser clay content, low CEC and exchangeable bases in surface horizons. This was also the reason for low available soil moisture content observed in 0–15 cm soil depth in the study. By using pure clay minerals, Gupta *et al* (2000) reported that water retention and release were maximum in bentonite clay followed by illite and kaolinite.

Effect of FYM and CM on soil moisture (%) during stress

Soil moisture (%) measured at two soil depths *viz*., 0–15 and 15–30 cm during the period of development stress showed that the soil moisture retention was better in those where the CM content was higher. The F–test for main and interaction effects of FYM and CM on soil moisture measured in two soil depths based on gravimetric method are given in Table 2.

At 0–15 cm depth, a maximum soil moisture of 11.42, 8.16 and 6.79% was attained with the application of FYM @ 10 t/ha together with CM @ 16 t/ha Compared to this, a minimum soil moisture of 6.73% was observed with the application of only FYM @ 10 t/ha. It is clear that FYM and CM significantly influenced available moisture in 0–15 cm. A significant interaction of FYM and CM was also observed. The treatment means for moisture were 8.57% with a variation of 19.3%; 6.37% with a variation of 22.9% and 5.19% with a variation of 18.1% during the development of soil moisture stress.

Under 15–30 cm depth, a maximum soil moisture of 13.01, 11.81 and 11.44% was attained with application of FYM @ 10 t/ha together with CM @ 16 t/ha. Compared to this, control gave minimum moisture of 7.05% and 4.98%, while only FYM @ 10 t/ha gave a minimum of 6.57%. The F–test indicated that FYM and CM significantly influenced available moisture in 15–30 cm depth on all dates of observation. There was a significant interaction effect of FYM and clay minerals on moisture on all the 3 dates. The treatments provided a mean moisture of 9.82% with a variation of 22.0% on 1–8–1998, 8.36% with a variation of 32.9% on 25–11–1998 and 7.99% with a variation of 24.5% on 12–8–1999 under 15–30 cm. The results indicated that moisture increased from 1st to 2nd depth in all treatments except control on 1–8–1998.

The soil moisture (%) during stress in 0–15 cm depth increased in CM and FYM application. The influence of soil amendments on moisture retention was greater in 15–30 cm than 0–15 cm depth. This was due to the finer fractions retained at 15–30 cm than in 0–15 cm depth.

Application of soil colloids in the form of CM and

Table 2. Effect of FYM and CM on soil moisture

FYM (t/ha)	CM (t/ha)	Soil moisture (%) at different depths during stress period					
		1–8–1998		25–11–1998		12–8–1999	
		0–15 cm	5–30 cm	0–15 cm	15–30 cm	0–15 cm	5–30 cm
0	0	7.40	7.05	4.27	4.98	4.09	6.57
0	8	7.91	8.36	6.93	9.59	4.53	6.79
0	16	8.96	11.05	7.26	10.69	5.08	6.90
10	0	6.73	8.76	5.00	5.84	5.07	7.00
10	8	9.03	10.67	6.62	7.24	5.62	9.27
10	16	11.42	13.01	8.16	11.81	6.79	11.44
Mean		8.57	9.82	6.37	8.36	5.19	7.99
CV (%)		19.30	22.00	22.90	32.90	18.10	24.50
F–test	FYM	**	**	NS	NS	**	**
	CM	**	**	**	**	**	**
	FYM x CM	**	**	**	**	**	**
LSD	FYM	0.43	0.43	NS	NS	0.42	0.42
	CM	0.53	0.53	0.48	0.48	0.51	0.51
	FYM x CM	0.75	0.75	0.68	0.68	0.73	0.73

** indicates significance at 1% level CV : Coefficient of variation
CM : Clay mineral NS : Not significant LSD : Least significant difference

FYM improved the organic colloidal fraction of soil after decomposition, retaining higher soil moisture (%) during stress. Prasuna Rani *et al* (1991) observed a positive relationship between soil moisture retention in clays with higher CEC. Gupta *et al* (2000) stated that water retention curves of alluvial, red, laterite and black soils reflected the influence of respective clay minerals present in the soils in influencing water retention characteristics.

Effect of FYM and clay minerals on physiological traits

The results of Analysis of Variance (ANOVA) of main effects of FYM and CM and their interaction are given in Table 3 which showed that there was no significant interaction of FYM and CM treatments on the plant parameters.

Survival

There were no significant difference between control and treatments on survival (%) of tomato. The treatments had a mean survival of 96.5%.

Leaf area

There was a reduction in leaf area when CM was applied without FYM. This may be due to the fact that N availability increased with application of CM along with FYM, rather than CM alone. A maximum leaf area of 3631 cm^2 was observed with application of FYM @ 10 t/ha together with CM @ 16 t/ha, while a minimum of 2086 cm^2 was observed with only CM @ 8 t/ha. The treatments had a mean leaf area of 2924 cm^2 with a variation of 21.9%.

Table 3. Effect of FYM and clay minerals on survival, leaf area, leaf N and relative water content in tomato

FYM (t/ha)	CM (t/ha)	Survival (%)	Leaf area (cm^2)	Leaf N (%)	RWC (%)
0	0	97.0	2912	2.60	75.2
0	8	96.5	2086	2.49	78.2
0	16	94.7	2279	2.34	80.2
10	0	96.5	3569	3.73	77.2
10	8	95.2	3065	3.79	81.7
10	16	98.7	3631	3.40	85.5
Mean		96.5	2924	3.06	79.7
CV (%)		1.5	21.9	21.5	4.6
F–test	FYM	NS	**	**	**
	CM	NS	NS	**	**
	FYM x CM	NS	NS	NS	NS
LSD	FYM	NS	955	0.65	2.2
	CM	NS	NS	0.79	2.7
	FYM x CM	NS	NS	NS	NS

** indicates significance at 1% level CV : Coefficient of variation
CM : Clay mineral NS : Not significant LSD : Least significant difference

Leaf nitrogen

The F–test carried out for leaf N indicated that there was a significant difference between treatments with FYM and without FYM, and also among CM levels. A minimum leaf N of 2.34% was observed with application of CM @ 16 t/ha, while a maximum leaf N of 3.4% was observed with application of FYM @ 10 t/ha together with CM @ 16 t/ha. The treatments had a mean leaf N of 3.06% with 21.5% variation. Application of CM with and without FYM decreased leaf N significantly. However, FYM had a significant effect in increasing leaf N when it was applied along with CM. This was due to the fact that montmorillonite clay present with fullers earth fixed N in the form of ammonia (Tisdale *et al*, 1985). Thus additional N supplied through FYM resulted in increased leaf N content.

Relative water content

The relative water content (RWC) during stress was significantly influenced by both FYM and CM application. A maximum RWC of 85.5% was observed with an application of FYM @ 10 t/ha together with CM @ 16 t/ ha, while a minimum of 75.25% was observed when only CM @ 8 t/ha was applied. The treatments gave a mean RWC of 79.7% with a variation of 4.6%. Application of CM and FYM increased moisture retention capacity of soil, which resulted in an increased RWC in leaves during stress period. The importance of RWC in stress period was emphasized by Boyer (1969).

Effect of application of FYM and CM on yield of tomato

Marketable yield

The ANOVA of marketable yield indicated that both FYM and CM had a significant effect on yield in both seasons as given in Table 4. It is observed that a maximum marketable yield of 10215 kg/ha was obtained when FYM was applied @ 10 t/ha together with CM @ 16 t/ha, while a minimum of 8035 kg/ha was attained under control during 1998–99. The respective treatment combinations provided a maximum yield of 13085 kg/ha and a minimum of 9870 kg/ha during 1999–2000. Application of only FYM increased marketable yield by 935 kg/ha in 1998–99 and 1020 kg/ha in 1999–2000. Similarly, application of only CM increased yield in both years. The application of only CM @ 8 and 16 t/ha gave an increased yield of 470 and 1200 kg/ha in 1999–2000 compared to 665 and 1140 kg/ha obtained in 1998–99. It was observed that relatively higher yields of tomato were realized in 1999–2000 as compared to 1998–99 in all treatments. There was a significant difference between yields attained with different combinations of FYM and CM in both seasons. The treatments gave a mean marketable yield of 9125 and 11255 kg/ha with a variation of 8.3 and 10.7% during 1998–99 and 1999–2000, respectively.

The marketable yield significantly increased with application of both FYM and CM. Keshava Murthy and Kotur (2000) made similar observations of increased yields in banana when tank silt was applied in combination with FYM, than when tank silt was applied alone. The fruit yield

Table 4. Effect of FYM and clay minerals on yield of tomato in an alfisol

FYM (t/ha)	CM (t/ha)	Yield (kg/ha)			
		Marketable		Unmarketable	
		1998–99	1999–2000	1998–99	1999–2000
0	0	8035	9870	350	540
0	8	8700	10340	315	425
0	16	9175	11070	290	340
10	0	8970	10890	600	690
10	8	9665	12270	490	590
10	16	10215	13085	365	190
Mean		9125	11255	400	465
CV (%)		8.3	10.7	29.7	39.2
F–test	FYM	**	**	NS	NS
	CM	**	**	NS	NS
	FYM x CM	NS	NS	NS	NS
LSD	FYM	1005	1445	NS	NS
	CM	960	1630	NS	NS
	FYM x CM	NS	NS	NS	NS

** indicates significance at 1% level CV : Coefficient of variation
CM : Clay mineral NS : Not significant LSD : Least significant difference

Table 5. Effect of FYM and CM on fruit firmness, total soluble solids and acidity in tomato

FYM (t/ha)	CM (t/ha)	Fruit firmness (kg/cm^2)	Total soluble solids (° brix)	Acidity (%)	TSS/Acidity ratio
0	0	0.70	5.65	0.81	8.37
0	8	0.78	5.40	0.72	9.15
0	16	0.85	5.10	0.69	9.36
10	0	0.98	5.15	0.54	9.57
10	8	1.29	5.30	0.46	7.24
10	16	1.35	5.25	0.40	10.10
Mean		0.99	5.31	0.60	8.97
CV (%)		27.3	3.7	26.7	11.4
F–test	FYM	NS	NS	NS	NS
	CM	**	NS	**	NS
	FYM x CM	NS	NS	NS	NS
LSD	FYM	NS	NS	NS	NS
	CM	0.45	NS	0.31	NS
	FYM x CM	NS	NS	NS	NS

** indicates significance at 1% level CV : Coefficient of variation
CM : Clay mineral NS : Not significant LSD : Least significant difference

in 1999–2000 with a rainfall of 408.3 mm was relatively higher than in 1998–99 with a rainfall of 588.5 mm during crop growth period. This was due to the fact that clay minerals helped in better crop growth and yield during less rainfall than high rainfall situations.

Effect of FYM and CM application on fruit quality traits

Fruit firmness

The ANOVA indicated significance of clay mineral and non-significance of FYM on fruit firmness in both seasons as given in Table 5. The fruit firmness increased when FYM and CM were applied together than when CM was applied alone. Maximum fruit firmness of 1.35 kg cm^{-2} was attained with an application of FYM @ 10 t/ha together with CM @ 16 t/ha, compared to a minimum of 0.70 kg cm^{-2} under control. The treatments gave a mean fruit firmness of 0.99 kg cm^{-2} with variation of 27.3%.

Total Soluble Solids

Both FYM and CM levels had no significant influence on total soluble solids (°Brix) as given in Table 5. The observations recorded on total soluble solids indicated that a maximum of 5.65 °Brix was attained under control, while a minimum of 5.1 was attained with CM @ 16 t/ha. The treatments gave a mean total soluble solids of 5.31 °Brix with a variation of 3.7%.

Acidity (%)

The CM levels affected acidity (%) significantly while FYM levels did not have an influence. Maximum acidity of 0.81% was recorded under control, while a minimum of 0.40% was observed in FYM @ 10 t/ha treatment together with CM @ 16 t/ha. The acidity (%) significantly decreased with application of CM under both FYM and no-FYM combinations, while the effect of FYM was non-significant in influencing acidity (%) in tomato. The treatments showed a mean fruit firmness of 0.60% with a variation of 27.3% in the study. Increased fruit firmness and reduced acidity which were significant due to CM application increased the availability of calcium and potassium to the plant (Tisdale *et al* 1985). The role of potassium in increasing fruit firmness and keeping quality of vegetables was also emphasized by Kemmler and Tandon (1988).

Total soluble solids–Acidity ratio

There was no significant influence of FYM and CM levels on TSS-acidity ratio (Table 5). The brix–acidity ratio was higher when FYM and CM were applied together than when FYM was not applied. It is observed that a maximum ratio of 10.1 was attained with an application of FYM @ 10 t/ha together with CM @ 16 t/ha, while a minimum of 7.24 was attained with FYM @ 10 t/ha together with CM @ 8 t/ha. The treatments gave a mean ratio of 8.97 with a variation of 11.4% in the study.

Estimates of correlation between different parameters

The estimates of correlation among the various parameters are presented in table 6. Among fruit quality parameters, fruit firmness had a significant correlation with available moisture in both depths under field capacity and permanent wilting point. The acidity was significantly correlated with soil moisture in 15–30 cm depth under field capacity and permanent wilting point and marketable yield.

Table 6. Estimates of significant correlation between different variables in tomato

Variable 1	Variable 2	r-value
Relative water content	Soil moisture in 0–15 cm (33 Kpa)	0.95**
Relative water content	Soil moisture in 0–15 cm (1500 Kpa)	0.99**
Relative water content	Water availability in 0–15 cm	0.81*
Relative water content	Soil moisture in 15–30 cm (33 Kpa)	0.96**
Relative water content	Soil moisture in 15–30 cm (1500 Kpa)	0.88*
Relative water content	Water availability in 15–30 cm	0.98**
Relative water content	Soil moisture in 0–15 cm (1–8–98) (stress)	0.94**
Relative water content	Soil moisture in 15–30 cm (1–8–98) (stress)	0.97**
Relative water content	Soil moisture in 0–15 cm (25–11–98) (stress)	0.88*
Relative water content	Soil moisture in 0–15 cm (12–8–99) (stress)	0.95**
Relative water content	Soil moisture in 15–30 cm (12–8–99) (stress)	0.88*
Relative water content	Marketable yield (1998–99)	0.97**
Relative water content	Marketable yield (1999–2000)	0.96**
Relative water content	Fruit firmness	0.86*
Relative water content	Acidity	-0.81*
Soil moisture in 0–15 cm (33 Kpa)	Marketable yield (1998–99)	0.91**
Soil moisture in 0–15 cm (33 Kpa)	Fruit firmness	0.91**
Soil moisture in 0–15 cm (1500 Kpa)	Marketable yield (1998–99)	0.94**
Soil moisture in 0–15 cm (1500 Kpa)	Fruit firmness	0.84*
Soil moisture in 15–30 cm (33 Kpa)	Marketable yield (1998–99)	0.99**
Soil moisture in 15–30 cm (33 Kpa)	Fruit firmness	0.93**
Soil moisture in 15–30 cm (33 Kpa)	Acidity	-0.90*
Soil moisture in 15–30 cm (1500 Kpa)	Marketable yield (1998–99)	0.96**
Soil moisture in 15–30 cm (1500 Kpa)	Fruit firmness	0.89*
Soil moisture in 15–30 cm (1500 Kpa)	Acidity	-0.91**
Soil moisture in 0–15 cm (1–8–98)	Marketable yield (1998–99)	0.83*
Soil moisture in 15–30 cm (1–8–98)	Marketable yield (1998–99)	0.95**
Soil moisture in 15–30 cm (1–8–98)	Fruit firmness	0.81*
Soil moisture in 0–15 cm (12–8–99)	Marketable yield (1999–2000)	0.98**
Soil moisture in 15–30 cm (12–8–99)	Marketable yield (1999–2000)	0.91**
Marketable yield	Fruit firmness	0.93**
Marketable yield	Acidity	-0.92**
Fruit firmness	Acidity	0.97**

* and ** indicate significance at 5% and 1% levels, respectively

The marketable yield was significantly correlated with available moisture in both depths under field capacity and permanent wilting point.

It was found from the study that application of 16 t/ha of CM together with 10 t/ha of FYM was superior for attaining maximum soil moisture, survival (%), leaf area and RWC. However, application of 8 t/ha of CM together with 10 t/ha of FYM was superior for attaining maximum leaf N, marketable yield, fruit firmness, total soluble solids, total soluble solids-acidity ratio in tomato under semi-arid alfisols.

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