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Influence of Paclobutrazol (PP_{333}) 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 (*Lycopersicone 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]. Abscisic 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" (PP_{333}), 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-poisonous, 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 (PP_{333}), 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 (PP_{333}) 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 T_1-Control, T_2- 0.5% Sridiamin, T_3-1.0% Sridiamin, T_4- 5mg Paclobutrazol, T_5- 10mg Paclobutrazol, T_6- 0.5% Sridiamin + 5mg Paclobutrazol, T_7- 1.0% Sridiamin + 5mg Paclobutrazol, T_8- 0.5% Sridiamin + 10mg Paclobutrazol, T_9- 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,

Mean fruit weight = Total yield per plant (g) / 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 aminoacids 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 (T_5) compare to control. The reduction percentage in T_5 was found to be on par with T_4. However, in the combined treatment T_7 showed increase in plant height and spread when compared to the other treatments.

b. Number of laterals per plant

Application of Sridiamin at T_2 and T_3 levels compare to control increased the laterals to about 13.6% and 27.2%. This was lesser when compared to that found in T_4. The increment in T_4 and T_5 was found to be 95.4% and 72.7% respectively. In combined treatments, T_7showed best result. Thus reduction in number of laterals due to combined treatment compare to individual treatment of PP333 was observed. This might be due to reduced apical dominance. The similar result was also reported in *Brassica junecea* by [25].

c. Number of days to first flowering

PP_{333} alone or combination with Sridiamin reduces the days to first flowering significantly compare to control. PP_{333} 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].

Table 1. Biometric parameters.

Treatments	Plant Height (in cm)	Plant Spread (in cm)	Laterals per plant (in number)	Days to first flowering (in number)	Flower clusters per plant	Flower per cluster (in number)
T_1	65.6±1.02	67.7±1.02	5.5±0.04	69.3±1.02	5.5±0.05	4.6±0.05
T_2	79.8±1.01	69.6±1.01	6.3±0.03	63.5±1.04	6.8±0.03	5.6±0.02
T_3	82.8±1.01	73.0±1.01	7.0±0.02	64.3±1.03	8.3±0.02	5.9±0.01
T_4	58.5±1.03	52.0±1.03	10.8±0.01	57.0±1.05	6.3±0.04	5.3±0.04
T_5	55.0±1.05	46.6±1.04	9.5±0.02	55.5±1.07	5.8±0.04	5.4±0.03
T_6	64.9±1.02	54.3±1.02	8.3±0.05	54.3±1.08	7.0±0.01	5.5±0.02
T_7	65.9±1.01	54.9±1.02	8.5±0.04	57.8±1.06	7.3±0.01	5.4±0.04
T_8	53.8±1.4	43.6±1.04	7.0±0.01	58.5±1.06	6.5±0.05	5.3±0.03
T_9	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 T_3 and T_2 (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 T_3. PP_{333} in T_4 and T_5 had more flower

cluster (6.3 and 5.8) than control. However in T_6 and T_7 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 $T_7$and T_6 compared to the other treated group.

Table 2. Fruit Characteristics

Treatments	Mean fruit weight (g)	Number of fruits per plant	Yield per plant (kg)
T_1	39.7 ±0.02	41.0 ±1.03	1.6 ±0.04
T_2	42.6 ±0.03	46..0 ±0.02	2.4 ±0.07
T_3	45.1 ±0.02	47.0 ±0.01	2.0 ±0.05
T_4	30.6 ±0.04	46.0 ±0.03	1.4 ±0.03
T_5	23.4 ±0.01	42.0 ±0.04	1.0 ±0.11
T_6	55.2 ±0.01	48.0 ±0.02	2.6 ±0.01
T_7	46.5 ±0.02	51.0 ±0.01	2.0 ±0.03
T_8	38.3 ±0.04	46.0 ±0.04	1.8 ±0.04
T_9	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 T_9 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 T_5 followed by T_8. Application of both PP_{333} 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)
T_1	0.313±0.08	0.85± 0.02
T_2	0.338±0.05	1.07±0.01
T_3	0.339±0.07	1.17±0.03
T_4	0.346±0.03	1.64±0.01
T_5	0.349±0.01	1.96±0.02
T_6	0.342±0.01	1.35±0.01
T_7	0.346±0.04	1.46±0.07
T_8	0.352±0.02	1.80±0.06
T_9	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 T_3 and T_9 followed by T_7 and T_8. There was no significant difference noticed between T_2 and T_6 (11.9mg/g). Thus in leaves PP_{333} 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 PP_{333} in either concentration has increased the quantity of protein in leaves and fruits.

The total free aminoacids content was found to be higher in fruits than leaves. Therefore Sridiamin shown highest amount of aminoacids 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. [29] Has also shown that PP333 increased the aminoacid content of olive plants.

Table 4. Total protein and total free amino acids in leaves.

Treatments	Total protein (mg/100g)	Total free aminoacids (g/100g)
T_1	10.4±0.04	3.5±0.31
T_2	11.9±0.01	3.9±0.11
T_3	13.4±0.07	3.4±0.07
T_4	10.9±0.05	4.1±0.03
T_5	11.4±0.02	4.5±0.06
T_6	11.9±0.04	4.2±0.01
T_7	12.9±0.01	5.0±0.02
T_8	12.4±0.03	5.3±1.04
T_9	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

Titrable acidity levels higher in T_2 and T_3 about 19.6% and 37.2% compared to control. However plants treated with PP_{333} both individually and in combination resulted higher titrable 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 T_5 followed by T_4 the highest ascorbic acid content was noticed. All other treatments did not differ significantly in the ascorbic acid content of fruits. PP_{333} 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]. P_{333} at T_4 and T_5 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 T_9 plant followed by T_7. Therefore titrable acidity, total soluble solids, ascorbic acid and lycopene contents in fruits were higher in plants treated with PP_{333} 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 birx)	Ascorbic acid (mg/100g)	Lycopene (mg/100g)
T_1	0.51±0.21	4.03±0.17	25.6±0.14	1.28±0.10
T_2	0.61±0.11	5.00±0.19	28.4±0.22	1.54±0.21
T_3	0.70±0.45	5.10±0.01	26.4±0.35	1.62±0.18
T_4	0.86±0.31	5.23±0.22	30.0±0.12	2.06±0.29
T_5	0.86±0.19	5.48±0.51	31.6±0.27	2.37±0.17
T_6	0.80±0.08	5.25±0.45	28.6±0.01	1.87±0.38
T_7	0.83±0.20	5.38±0.36	27.2±1.01	2.25±0.28
T_8	0.86±0.11	5.10±0.50	26.4±0.25	1.96±0.05
T_9	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)
T_1	9.6±0.21
T_2	12.4±0.23
T_3	13.2±0.56
T_4	15.2±0.11
T_5	14.4±0.38
T_6	13.0±0.22
T_7	14.8±0.31
T_8	13.6±0.11
T_9	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 T_9 was the highest followed by T_8. Individual application of Sridiamin and PP_{333} not showed any significant influence on the nitrogen content of the fruit.

b. Phosphorus- The phosphorus content was also high in T_9 fruits as well as leaves in both stages. The individual treatments, both Sridiamin and PP_{333} increased level of phosphorus but that was not effective.

c. Potassium- Sridiamin and PP_{333} 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 (T_9) fruits and leaves were observed. PP_{333} 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 %)
T_1	1.30±0.34	0.68±0.22	2.70±0.034
T_2	1.58±0.12	0.68±0.18	3.01±0.22
T_3	1.81±0.16	0.70±0.36	3.20±0.15
T_4	1.89±0.45	0.72±0.11	3.05±0.28
T_5	2.00±0.23	0.84±0.25	3.20±0.24
T_6	1.76±0.31	0.88±0.16	3.18±0.19
T_7	1.65±0.12	0.97±0.35	3.18±0.10
T_8	1.94±0.04	1.20±0.17	3.70±0.23
T_9	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 (T_9) followed by T_5 (fruits) and T_7 and T_8 (leaves) when compare to control.

b. Zinc-A similar amount of zinc content was found in fruits except T_5, T_8 and T_9 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 T_3 followed by T_7. [35] Have reported that PP_{333} had enhanced the growth parameters as well as Ca, Mg, Fe and Zn in the leaves of Mango.

Table 8. Micronutrients- Mn, Zn, Fe and Cu in fruits.

Treatments	Manganese(ppm)	Zinc(ppm)	Iron(ppm)	Copper(ppm)
T_1	31±0.12	30±0.32	160±0.19	16±1.01
T_2	40±1.01	30±0.21	198±0.76	18±0.12
T_3	45±1.12	30±0.34	213±0.26	22±0.56
T_4	45±0.12	30±0.45	199±0.67	19±0.72
T_5	47±0.45	40±0.49	206±0.45	19±0.56
T_6	32±0.52	30±0.19	218±0.35	17±0.57
T_7	36±1.17	30±0.19	267±0.11	21±0.01
T_8	46±0.24	40±0.50	252±0.21	18±0.14
T_9	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 PP_{333} 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 PP_{333} 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.

References

[1] Varela AM, Seif A and Lohr B 2003 *A Guide to IPM in Tomato Production* (The International Centre of Insect Physiology and Ecology No.14)

[2] Naika S, Van Lidt de Jeude V, De Goffau M, Hilmi M and Van Dam B 2005 Cultivation of tomato: production processing and marketing. *CTA*. Series no 17

[3] Araujo JC and Telhado SF 2015 Organic food: a comparative study of the effect of tomato cultivars and cultivation conditions on the physico-chemical properties *Foods* **3** 263-270.

[4] Nick J, Bradley FM and Atthowe H, 1994 *Growing fruits & vegetables organically* Distributed in the book trade by St. Martin's Press

[5] Tiwari AK and Singh DK 2014 Use of plant growth regulators in tomato (Solanum lycopersicum L) under tarai conditions of Uttarkhand *Indian J Hill Fmg.* **2**

[6] Gemici M, Bengu T and Kit T 2006 Effects of 2 4-D and 4-CPA on yield and quality of the tomato (Lycopersicon esculentum Miller) *J. Fac. Sci.* **29** 24-32

7] Zhou L, Jang JC, Jones TL and Sheen J 1998 Glucose and ethylene signal transduction crosstalk revealed by an Arabidopsis glucose-insensitive mutant. *Proceedings of the National Academy of Sciences* **17** 10294-10299

[8] Baruah GKS, Arora SK and Pandita ML 1994 Effect of paclobutrazol (PP_{333}) on fruit set and fruit ripening of tomato *Veg. Sci.* **21** 106-110

[9] Webster AD and Quinlan JD 1984 Chemical control of tree growth of plum (Prunus domestica L.)I preliminary studies with the growth retardant paclobutrazol (PP333) *J. Hor. Sci.* **3** 367-375
[10] Richardson PJ, Webster AD and Quinlan JD 1986 The effect of paclobutrazol sprays with or without the addition of surfactants on the shoot growth, yield and fruit quality of the apple cultivars Cox and Suntan *J. Hor. Sci.* **4** 439-446
[11] Dheim MA and Browning G 1988 The mechanism of the effect of (2RS, 3RS) paclobutrazol on flower initiation of pear cv. Doyenne du Comice and Conference *J. Hort. Sci.* **63** 393-405.
[12] Beevers L and Hageman RH 1983 Uptake and reduction of nitrate bacteria and higher plants In Inorganic plant nutrition Springer Berlin Heidelberg. 351-375
[13] Arnon DI 1949 Copper enzymes in isolated chloroplasts Polyphenoloxidase in Beta vulgaris *Plant Physiol.***1** 1
[14] Hedge IE and Hofreiter BT 1962 Methods in carbohydrate chemistry (Eds Whistler RL, and Be Miller JN,) Academic Press New York
[15] Lowry OH, Rosebrough NJ, Farr AL and Randall RJ 1951 Protein measurement with the Folin phenol reagent. *J.Bio.Chem.***1** 265-275
[16] Moore S and Stein WH 1948 In methods in enzymol (Eds Colowick SP and Kalpan ND) Academic Press New York **3** 468
[17] Official AOAC 1960 Tentative methods of analysis (Association of Official Agricultural Chemists) Washington DC 494.
[18] Harris L and Ray SN 1935 Diagnosis of vitamin-C subnutrition by urine analysis with a note on the antiscorbutic value of human milk *The Lancet* **5811** 71-77.
[19] Ranganna S 1976 In manual analysis of fruits and vegetable product McGraw Hill New Delhi 77.
[20] Hedge IE and Hofreiter BT 1962 Methods in carbohydrate chemistry (Eds Whistler RL and Be Miller JN) Academic Press New York.
[21] APHA 1976 American Public Health Association, American water works association and water pollution control federation. Standard methods for the examination of water and waste water. (14th Edition, American Public Health Association Inc) New York **2** 35
[22] Jackson ML 1973 Soil chemical analysis (Prentice Hall of India Private Ltd) New Delhi
[23] Piper CS 1966 Soil and plant analysis (Hans Publications) Bombay 368.
[24] Lindsay WL and Norvell WA 1978 Development of a DTPA soil test for zinc, iron, manganese, and copper *Soil Sci Soc Am J.* **3** 421-428.
[25] Setia N, Setia RC and Kaur P 1997 Morphological development and anatomical features of *Brassica juncea* as influenced by paclobutrazol, *Phytomorphology* **47** 427-436.
[26] Voon CH, Pitakpaivan C and Tan SJ 1989 Mango cropping manipulation with Cultar. *III International Mango Symposium* **291** 219-228.
[27] Kalpana S & Saroja S 1999 Effect of paclobutrazol (pp333) and human hair-derived amino acids mixture (sridiamin) on growth yield and quality of tomato cv. PKM-1 (Lycopersicon esculentum Mill) South Indian Hortculture **1/6** 262-266.
[28] Muthukumarasamy M and Panneerselvam R 1997 Amelioration of NaCl stress by triadimefon in peanut seedlings. *Plant growth regulation* **3** 157-162.
[29] Thakur A, Thakur PS and Singh RP 1998 Influence of paclobutrazol and triacontanol on growth and water relations in olive varieties under water stress *Indian J Plant Physiol* **3** 116-120.
[30] Yulan , Yuxiang and Yueshen M 1997 Effect of PP_{333} on the growth and development of Actinida Arguta [J]. *Scientia Agricultura Sinica* **30** 65-70.
[31] Baruah GKS, Arora SK and Pandita ML 1994 Effect of Paclobutrazol (PP_{333}) on fruit set and fruit ripening of tomato *Veg. Sci.* **21** 106-110.
[32] Sadasivam S and Manickam A 1996 Biochemical Methods (II Edition, New Age International Publishers) 188-189.

[33] Mabvongwe O, Manenji BT, Gwazane M and Chandiposha M 2016 The effect of Paclobutrazol application time and variety on growth, yield, and quality of potato (Solanum tuberosum L.) *Advances in Agriculture*.
[34] Borowski E, Blamowski ZK and Kozlowska L 1998 Growth and physiological reactions to cold in weet peppers exposed to Paclobutrazol *Horticultura* **6** 129-136.
[35] Helail BM and Eissa MA 1997 Effect of some cultural practices and growth regulator treatments on growth of mango seedlings *Annals of Agricultural Science* Moshtohor (Egypt) **35** 883-894.