Influence of Paclobutrazol (PP333) and Sridiamin (Human hair-derived aminoacid mixture) on growth and quality of Tomato PKM-1

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Abstract. Tomato is one of the most popular vegetable in subtropics and tropics. Plant growth regulators have potential for manipulating growth of many agricultural crops. Among the plant growth retardants, paclobutrazol (PP333) has been reported to exert profound effects on improving the yield of certain vegetables. Aminoacids are essential prerequisite for plant growth. Sridiamin a natural blend of 17 essential L-aminoacids, fortified with vitamins ensuring better crop growth and higher productivity. Therefore the present study was designed with 5mg and 10 mg concentration of PP333 as soil drench and a foliar spray of sridiamin of 0.5% and 1% concentration as individual and as combined treatment improved the yield and quality of tomato PKM1. Various biometric parameters, along with chlorophyll, starch, aminoacid and protein content were analysed in the leaves. In fruit analysis like titrable acidity, total soluble solids, ascorbic acid, lycopene, total sugars, macronutrients and micronutrients were analysed.

1. Introduction
One of the most popular Solanaceae families of self-pollinated crop is Tomato (Lycopersicon sculentum Mill.). It cultivated in all countries from temperate to tropical region. It is a functional food, plays a major role in human nutrition due to its good levels of vitamins, minerals and excellent antioxidant qualities [1,2]. Tomato requires a day temperature of 21–28°C and moderately cool night temperature of 15–20°C for proper fruit setting. Its production in the world in 2013 reached to 163.9 million tons and average yield of 34.7 tons per hectare [3]. The utility of tomato vary based on the type; cherry tomato for salads, big slicers for sandwiches and firm fleshed paste tomatoes for sauces, freezing and canning [4]. In 1978 sour type PKM-1 tomatoes were released and cultivated in Tamil Nadu Agricultural University and the result was extremely high yield and good quality of tomatoes.

The beneficial effects of growth regulators may vary based upon the type, concentration, and method of application [5]. For instance plant growth regulators of auxin and gibberellins are effective in increasing both yield and quality of tomato reported one by [6]. Abscissic acid is a direct mediator for inhibition of lateral root development, photosynthesis and respiration in leaves [7]. Salicylic acid
plays a vital role in plant defense response against pathogen attack. Therefore the use of fertilizers
and synthetic growth regulants not only increase fruit set and fruit ripening but also alters the quality
of tomato fruit [8].

The anti-gibberellin a potent growth retardant and triazole group of fungicide is “Paclobutrazol”
(PP333), used for flower induction, fruit setting and reducing the extension of shoot growth for many
crops. In addition, it is more stable in xylem and sub-xylem vessels [9,10,11]. Soil drenches and
foliar application is the two main methods of application.

Another essential and required material for plant growth is the amino acids. Their importance has
been accepted worldwide as a means to increase the yield and overall quality of crops. Sridiamin is a
mixture of 17 natural and essential amino acids derived from natural protein (Keratin). It is non-
opoisonous, non-hazardous and a liquid amino acid product (protein hydrolysate). This formulated
product was developed by Srinivasa Cystine Ltd., Hyderabad, for the first time in India. And it was
fortified with vitamins ensuring better crop growth and higher productivity. Foliar nutrition in the
form of protein hydrolysates (liquid amino acid) and foliar spray provide readymade building blocks
for protein synthesis [12].

The present investigation was conducted to evaluate the effect of Paclobutrazol (PP333), and
Sridiamin (Human hair derived amino acid) on the growth and quality of Tomato cv.PKM-1.

2. Material and Methods
The experiment was carried out using randomized block design with four replications for each
treatment.

Crop Husbandry- Initially the breeder’s quality seeds of tomato cv.PKM-1 were sown in raised
beds. Then the seedlings were 12-15cm tall, they were transplanted on the sides of ridges spaced at
60cm in the row and 60cm between rows.

Treatment Schedule- Paclobutrazol (PP333) was applied as soil drench one month after
transplanting. Sridiamin, exogenous mixture was applied on fortnightly basis as a foliar spray upto a
period of 2 months. The T1-Control, T2- 0.5% Sridiamin, T3-1.0% Sridiamin, T4- 5mg Paclobutrazol,
T5- 10mg Paclobutrazol, T6- 0.5% Sridiamin + 5mg Paclobutrazol, T7- 1.0% Sridiamin + 5mg
Paclobutrazol, T8- 0.5% Sridiamin + 10mg Paclobutrazol, T9- 1.0% Sridiamin + 10mg Paclobutrazol.

Plant Biometric Parameters- The plant height and spread, number of laterals per plant, flower
clusters and flowers per cluster, days to first flowering were counted in the experiment part.

Fruit Characters- The number of fruits and yield per plant were counted and expressed in grams.
Mean fruit weight was also obtained by,

\[
\text{Mean fruit weight} = \frac{\text{Total yield per plant (g)}}{\text{Total number of fruits per plant (g)}}
\]

Biochemical Parameters

Estimation of total leaf chlorophyll- The total chlorophyll estimation in leaf was followed by the
method of [13].

Estimation of starch in leaves- Starch estimation in leaves was determined by the method of [14].

Total protein in leaves- The estimation of total protein in fruits and leaves were identified by the
method [15].

Total free amino acids in leaves- The total free amino acids in the fruit and leaves were estimated by
[16] method.

Titrable acidity in fruits- The titrable acidity in fruits was estimation was followed by the method
[17].

Total soluble solids (TSS)- The TSS of fruit pulp was determined using ERMA Hand Refractometer
and expressed as degree brix.

Ascorbic acid in fruits- The ascorbic acid in fruits was estimated by the [18] method.

Lycopene estimation in fruits- The estimation of lycopene content in fruits was followed by the
method of [19].

Determination of total sugars in fruits- The total sugars in fruits were determined by [20] method.
**Determination of Total Nitrogen**- The total nitrogen content determination was followed by the method of [21].

**Estimation of Phosphorous**- The estimation of phosphorus was determined by [22] method.

**Estimation of Potassium**- The estimation of potassium content in the sample was measured by [23] method.

**Estimation of Manganese, Zinc, Iron and Copper**- The estimation of micronutrients was followed by the method of [24].

3. Result and Discussion
3.1 Plant biometric parameters

**a. Plant height and spread**

In tomato plant biometric parameters to the various treatments are given Table 1. As the foliar spray of Sridiamin individually influenced the plant height and spread to a greater extent than the other treatments. This might be due to enhancement of cell division and cell elongation. Paclobutrazol has reduced the plant height about 16.1% and spread about 13.1% at 10mg per plant (T3) compared to control. The reduction percentage in T3 was found to be on par with T4. However, in the combined treatment T4 showed increase in plant height and spread when compared to the other treatments.

**b. Number of laterals per plant**

Application of Sridiamin at T3 and T4 levels compared to control increased the laterals to about 13.6% and 27.2%. This was lesser when compared to that found in T4. The increment in T4 and T5 was found to be 95.4% and 72.7% respectively. In combined treatments, T showed best result. Thus reduction in number of laterals due to combined treatment compared to individual treatment of PP333 was observed. This might be due to reduced apical dominance. The similar result was also reported in *Brassica juncea* by [25].

**c. Number of days to first flowering**

PP333 alone or combination with Sridiamin reduces the days to first flowering significantly compared to control. PP333 owing to its antigibberellin activity could induce or intensify flowering by blocking the conversion of kaurene to kaurenoic acid a precursor of gibberellins [26]. The similar result obtained by [27].

| Treatments | Plant Height (in cm) | Plant Spread (in cm) | Lateral per plant (in number) | Days to first flowering (in number) | Flower clusters per plant | Flower per cluster (in number) |
|------------|----------------------|----------------------|-------------------------------|------------------------------------|---------------------------|------------------------------|
| T1         | 65.6±1.02            | 67.7±1.02            | 5.5±0.04                      | 69.3±1.02                          | 5.5±0.05                  | 4.6±0.05                     |
| T2         | 79.8±1.01            | 69.6±1.01            | 6.3±0.03                      | 63.5±1.04                          | 6.8±0.03                  | 5.6±0.02                     |
| T3         | 82.8±1.01            | 73.0±1.01            | 7.0±0.02                      | 64.3±1.03                          | 8.3±0.02                  | 5.9±0.01                     |
| T4         | 58.5±1.03            | 52.0±1.03            | 10.8±0.01                     | 57.0±1.05                          | 6.3±0.04                  | 5.3±0.04                     |
| T5         | 55.0±1.05            | 46.6±1.04            | 9.5±0.02                      | 55.5±1.07                          | 5.8±0.04                  | 5.4±0.03                     |
| T6         | 64.9±1.02            | 54.3±1.02            | 8.3±0.05                      | 54.3±1.08                          | 7.0±0.01                  | 5.5±0.02                     |
| T7         | 65.9±1.01            | 54.9±1.02            | 8.5±0.04                      | 57.8±1.06                          | 7.3±0.01                  | 5.4±0.04                     |
| T8         | 53.8±1.4             | 43.6±1.04            | 7.0±0.01                      | 58.5±1.06                          | 6.5±0.05                  | 5.3±0.03                     |
| T9         | 50.4±1.5             | 44.3±1.01            | 7.5±0.03                      | 56.5±1.05                          | 6.3±0.03                  | 5.2±0.01                     |
| SED        | 2.521                | 2.289                | 0.918                         | 2.475                              | 0.413                     | 0.154                        |
| CD (0.05%) | 5.202                | 4.725                | 1.895                         | 5.108                              | 0.851                     | 0.318                        |

Values are mean± SD of four replications

d. Number of flower clusters and flowers per cluster per plant

In T3 and T2 (8.3 and 5.9) increased number of flower clusters and flowers per cluster were seen among all the treatments compared with control but less than T3. PP333 in T4 and T3 had more flower
cluster (6.3 and 5.8) than control. However in T₆ and T₇ had (7 and 7.3) clusters, therefore a similar result was found.

e. Fruit Characters
Among all the treatments mean fruit weight, number of fruits per plant and yield per plant were found to be higher in T₇ and T₆ compared to the other treated group.

Table 2. Fruit Characteristics

| Treatments | Mean fruit weight (g) | Number of fruits per plant | Yield per plant (kg) |
|------------|-----------------------|----------------------------|----------------------|
| T₁         | 39.7 ±0.02            | 41.0 ±1.03                 | 1.6 ±0.04            |
| T₂         | 42.6 ±0.03            | 46.0 ±0.02                 | 2.4 ±0.07            |
| T₃         | 45.1 ±0.02            | 47.0 ±0.01                 | 2.0 ±0.05            |
| T₄         | 30.6 ±0.04            | 46.0 ±0.03                 | 1.4 ±0.03            |
| T₅         | 23.4 ±0.01            | 42.0 ±0.04                 | 1.0 ±0.11            |
| T₆         | 55.2 ±0.01            | 48.0 ±0.02                 | 2.6 ±0.01            |
| T₇         | 46.5 ±0.02            | 51.0 ±0.01                 | 2.0 ±0.03            |
| T₈         | 38.3 ±0.04            | 46.0 ±0.04                 | 1.8 ±0.04            |
| T₉         | 33.3 ±0.01            | 41.0 ±0.05                 | 1.7 ±0.06            |
| SED        | 1.058                 | 1.036                      | 0.059                |
| CD (0.05%) | 2.184                 | 2.198                      | 0.124                |

Values are mean ± SD of four replications

3.2 Biochemical parameters

a. Total leaf chlorophyll and starch
Among all the treatments T₉ resulted in highest content of chlorophyll and all other treatment results found to be on par with each other. In addition the high level of starch observed (1.95g/100g) in T₅ followed by T₈. Application of both PP₃₃₃ and Sridiamin individually and in combination has influenced the chlorophyll as well as starch content of the leaves. Paclobutrazol increases the chlorophyll content when compared to control in all the sampling of barley seedlings and tomato [28].

Table 3- Total chlorophyll and starch content in leaves.

| Treatments | Total chlorophyll (mg/100g) | Starch content (g/100g) |
|------------|-----------------------------|-------------------------|
| T₁         | 0.313±0.08                  | 0.85±0.02               |
| T₂         | 0.338±0.05                  | 1.07±0.01               |
| T₃         | 0.339±0.07                  | 1.17±0.03               |
| T₄         | 0.346±0.03                  | 1.64±0.01               |
| T₅         | 0.349±0.01                  | 1.96±0.02               |
| T₆         | 0.342±0.01                  | 1.35±0.01               |
| T₇         | 0.346±0.04                  | 1.46±0.07               |
| T₈         | 0.352±0.02                  | 1.80±0.06               |
| T₉         | 0.372±0.01                  | 1.51±0.08               |
| SED        | 0.004                       | 0.043                   |
| CD (0.05%) | 0.009                       | 0.088                   |

Values are mean ± SD of four replications

b. Total protein and free amino acids in leaves
In leaves highest protein content was noticed in T₃ and T₉ followed by T₇ and T₈. There was no significant difference noticed between T₂ and T₆ (11.9mg/g). Thus in leaves PP₃₃₃ alone and in combination not showed any increased protein content but in fruits the level of protein is high when compared with Sridiamin alone and in combination treatments. Therefore combined application of Sridiamin and PP₃₃₃ in either concentration has increased the quantity of protein in leaves and fruits.
The total free amino acids content was found to be higher in fruits than leaves. Therefore Sridiamin shown highest amount of amino acids individually and in combination. The results were depicted in Table 4. A positive correlation (r=+0.3866) and (r=+0.2791) were observed between total protein and free amino acids in leaves and fruit. [32] Has also shown that PP333 increased the amino acid content of olive plants.

| Treatments | Total protein (mg/100g) | Total free amino acids (g/100g) |
|------------|-------------------------|-------------------------------|
| T1         | 10.4±0.04               | 3.5±0.31                     |
| T2         | 11.9±0.01               | 3.9±0.11                     |
| T3         | 13.4±0.07               | 3.4±0.07                     |
| T4         | 10.9±0.05               | 4.1±0.03                     |
| T5         | 11.4±0.02               | 4.5±0.06                     |
| T6         | 11.9±0.04               | 4.2±0.01                     |
| T7         | 12.9±0.01               | 5.0±0.02                     |
| T8         | 12.4±0.03               | 5.3±1.04                     |
| T9         | 13.4±0.08               | 5.6±0.10                     |
| SED        | 0.085                   | 0.141                        |
| CD (0.05%) | 0.179                   | 0.291                        |

Values are mean ± SD of four replications

c. Titrable acidity, total soluble solids, ascorbic acid and lycopene in fruits

Titratable acidity levels higher in T2 and T3 about 19.6% and 37.2% compared to control. However plants treated with PP333 both individually and in combination resulted higher titratable acidity than control. The Total soluble solids content of the fruit varied between 4.03-5.48 degree brix.

Ascorbic acid content of the treatment was higher than the control. In T3 followed by T4 the highest ascorbic acid content was noticed. All other treatments did not differ significantly in the ascorbic acid content of fruits. PP333 had increased ascorbic acid content in Actinidia arguta [30] and in Tomato cv. Pusa ruby [31]. Lycopene is responsible for the red colour in tomato, though it has no nutritional value, its contribution to the colour of tomato has a great role in consumer acceptability [32]. PP333 at T2 and T3 caused 60.9% and 85.85% increased lycopene content compared to control were observed. About 94.5% of highest lycopene content was noted in the T9 plant followed by T7. Therefore titratable acidity, total soluble solids, ascorbic acid and lycopene contents in fruits were higher in plants treated with PP333 individually or in combination were showed in Table 5.

### Table 5. Titrable acidity, total soluble solids, ascorbic acid, and lycopene content in fruits.

| Treatments | Titrable acidity (g/100g) | Total Soluble Solids (Degree brix) | Ascorbic acid (mg/100g) | Lycopene (mg/100g) |
|------------|--------------------------|-----------------------------------|-------------------------|-------------------|
| T1         | 0.51±0.21                | 4.03±0.17                         | 25.6±0.14               | 1.28±0.10         |
| T2         | 0.61±0.11                | 5.00±0.19                         | 28.4±0.22               | 1.54±0.21         |
| T3         | 0.70±0.45                | 5.10±0.01                         | 26.4±0.35               | 1.62±0.18         |
| T4         | 0.86±0.31                | 5.23±0.22                         | 30.0±0.12               | 2.06±0.29         |
| T5         | 0.86±0.19                | 5.48±0.51                         | 31.6±0.27               | 2.37±0.17         |
| T6         | 0.80±0.08                | 5.25±0.45                         | 28.6±0.01               | 1.87±0.38         |
| T7         | 0.83±0.20                | 5.38±0.36                         | 27.2±1.01               | 2.25±0.28         |
| T8         | 0.86±0.11                | 5.10±0.50                         | 26.4±0.25               | 1.96±0.05         |
| T9         | 0.83±0.23                | 5.45±0.34                         | 29.2±0.11               | 2.49±0.13         |
| SED        | 0.013                    | 0.043                             | 0.272                   | 0.076             |
| CD (0.05%) | 0.026                    | 0.088                             | 0.562                   | 0.158             |

Values are mean ± SD of four replications
d. **Total sugars in fruits**

The content of total sugars in the fruits are shown in Table 6. The total sugars were found to be more in T4 and T5 followed by T7 where the sugar content was found to be higher in the combined treatments. [33] Showed that application of paclobutrazol reduced stem length, number of tubers per plant and sugar content of potato.

### Table 6. Total, reducing and non-reducing sugar content of fruits

| Treatments | Total sugar (g/100g) |
|------------|----------------------|
| T1         | 9.6±0.21             |
| T2         | 12.4±0.23            |
| T3         | 13.2±0.56            |
| T4         | 15.2±0.11            |
| T5         | 14.4±0.38            |
| T6         | 13.0±0.22            |
| T7         | 14.8±0.31            |
| T8         | 13.6±0.11            |
| T9         | 13.2±0.29            |
| SED        | 0.049                |
| CD (0.05%) | 1.101                |

Values are mean ± SD of four replications

3.3 **Determination of macronutrients in fruits and leaves**

The plants up taking macronutrients of nitrogen, phosphorus, potassium were determined in the fruits are described in Table 7.

a. **Nitrogen**- Among all the treatments nitrogen content of the fruit T9 was the highest followed by T8. Individual application of Sridiamin and PP333 not showed any significant influence on the nitrogen content of the fruit.

b. **Phosphorus**- The phosphorus content was also high in T9 fruits as well as leaves in both stages. The individual treatments, both Sridiamin and PP333 increased level of phosphorus but that was not effective.

c. **Potassium**- Sridiamin and PP333 as individual spray at both concentration not effective levels of potassium found in both leaves and fruits, compare to combined treatment. All other treatments did not show significant difference in the quantity of potassium. Among the treatments the macronutrient content was higher in the combined treatment (T9) fruits and leaves were observed. PP333 inhibited growth and increased most of the macronutrients in the leaves of sweet peppers [34]. The results obtained are agreement with the findings.

### Table 7. Macronutrients- N, P and K in fruits.

| Treatments | Nitrogen (g %) | Phosphorus (g %) | Potassium (g %) |
|------------|----------------|------------------|-----------------|
| T1         | 1.30±0.34      | 0.68±0.22        | 2.70±0.034      |
| T2         | 1.58±0.12      | 0.68±0.18        | 3.01±0.22       |
| T3         | 1.81±0.16      | 0.70±0.36        | 3.20±0.15       |
| T4         | 1.89±0.45      | 0.72±0.11        | 3.05±0.28       |
| T5         | 2.00±0.23      | 0.84±0.25        | 3.20±0.24       |
| T6         | 1.76±0.31      | 0.88±0.16        | 3.18±0.19       |
| T7         | 1.65±0.12      | 0.97±0.35        | 3.18±0.10       |
| T8         | 1.94±0.04      | 1.20±0.17        | 3.70±0.23       |
| T9         | 2.06±0.01      | 1.40±0.21        | 3.98±0.12       |
| SED        | 0.019          | 0.030            | 0.060           |
| CD (0.05%) | 0.040          | 0.060            | 0.130           |

Values are mean ± SD of four replications
3.4 Determination of micronutrients in fruits
Micronutrient of Mn, Zn, Fe and Cu contents were shown in Table 8.

**a. Manganese**- The highest manganese content was also observed in combined treatment (T₃) followed by T₅ (fruits) and T₇ and T₈ (leaves) when compare to control.

**b. Zinc**- A similar amount of zinc content was found in fruits except T₅, T₈ and T₉ which contained 40ppm. During the harvest stage like other nutrients zinc content was low.

**c. Iron**- Iron content remained high in the combined treatment than in the individual treatment, which also showed a significant difference when compared to the control.

**d. Copper**- The copper content in fruits ranged between 16-22ppm. The highest copper content in fruits was noted in T₅ followed by T₇. [35] Have reported that PP₃₃₃ had enhanced the growth parameters as well as Ca, Mg, Fe and Zn in the leaves of Mango.

| Treatments | Manganese(ppm) | Zinc(ppm) | Iron(ppm) | Copper(ppm) |
|------------|----------------|-----------|-----------|-------------|
| T₁         | 31±0.12        | 30±0.32   | 160±0.19  | 16±1.01     |
| T₂         | 40±1.01        | 30±0.21   | 198±0.76  | 18±0.12     |
| T₃         | 45±1.12        | 30±0.34   | 213±0.26  | 22±0.56     |
| T₄         | 45±0.12        | 30±0.45   | 199±0.67  | 19±0.72     |
| T₅         | 47±0.45        | 40±0.49   | 206±0.45  | 19±0.56     |
| T₆         | 32±0.52        | 30±0.19   | 218±0.35  | 17±0.57     |
| T₇         | 36±1.17        | 30±0.19   | 267±0.11  | 21±0.01     |
| T₈         | 46±0.24        | 40±0.50   | 252±0.21  | 18±0.14     |
| T₉         | 50±1.33        | 40±0.15   | 279±0.17  | 20±0.18     |
| SED        | 1.223          | 0.408     | 0.544     | 0.817       |
| CD (0.05%) | 2.596          | 0.866     | 1.154     | 1.731       |

Values are mean± SD of four replications

4. Conclusion
Therefore, the results revealed that PP₃₃₃ individually reduces the plant height but also the yield of fruit, whereas application of 1% Sridiamin enhances the effect. From the result it was concluded that application of PP₃₃₃ at 5mg concentration as soil drench and Sridiamin at 1% concentration as foliar spray provided a good yield and enhanced in nutrition value when compared to the other treatments.

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