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IMPACT OF ASA (ACETYL SALICYLICACID) AND APAP (ACETYL PARA AMINOPHENOL) ON MORPHOLOGICAL CHARACTERISTICS AND YIELD FORMATION OF TOMATO PLANT (*SOLANUM LYCOPERSICUM L.*)

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INTRODUCTION

Plant morphology deals with knowledge of physical form and external structure of plants (Raven et al., Biology of plants 7th ed., 2005)[1] which includes plant development and formation. Plant morphology is always comparative approach to examine structural and developmental characteristics of same or different floral species and by virtue of different internal and external factors on them. The Structural and developmental aspects in plant morphology are not confined to only vegetative (somatic) parameters but also include, the reproductive parameters.[44] The vegetative parameters deals with characteristics of stem, root and leaves where as reproductive parameters deal with characteristics of flower, fruit and seed. Morphological characteristics related to growth factors have greater attraction for studying the impact of physical factors like light, gravity etc., Growth in the plants is not only account of cell division but also due to cell elongation. Both the things are mediated by specific plant hormones and plant growth regulators (PGRs) (Ross et al., 1983)[3] Usually these PGRs produced endogenously and show their deep impact on plant morphology. Certain exogenous chemical compounds also show significant impact on plant morphology by direct interaction or modulating plant physiology.

Morphological characteristics always indicate the status of plant physiology in certain aspects. Change in physiology is affected primarily in photosynthesis of plant. All those factors which trigger changes in physiology of plants also affects photosynthesis directly or indirectly. The variations in photosynthesis reflected into certain morphological characters like biomass of plant, plant growth in terms of length (shoot, root length, yielding, tillering of leaves, leaf area, qualitative and quantitative measurements of seeds, no. of seeds per plant, seed germination etc.,)

Monitoring physiological change by exogenous supplements, changes in morphological characteristics can occur from the scale of entire plants to the scale of individual leaves, buds, flowers, and grains or fruits.[4] For this type of characterization an entire tree, shrub, or herb can be considered as an array of repeating individual units or modules (Bell, 1991; Harper, 1977; stafstorm 1995; Watson and Casper 1984; White 1979).[5-9]

Due to significant influence of exogenous PAOMs (Physiologically active organic molecules) like drugs on plant development, morphological characteristics can be correlated with a number of internal phytochemical factors which influence physiology of the plants which further lead to changes in these morphological parameters.

Impact of PAOM's on plant morphology: As we know that PAOMs can interact with plant physiology directly or indirectly, they show their virtual or actual impact on plant morphology in a sequential manner. PAOMs like drugs usually have similar combination of functional groups to that of intermediates of biosynthetic pathways of many phytochemicals and secondary metabolites. Hence drugs interact with phytochemical intermediates of these bio synthetic pathways at a particular juncture leading to blocking, modulating, or regulating of their biosynthesis. Accounting on this new sort of compounds appeared in plant phytochemical system which may responsible for physiological changes in plants which in turn change plant morphology.

In addition to earlier aspects mentioned, PAOMs could initiate their own physiological activity directly in the phytochemical system. Some drugs mimic the activity of plant growth regulators like Auxins, Gibberillins etc. and might stimulate vegetative characterization of plant. In certain cases drugs interacts with plant growth regulators and changes plant morphology in an unexpected manner. The direct effects of PAOMs might include precursor activity in plant causing enhanced production of endogenous phyto-compounds. The increased quantity of these phyto-compounds will modify plant morphology.

The ability of certain PAOMs may affect plant genome system, and could provoke mutation or irregular Cell growth/ Cell division, which is also believed to be associated with changes in morphology of plants.

The plant selected for the current study is *Solanum lycopersicum* L. commonly known as a tomato which belongs to Solanaceae family.[45] Numerous varieties of tomatoes are cultivated globally in temperate climates. China and India together produces tomatoes approximately 42% of the total global production.[46-48] (*FAOSTAT, 2013*). Tomato is eighth most valuable agriculture product worldwide (*FAOSTAT, 2012*)[47] and the monthly per capita consumption of tomatoes in India is 0.537kg in rural areas and 0.757kg in urban areas(www.indiastat.com).[49]

In most of the developing and developed countries Industrial waste water is treated and reclaimed water is used for cultivation of tomatoes and other vegetables which have global demand.[16,50] Waste water from pharmaceutical Industries contains pharmaceutical Contaminants of process and fresh tomatoes there might be always a possibility of accumulated trace amount of pharmaceutical contaminants into human body through food products when they are consumed regularly in large qualities.

The present experiment deals with the impact of ASA (Acetyl Salicylic Acid) and APAP (Acetyl Para Amino Phenol) on morphological characteristic and yield formation of *Solanum lycopersicum L.* plants by comparative study with control plants. The plants response to these drugs in multiple aspects of morphology and physiology was recorded and analyzed to determine interaction of particular drugs and plant when it is present in pharmaceutical effluents.

MATERIALS AND METHODS

Determination of Mean Tolerance Concentration (MTC) of Drug: Mean Tolerance concentration of Drug is determined by observing tolerance levels tomato plants (15days old) under hydroponic culturing in 100ppm, 50ppm, 20ppm, 10ppm, 6ppm and 2ppm solutions of ASA and APAP separately for the period of seven days. The tolerance duration of 4days or above were considered for the calculation of MTC. The tomato plants in high concentration (100ppm) were denatured in two days. The tomato plants in 50ppm were denatured after 4 days. The plant in 20ppm, 10ppm 6ppm and 2ppm were grown normally.

MTC (*Solanum lycopersicum L.*)=(50ppm+20ppm+10ppm+6ppm+2ppm)/5=17.6ppm

Culturing the Tomato plants with Drug Treatment[10, 16]: The pot experiment was conducted in silty loam soil with alkali hydrolysable N, P_2O_5, K_2O. The contents contents were thoroughly mixed. 5kg of soil was placed in each pot (20cm in diameter and 20 cm in height). Tomato seeds (*Solanum lycopersicum L.)* were sterilised with 5% sodium hypochlorite and rinsed thoroughly under running tap water and dried with on filter paper during 20 minutes. These seeds were sown and allowed to germinate in uncontaminated soil. After 15days seedlings were hand-transplanted into the pots. (3plants per pot). Minimum amount of Fertilizers were applied as a basal dressing after 5 days (0.75g N, 0.5gP_2O_5 and 0.75g K_2O). pots were arranged in a randomized design with three replicates per treatment of the drug and distributed into three groups; APAP treatment plants, ASA Treatment Plants and Control Plants. The first doses of APAP and ASA (20 ppm each with respect to soil weight) was administered on 25th day and subsequent doses of APAP and ASA equivalent to 20 ppm were administered 30th day, 35th day, 40th day, 45th day and 50th day through aqueous solution of the drugs using 5mm micro tube drip emitters with a flow rate of 500mL hr.[1] All the precautions were taken to secure growth of the plants throughout the period. The samples are harvested at maturity and measured for various vegetative and morphological parameters i.e. wet and dry weights of fruit, root and shoot, fruit periphery, fruit diameter, No. Of fruits, total leaf area per plant, stem length, root length, periphery of root and stem etc.

RESULTS AND DISCUSSIONS

a) Effect on Fruit Weight and Measurement: Fruits of Control plants have shown the highest Average fresh weight (131.60g), whereas, the fruits of plants treated ASA and APAP has decreased their Average fresh weights by 46.05%(71.0g) and 67.63%(42.61g) respectively compared to control. Similarly, Fruit's size and dry weight also decreased in plants treated with ASA and APAP. The plants treated with APAP have shown the lowest Fruit periphery (12.83cm) and have also shown the lowest Fruit diameter (4.082cm). (Table 1).

Table 1. Effect of ASA and APAP on tomato Fruit Weight

Plant exposure	Flowers	No.of fruits	Total fruit Weight (wet, in gm)	Total dry fruit weight	Per Fruit Weight (Wet, in gm)	Fruit periphery (in cm) $2\pi r$	Fruit diameter (cm)
Control Tomato Plant	2.33±0.33	4 ±0	131.60 ±1.14	11.31±0.34	57.01 ±0.07	15.5 ±0.28	4.93 ± 0.09
Tomato plant Treated with ASA	1.66±0.33	4 ±0	71 ±0.57	6.10 ±0.16	34.27 ±1.39	13.5 ±0.28	4.29 ±0.09
Tomato plant Treated with APAP	0.33 ±0.3	2.66±0.33	42.61 ±1.71	3.12±0.17	29.91 ±0.5	12.83±0.16	4.08±0.05
Values are mean ± S.E(n=3)							

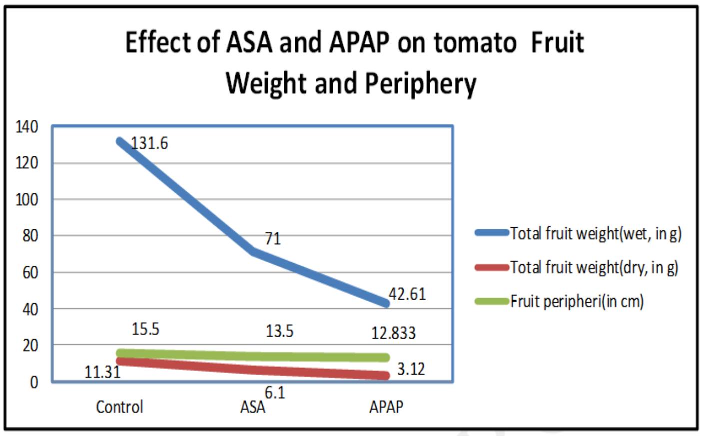

Fig.1. Effect of ASA and APAP on tomato Fruit Weight and Periphery.

b) Effect on Plant Length: Compared to the control, the plant stem length determined on 80th day was decreased by 2.166cm (7.81%) and root length decreased by 6.8cm (27.76%) in plant treated with ASA. Whereas in plant treated with APAP stem length decreased by 5.033cm (18.19%) and root length decreased by 8.35cm (34.09%). This result suggests that ASA and APAP have growth retarding action on stem and similar action on root of the plants. (Table 2).

Table 2. Effect of ASA and APAP on tomato Plant Length

Plant Exposure	Stem length(cm)	Root length(cm)
Control Tomato Plant	27.66 ±0.33	24.5 ±0.28
Tomato plant Treated with ASA	25.5 ±0.28	17.7 ±0.35
Tomato plant Treated with APAP	22.63 ±0.31	16.15 ±1.17
Values are mean ±S.E(n=3)		

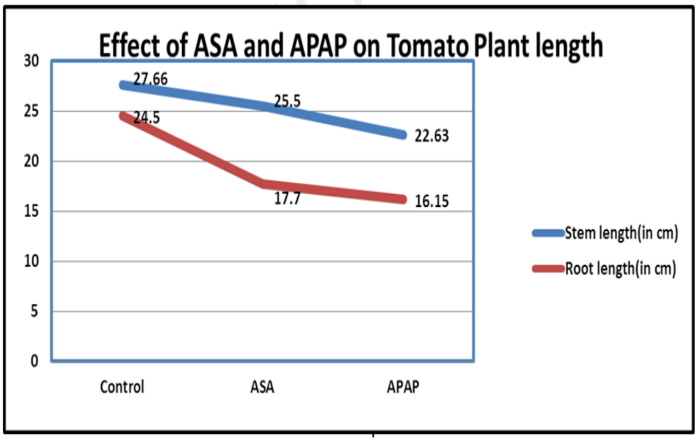

Fig.2. Effect of ASA and APAP on tomato plant length.

c) Effect on Leaves: With the treatment of ASA and APAP, total leaf area severely affected. The decrease is in total leaf area per plant was 68.17% (405.72cm^2) in the case of ASA treatment and 55.32% (569.4 cm^2) in APAP treatment compared to the control (1274cm^2), which will greatly slowdowns the rate of photosynthesis which in turn decreases plant's yield, productivity and biomass. This results suggests the strong phytohormone activity of ASA and APAP.

Table 3. Effect of ASA and APAP on tomato Leaf Measurements

Plant Exposure	No. Of leaves	Leaf length(cm)	Width (cm)	Total leaf area per plant (cm)^2
Control Tomato Plant	9±0	17.73 ±0.37	10.63±0.31	1274±63.43
Tomato Plant treated with ASA	6±0	11.25 ±0.2	7.93 ±0.06	405.72 ±5.24
Tomato Plant treated with APAP	8 ±0	10.23 ±0.14	9 ±0	569.4 ±14.92
Values are mean ±S.E (n=3)				

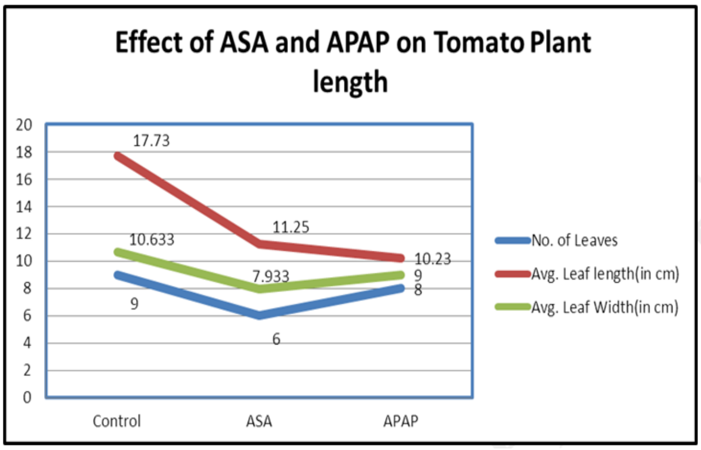

Fig. 3. Effect of ASA and APAP on tomato Leaf Measurements.

d)Effect on Plant Weight: Highest plant weight (both dry and wet) was recorded in control plant. Compared to the control, the plant's root wet weight determined on 80th day was decreased by 3.96g (56.74%) per plant cultivated in ASA and 4.73g (67.77%) per plant cultivated in APAP. Whereas in terms of dry weight decreases about 0.613gm(40.94%) in case of ASA and 0.893g (59.54%) in case of APAP. Similar trends have shown in the shoot weights of the tomato plant which were treated with ASA and APAP. Compared to the control, the plant's shoot wet weight determined on 80th day was decreased by 40.84g (31.2%) per plant treated with ASA and 76.31g (58.3%) per plant cultivated in APAP. On the other hand, the dry weight of shoot decreases about 7.02gm (41.67%) in case of ASA and 14.11g (83.74%) in case of APAP. (Table.4).

The results suggest that ASA and APAP decrease Biomass of the plant drastically, especially in the case of APAP treatment.

Table 4. Effect of ASA and APAP on tomato Plant Weight

Plant Exposure	Root weight (wet, in gm)	Root weight (dry, in gm)	Shoot weight (wet, in gm)	Shoot weight (dry, in gm)
Control Tomato Plant	6.98 ±0.04	1.49 ±0.15	130.93±1.46	16.85 ±0.47
Tomato Plant Treated with ASA	3.02±0.07	0.88 ±0.04	90.09±0.58	9.83±0.13
Tomato Plant Treated with APAP	2.25 ±0.02	0.60 ±0.003	54.61 ±0.41	2.74 ±0.12
Values are mean ±S.E(n=3)				

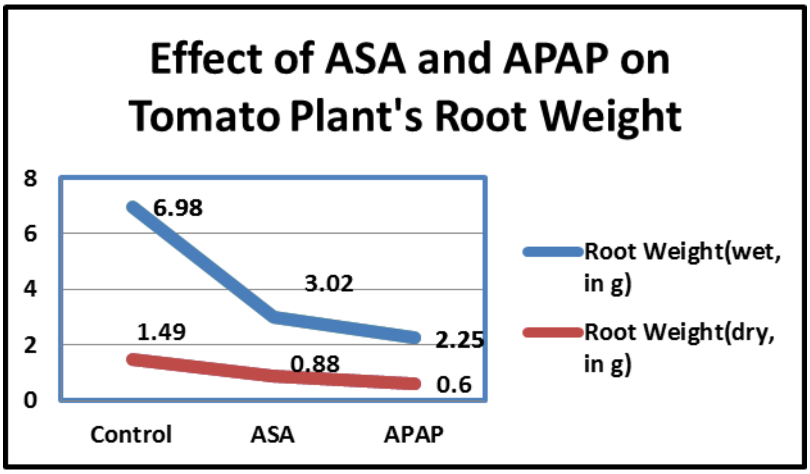

Fig. 4. Effect of ASA and APAP on Tomato Plant's Root Weight.

e) Effect on Plant Peripheries: Control plants have shown the highest Average stem and root peripheries (3.36cm, 3.46cm), whereas, the plants treated with ASA have decreased their Average stem and root peripheries by 10.98%(3.0cm) and 16.43%(2.9cm) respectively compared to control. Similarly, the plants treated with APAP have decreased their Average stem and root peripheries by 13.95% (2.9cm) and 22.2% (2.73cm) respectively compared to control. Furthermore, the stem and root diameters of plants treated with ASA and APAP, were also decreases as accordingly. (Table 5).

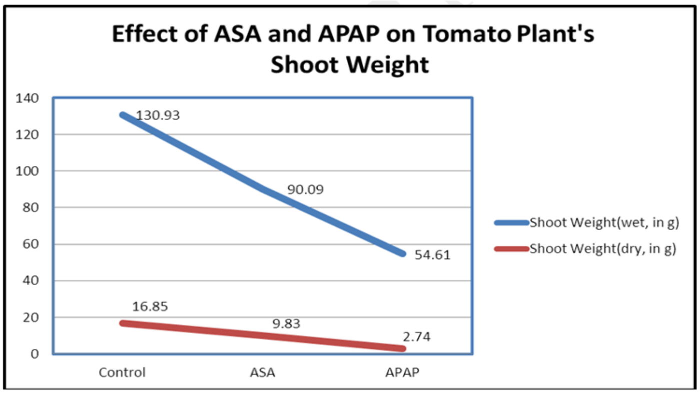

Fig.5. Effect of ASA and APAP on Tomato Plant's Shoot Weight.

Table 5. Effect of ASA and APAP on tomato Plant Peripheries

Plant Exposure	Stem Periphery (cm.)2πr	Stem at the bottom Diameter(cm)	Root Periphery (cm.)2πr	Root at the top Diameter(cm)
Control tomato plant	3.36 ±0.08	1.06 ± 0.03	3.46 ±0.08	1.10 ±0.02
Tomato Plant treated with ASA	3±0.05	0.954 ±0.01	2.9 ±0.05	0.922 ±0.01
Tomato Plant treated with APAP	2.9 ±0.05	0.92 ±0.01	2.73±0.12	0.86±0.03
Values are mean ± S.E(n=3)				

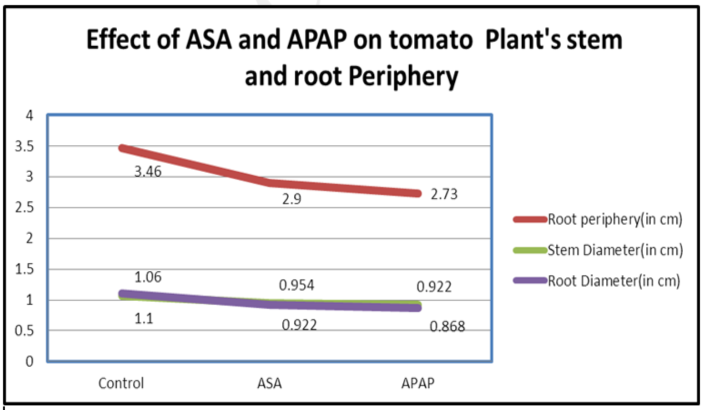

Fig.6. Effect of ASA and APAP on Tomato Plant's Stem and Root periphery.

CONCLUSION

There was mere research concerning the effects of pharmaceutical drugs on plant growth. The current experiment clearly indicated that ASA and APAP show incredible changes in morphological and vegetative parameters of *Solanum lycopersicum L*. in many aspects. This is due to either the interaction of these Physiologically Active Organic Molecules directly with phyto-hormones /Growth Regulators or it acts as growth regulators. The above said drugs gradually degraded by soil bacteria and environmental factors into their phenolic monographs (4-amino phenol in case of APAP and Salicylic acid in case of ASA) which are more physiologically active as the polarity of functional group increases.

ASA and APAP retards all agronomical and vegetative parameters of tomato plant, especially with the treatment of APAP morphology of tomato plant perished significantly. The yield of tomato decreased by 46.07% with ASA, and 67.63% with APAP in terms of total fruit's fresh weight, on 80th day observation. It might be due to suppressive action of drugs on plant growth hormones. These drugs drastically change plant physiology which had been reflected in their morphology.

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