

Full Length Research Paper

Comparative study of maturity stages influenced by tomato under two different farming systems

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In the present study, comparative advantages were computed to check on the existing status of cultivation practices with the precision farming practices. The study would be helpful to the tomato industries to manage their supply chain effectively by minimizing the cost and increasing the marketing efficiency and thereby enhancing their profit. Study was conducted in the Department of vegetable crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu from 2007 to 2010. Field experiments were conducted in two different fields of villages at Saragapalli, Krishnagiri district to obtain the best results from harvesting of tomatoes at three different maturity stages from two different farming systems. Harvested fruits were transported from Hosur to Coimbatore. The treatment F₂M₁ (Harvesting at mature green stage of precision farming tomato) was found to be better because the lowest enzymatic activities with increased shelf life of 28.50 days.

Key words: Maturity stages, tomato, precision farming, post harvest, shelf life.

INTRODUCTION

Tomato is known for its rapid deterioration and poor shelf life due to diverse factors such as thin fruit peel, low firmness, slow rate of conversion of sugars, high pH, high rate of deterioration and high ethylene production. Tomato is being cultivated in India with the area of 826 million hectare, production of 16.53 million metric tonnes (National Horticulture Database, 2011). The shelf life is the resultant of pericarp thickness, acidity, ascorbic acid and TSS (Balasubramanian, 2008). Consequent to the introduction of precision farming system to Tamil Nadu, India, nearly 80% of the area under tomato was brought under this system and nearly 20% alone being cultivated under conventional system. Precision farming or satellite farming is a farming management concept based on observing and responding to intra-field variations.

Today, precision agriculture is about whole farm management with the goal of optimizing returns on inputs

while preserving resources. In as much between 2006 to 2009 to 2009 to 2010 and tomatoes are predominantly being grown under precision system in the districts, enhanced productivity and extended harvest may lead to immediate market surplus. In order to sustain the productivity and profitability of tomato in the years to come, both the post harvest management of produce and supply chain management need to be studied together to address the issues of post harvest loss and to maximize the farmer's share of consumer price.

In this context, the present study on comparative study of maturity stages influenced by tomato growing under different production systems was taken up with the objective to study the effect of maturity stages as the elements of post harvest management of tomatoes grown under conventional and precision system of farming. Development of geomatics technology in the later part of

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the 20th century has aided in the adoption of site specific management systems using remote sensing, global positioning system and geographical information system. This approach is called precision farming or site specific management (Carr et al., 1991; Palmer, 1996). It is a paradigm shift from conventional management practice of soil and crop in consequence with spatial variability. It is a refinement of good whole field management, where management decisions are adjusted to suit variations in resource conditions.

MATERIALS AND METHODS

Tomato Syngenta Hybrid 516 was cultivated in different farming systems under open condition. Precision farming is getting differed from conventional farming by means of practicing advanced technologies like portray nursery, drip irrigation, fertigation, plant protection measures at appropriate time. Tomato fruits were harvested at different maturity stages of mature green (M₁), turning stage (M₂), and light red stage (M₃). Factors considered as different production systems were conventional and precision farming. Farm practices for conventional and precision farming were followed as per Crop production guide, 2004 and Tamil Nadu Precision Farming guide. Biochemical analysis was carried out at the Department of Vegetable crops, Horticultural College and Research Institute, TNAU, Coimbatore. Coimbatore was represented as terminal market. The experimental data was analysed with factorial randomized block design as statistical design. Number of replications was 6.

The parameters considered for the experiment were physiological loss of weight (%) (PLW), shelf life (number of days) (shelf life was measured by using score chart based on color, size, shape, etc.), pectin methyl esterase enzymes activity. These parameters were estimated using the method suggested by A.O.A.C. (1975).

Physiological loss in weight

The initial weight of fresh fruit was recorded and subsequently the weights were taken on all days. The physiological loss in weight was estimated as given below and expressed as percentage:

$$\text{PLW (\%)} = \frac{\text{Initial weight of the fruit} - \text{Final weight of the fruit}}{\text{Initial weight of the fruit}} \times 100$$

Pectin methyl esterase

Pectin methyl esterase (PME) enzyme assay was done as per Ranganna (1986). The PME was assayed by the addition of 2 ml of 1.5 M NaCl to 10 ml of 1% protein solution. A few drops of Hinton's indicators were then added and it was titrated to pH 7.5 with 0.02 N NaOH. The mixture was transferred to constant temperature water bath maintained at 30°C. When the pectin solution has attained the temperature of bath, enzyme sample and water was added to adjust the volume to 20 ml. Immediately, time and volume of alkali required to maintain the pH value at the constant value was recorded and expressed the results in PME units (PME U/g of the expression of the ester hydrolysed per minute per gram of enzyme;

Statistical analysis

The data collected from the investigations were analysed by

adopting the statistical procedures of Panse and Sukhatme (1985). The significance of the mean difference between the treatments was determined by computing the standard error and critical difference. Statistical analysis was done with MS Excel software.

RESULTS AND DISCUSSION

Physiological loss of weight

Tomatoes harvested at mature green stage (M₁) registered the lowest physiological loss of weight (PLW) and fruits harvested at light red stage recorded the highest PLW at 8, 16 and 24 days after storage (DAS). It ranged from 8.3 to 12.7% at 8 DAS, 17.3 to 24.7% at 16 DAS and 27.6 to 36.4% at 24 DAS (Table 1).

Significant differences were also observed among the treatment combinations of farming system and stage of harvest at 8, 16 and 24 DAS. Among the combinations, the PLW ranged from 7.53 to 13.65% at 8 DAS, 15.07 to 25.84% at 16 DAS and 24.61 to 37.12% at 24 DAS. Harvesting at mature green stage in the precision farming system (F₂M₁) resulted in significantly lower PLW at 8, 16 and 24 DAS. The highest PLW were recorded with light red stage in conventional farming system (F₁M₃) at 8, 16 and 24 DAS. F₂M₂ also recorded a lower PLW content at 8, 16 and 24 DAS. The fruit weight decreased gradually as the days to storage advanced. Moisture loss through transpiration represents the assessment of saleable weight and eventually the material becomes unusable as a result of wilting and shrinking. The loss is continuous during storage and is due to moisture loss (Balasubramanian, 2004).

In the present investigation, the PLW was highest in the fruits of light red stage maturity. This may be attributed to the fact that, the fruits harvested light red stage was in rapid growth, with a high rate of respiration accompanied by simultaneous loss of water from tissues. Differing stages of maturity can have considerable effect on water loss as the structure of outer layers change during the development of fruit. Maximum physiological loss in weight was recorded in fruits of conventional farming (34.77%) than the precision farming (30.90%) at 24 DAS. The results revealed that systems of irrigation and fertilization significantly influenced the growth characters of tomato. This might be due to the fact that frequent irrigation cum fertilization maintained at the root zone with well aerated condition and at adequate soil moisture content that did not fluctuate between wet and dry extremes (Patil and Janawade, 1999).

The PLW also increased as the period of storage advanced, irrespective of treatments. In the present study, the lowest weight loss was recorded in fruits of mature green stage from precision farming system and is continued throughout the storage period. The decrease in the fruit weight obtained during ripening would be the result of moisture loss as well as due to climacteric degradation of substrate (Salunkhe and Desai, 1984).

Table 1. Effect of maturity stages on the physiological loss of weight (%) of conventional and precision farming tomato at 8, 16 and 24 days after storage (DAS).

Treatments	8 DAS			16 DAS			24 DAS		
	F ₁	F ₂	Mean	F ₁	F ₂	Mean	F ₁	F ₂	Mean
M ₁	9.11	7.53	8.32	19.46	15.07	17.26	30.65	24.61	27.63
M ₂	12.45	9.32	10.89	24.25	20.22	22.24	36.54	32.46	34.50
M ₃	13.65	11.69	12.67	25.84	23.45	24.65	37.12	35.64	36.38
Mean	11.74	9.51	10.63	23.18	19.58	21.38	34.77	30.90	32.84
	M	F	M X F	M	F	M X F	M	F	M X F
SEd	0.1069	0.0873	0.1512	0.2170	0.1772	0.3069	0.3334	0.2722	0.4715
CD (0.05)	0.2202	0.1798	0.3114	0.4470	0.3650	0.6321	0.6867	0.5607	0.9711

M₁, Mature green; M₂, breaker; M₃, light red; F₁, conventional farming; F₂, precision farming.

Table 2. Effect of maturity stages on Shelf life (No. of days) of conventional and precision farming tomato.

Treatments	F ₁	F ₂	Mean
M ₁	16.00	28.50	22.25
M ₂	13.00	24.50	18.75
M ₃	9.50	20.50	15.00
Mean	12.83	24.50	28
	M	F	M X F
SEd	0.2092	0.1709	0.2959
CD (0.05)	0.4310	0.3519	0.6095

M₁, Mature green; M₂, breaker; M₃, light red; F₁, conventional farming; F₂, precision farming.

This is in line with the reports of Rajadurai (2008) and Priyadharshini (2009) in tomato.

Shelf life

When the effects of the farming systems were compared, precision farming system (F₂) registered significantly the highest number of days (24.50) followed by conventional system (F₁) with 12.8 days (Table 2 and Figure 1). Significant differences were observed due to the farming system in maturity stages. F₂M₁ registered significantly the most number of days (28.50) for shelf life and it was followed by F₂M₂ (Figure 1). The lowest number of days (9.50) for shelf was recorded in F₁M₃. In the present investigation, fruits harvested at mature green stage from precision farming recorded the highest shelf life (28.50 days). Sufficient supply of nutrients might have increased the production of Indole Acetic Acid (IAA) which consequently would have shown stimulatory action, in terms of cell elongation and thus resulting in increased plant growth. Pafli (1965) suggested that nitrogen, being the chief constituent of chlorophyll, protein and amino acids, is accumulated in the shoot through increased

supply of nitrogen to the plants at appropriate time. Thus, fertigation deserves as an important aspect that contribute to increased plant growth. Fruits from well grown plants with well nutrient supplement give the highest shelf life (Balasubramanian, 2008).

Higher availability of nutrients and moisture in the root zone might have induced more root growth; hence, higher root volume was obtained which helps to get higher shelf life. Similar results were reported by Besford (1979) and Pandey et al. (1996). This result was in agreement with the findings of Puttaraju and Reddy (1997) and Kapse and Kalrodia (1997) in mango, Sreemathy (2004) in tomato, Rajadurai (2008) in tomato and Priyadharshini (2009) in tomato.

Enzyme activity influenced by maturity stage at harvest

Pectin methyl esterase

The pectin methyl esterase enzyme activity of fruits was influenced by farming systems and maturity stages (Table 3). When the effects of the farming systems were

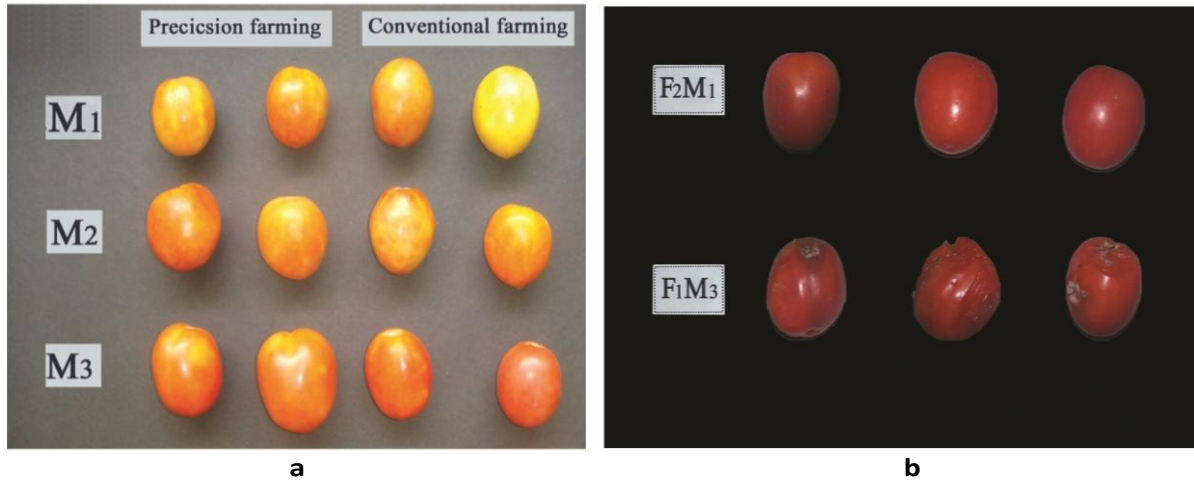


Figure 1. Effect of different maturity stages on two different farming systems of tomato (a) All treatments (b) Comparison of control with best treatment.

Table 3. Effect of maturity stages on Pectin methyl esterase activity (meq/g/hr) of conventional and precision farming tomato.

Treatments	F ₁	F ₂	Mean
M ₁	1.38	0.92	1.15
M ₂	1.56	1.32	1.44
M ₃	1.78	1.62	1.70
Mean	1.57	1.29	1.43
	M	F	M X F
SEd	0.0178	0.0145	0.02517
CD (0.05)	0.0367	0.0299	0.0518

M₁, Mature green; M₂, breaker; M₃, light red; F₁, conventional farming; F₂, precision farming.

compared, precision farming system (F₂) registered significantly the lowest activity followed by the conventional farming system (F₁) for pectin methyl esterase enzyme activity (Figure 1). Among the maturity stages, harvest at mature green stage (M₁) recorded significantly the least value of pectin methyl esterase activity followed by breaker stage (M₂). The highest enzyme activity was recorded with light red stage. Significant differences were observed due to the farming system in maturity stages. F₂M₁ registered significantly the lowest enzyme activity and it was followed by F₂M₂. The highest value of pectin methyl esterase enzyme activity was recorded in F₁M₃.

Maturity is the most important determinant of storage life and final fruit quality. Maturity stages are determined for vegetables for enhanced shelf life. Harvesting crops at proper maturity allows handlers to begin their work with the best possible quality produce. Produce harvested too early lack flavor and may not ripen properly, while produce harvested too late may be fibrous or over ripe.

Generally, fruits become sweeter, more colourful and softer as they mature. A few fruits are usually harvested

mature but unripe so that they withstand post harvest handling system when shipped to long distances. Most of currently used maturity evaluation is based on a compromise between those methods that would ensure the best eating quality and those that provide flexibility in transportation and marketing. Optimum harvesting stage depends upon type of fruit or vegetable and their final use. Tomatoes are harvested at firm ripe stage when it needs for processing whereas it is not suited for transport purpose.

Definition of maturity as stage of development giving minimum acceptable quality to ultimate consumer implies measurable points in commodity's development, and need for techniques to measure maturity. Maturity index for a commodity is a measurement or measurements that can be used to determine whether a particular commodity is mature. These stages are important to trade regulation, marketing strategy and for the efficient use of labor and resources.

The major causes for spoilage of tomato are harvesting at immature stage, physical damage during harvest,

fungal infections, improper storage and internal breakdown. Tomato is a climacteric fruit and hence it is highly perishable after harvest due to high metabolic rate and ethylene production. A fruit can have a long storage life only if the metabolic rate is low, with consequent minimal loss of quality. So efforts to increase the shelf life of tomato should necessarily focus on decreasing the metabolic rate and reducing the synthesis of ethylene in harvested produce (Rao and Rao, 1979).

Postharvest metabolic changes are of particular importance because the fruits are harvested at unripe and inedible stage and the quality of fruits ultimately depends upon the postharvest handling and storage methods. A proper understanding of the morphological, physiological and biochemical changes that occur in the fruit during ripening is essential for the development of good storage techniques (Sudheer and Indira, 2007).

Conclusion

The treatment F₂M₁ (Harvesting at mature green stage of precision farming tomato) was found to be better because the lowest PLW 7.53% on 8 DAS with 28.50 days of shelf life. The highest firmness with reduced spoilage was found. Lowest enzyme activity of pectin methyl esterase was found in the best treatment.

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REFERENCES

- AOAC (1975). Official methods of analysis. Association of Agricultural chemists, 9th Ed, Washington D.C. 2004.
- Balasubramanian, P (2004). Studies on the effect of pre and postharvest treatments on dehydration and storage of bhendi var. Arka Anamika. M.Sc., (Hort.) Thesis. Tamil Nadu Agriculture University, Coimbatore, P. 3.
- Balasubramanian P (2008). Comparative analysis of growth, physiology, nutritional and production changes of tomato (*Lycopersicon esculentum* Mill.) under drip, fertigation and conventional systems. Ph.D. (Hort.) Thesis. Tamil Nadu Agriculture University, Coimbatore, India.
- Besford RT (1979). Uptake and distribution of phosphorus in tomato plants. *Plant Soil* 51: 331-340.
- Carr PM, Carlson GR, Jacobsen JS, Nielsen GA and Skogley EO (1991). "Farming by Soils, Not Fields: A Strategy for Increasing Fertilizer Profitability." *J. Prod. Agric.* 4:57-61
- Indian Horticulture Database (2011). (Ed) Bijay Kumar. <http://nhb.gov.in/area-pro/database-2011.pdf> accessed on 10.07.2013
- Kapse BM, Kalrodia JS (1997). Studies on hydro cooling in Kesar mango (*Mangifera indica*). *Acta. Hort.* 455:707-717.
- Palmer RJ (1996). In Proc. Site-Specific Management for Agric. Syst., Minneapolis, MN, ASA-CSSA-SSSA, Madison, WI, 27-30 March, pp. 613-618.
- Pandey RP, Solanki, PN, Saraf RK, Parihar, MS (1996). Effect of nitrogen and phosphorus on growth and yield of tomato varieties. *Punjab Veg. Growers* 31:1-5.
- Panse VG, Sukhatme PV (1985). Statistical methods for Agricultural workers. Indian Council for Agricultural Research, New Delhi.
- Patil VS, anawade AD (1999). Soil water plant atmosphere relationships. In : Proc. Advances in microirrigation and fertigation. June 21-30. Dharwad. Karnataka. pp. 19-32.
- Priyadarshini G (2009). Pre and Post harvest handling, storage, packaging and value addition in Hybrid Tomato (*Solanum lycopersicon* Mill.) M.Sc. (Hort.) Thesis. Tamil Nadu Agriculture University, Coimbatore, India.
- Puttaraju TB, Reddy TV (1997). Effect of pre cooling in the quality of mango (cv. Mallika). *J. Food Sci. Technol.* Quoted in post harvest News Info. 8:2088.
- Rajadurai, V (2008). Standardization of pre and post harvest protocols for hybrid tomato (*Solanum lycopersicon* Mill.) under open condition. M.Sc. (Hort.) Thesis. Tamil Nadu Agriculture University, Coimbatore, India.
- Ranganna S (1986), Handbook of Analysis of quality control for fruit and vegetable products. 2nd Edition. Tata McGraw Hill Publication, New Delhi,
- Rao DM, Rao MR (1979). Post harvest changes in banana cv. Robusta. *Indian J. Hort.* 36:387-393.
- Salunkhe KK, Desai BE (1984). In: Post harvest Biotechnology of fruits Vol.1. Boca Raton, FL: CRC press, London, p. 168.
- Sreemathy B (2004). Pre and post harvest treatments to enhance shelf life in tomato (*Lycopersicon esculentum* Mill). M.Sc. (Hort.) Thesis. Tamil Nadu Agricultural University, Coimbatore.
- Sudheer, Indira (2007). Post harvest technology of horticultural crops. Ed. K. V. Peter. New India Publishing Agency, New Delhi.