***Original Research Article***

**Effect of Indole-3-butyric acid, Aspirin and Natural Plant Extracts on Rooting of Chrysanthemum (*Dendranthema grandiflora* L.) cv. Flirt**

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ABSTRACT

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| Study entitled “Effect of Indole-3-butyric acid, Aspirin and Natural Plant Extracts on Rooting of Chrysanthemum (*Dendranthema grandiflora* L.) cv. Flirt” was carried out in form of pro-tray experiment under polyhouse of the Department of Floriculture and Landscaping of College of Agriculture, OUAT, Bhubaneswar with the objective to investigate the effect of Indole-3-butyric acid (IBA), Aspirin and Natural Plant Extracts on rooting of cuttings of chrysanthemum by using Completely Randomized Design (CRD) with 8 treatments and 3 replications at 10, 15 and 20 DAP. Results obtained showed that the treatment (T4)i.e., IBA 750 ppm + Aspirin 40mg/l of distilled water proved to be the best treatment for rooting in Chrysanthemum cuttings in comparison to other treatments since it exhibited the best results on cuttings with minimum number of days to callus formation (2.40), least number of days for root initiation (6.83), highest number of roots per cutting (15.10 at 10 DAP, 33.93 at 15 DAP, 45.83 at 20 DAP), highest number of secondary roots per cutting at 20 DAP (6.17), maximum length of longest root per cutting (9.15 mm at 10 DAP, 19.58 mm at 15 DAP, 28.90 mm at 20 DAP), maximum fresh weight of roots per cutting (0.23 gm at 15 DAP, 0.34 gm at 20 DAP), lowest number of senescence leaves per cutting (0.33 at 10 DAP, 0.03 at 20 DAP) and highest rooting percentage in cuttings (96.67 %). Naturally available plant extracts and products are organic, non-toxic, readily available at low cost and contain phytohormones and active compounds stimulating rooting in cuttings, infection prevention and support plant growth. These can be used as effective alternatives of synthetic rooting hormones that are expensive and toxic to plant environment at high concentrations. Thus, this opens up many opportunities for further research in future for use of plant extracts and natural products in commercial propagation of floricultural crops. |

*Keywords: Chrysanthemum, Cutting, Rooting, IBA, Aspirin, Natural Plant Extract, Polyhouse*

1. INTRODUCTION

“Chrysanthemum is a herbaceous perennial plant extensively grown all over the world for its beautiful delightful flowers with excellent vase-life” (Shella, 2008). It is originated from China and Japan, and widely produced for commercial purpose mainly in USA, Japan and Europe (Bhattacharjee, 2006). It ranks second in the international cut flower industry after rose, while fifth for pot production in world market.

Scientifically, it belongs to genus *Dendranthema*, and has many species, the most important one is *grandiflora*. Commonly, it is called as Queen of East, Golden flower, Guldaudi, Glory of East, Autumn Queen and Mums. It belongs to Compositae (Asteraceae) family. The basic chromosome number of the genus is X = 9 and a wide range of ploidy level is found in different cultivars of the species with 2n = 30, 45, 47, 51 and 75.

“Chrysanthemum is a very useful flower due to its diversity in flower shapes, sizes, colour, form, growth habit, foliage and also for its excellent shelf and vase-life to fulfil all the diverse requirement of the grower and user” (Mao *et* *al*., 2012). “Erect and tall growing cultivars are suitable for background planting in border and can be used as cut flowers for making flower arrangements and flower bouquets, whereas the dwarf and compact growing cultivars are suitable for front row planting or pot culture. The decorative and soft bloomed small flowered cultivars are ideal for garland making, decoration and worship purpose all over India, while the extra-large bloomed cultivars are important for their display value and used for exhibition purpose” (Bhattacharjee and De, 2010).

“More than 15,000 varieties of Chrysanthemum have been reported from different parts of the world and more than 1000 varieties have been reported from India” (Shella, 2008). “Chrysanthemum is very popular among the flower growers because of its easy cultivation and wider adaptability” (Blythe *et* *al*., 2004). “In India, it is commercially cultivated in West Bengal, Karnataka, Andhra Pradesh, Telangana, Madhya Pradesh, Himachal Pradesh, Maharashtra, Assam and Tamil Nadu” (Bhattacharjee and De, 2010). “In India, 20.55 thousand hectares area is under Chrysanthemum cultivation and about 184.31 thousand MT for loose flower production and 14.64 lakh stems” (Anonymous, 2017).

“Chrysanthemum can be propagated through both sexual and asexual means. Since Chrysanthemum is a highly cross-pollinated crop and due to its nature of polyploidy and heterozygosity as well as presence of sporophytic self-incompatibility, a wide range of variations are observed in plants grown from seeds. Chrysanthemum can be vegetatively propagated through suckers, terminal stem cuttings and micropropagation. Chrysanthemums propagated from suckers produce tall plants which are less useful for decoration purpose, this makes the suckers less suitable for propagation. The terminal stem cuttings are commercially suitable for propagation because they are cheap, rapid and true-to-types” (Waseem *et* *al*., 2011). “Standard varieties have low propagation rate which trigger the importance and use of rooting hormones to improve rooting, root initiation, uniformity, number and quality of roots” (Mukherjee, 2008). “But these methods are relatively very slow processes. Also, there is risk of transmission of the virus and other diseases. Tissue culture or micropropagation techniques can improve the efficiency of plant propagation processes and as well as facilitates the rapid replication and development of superior genotypes” (Jena *et al*., 2025). “Although multiplication through micropropagation or tissue culture is relatively fast, but it is not profitable for small and marginal farmers since the accessibility of large quantity and good quality plant propagation material at reasonable price by small scale Chrysanthemum farmers has continuously been a great hindrance in commercial cultivation of Chrysanthemum in India” (Navale *et al*., 2010).

The process of regeneration and multiplication during propagation is mostly dependent on internal and external factors, and rooting of cuttings is largely influenced by physiological condition of mother plants, type of cuttings used, treatment of cuttings and environmental conditions like temperature, light, rainfall and relative humidity (Farooqi *et* *al*., 1994). Rooting in cuttings of Chrysanthemum is easy but needs more care. Rapid degradation of agricultural areas, uncertainties related to climate change, decreasing green space led to shift in nutrient application from chemical to organic based like bio stimulants (Jena *et al*., 2025). “The treatment of cuttings with rooting hormones for root initiation was a major milestone in the history of plant propagation, especially with discovery of auxin in 1934” (Debasis, 2000). “Among all the rooting hormones, auxins are commonly used like Indole-3-Butyric Acid (IBA), Naphthalene Acetic Acid (NAA) and Indole Acetic Acid (IAA) that can be applied in liquid or powdered form for promoting rooting in cuttings. Auxin treatment can also influence high rooting percentage and quality of root system. The purpose of treating the cuttings with rooting hormone is to hasten root initiation, increase the percentage of rooting in cuttings and increase the number of roots per cutting. The treatment of cuttings with auxin varies from plant to plant and type of cuttings used, however, a higher concentration may be required in difficult to root cultivars” (Gautam and Chauhan, 1990).

“Effectiveness of exogenous application of auxin in promoting rooting of stem cuttings is dependent on adequate absorption of rooting hormone solution by the plant tissue. The time between cutting preparation and treatment also influences the absorption, cuttings with greater water loss from their base prior to treatment increasing the suction that develops at the base of cuttings” (Panwar *et al*., 1994). The depth of treatment can also affect the absorption and subsequent rooting response; with increased depth providing additional solution that can run down the epidermis and absorbed through cut end at the base. The effectiveness of auxin also depends on adequate translocation from the site of application to the site of adventitious root formation of plant (Chovatia *et* *al*., 1995).

But use of such synthetic rooting hormones is quite expensive and at higher concentrations may prove harmful for plants as well as for environment, so many types of natural substances are now being used for promoting rooting in cuttings and reducing mortality in ornamental plants, such as undiluted Honey, Cinnamon powder, Aloe vera gel, Coconut water, Moringa leaf extract, Garlic cloves extract, Vermin wash, Humic acid etc. These natural root promoting substances are cheap, easily available and safe to use. They are not only environmentally friendly but also reduce the dependence on external inputs and improve root quality by providing necessary hormones and thus, can be used as an effective substitute for synthetic rooting hormones.

Aspirin is acetylsalicylic acid (ASA), very similar to the salicylic acid that plants themselves produce during stressful conditions. Acetylsalicylic acid is the active ingredient in aspirin and is derived from salicylic acid, which is naturally found in willow bark and many other trees. Salicylic acid is a common plant phenolic compound that influences many physiological and biochemical process in plants such as adventitious root initiation, inhibition of ethylene biosynthesis, disease resistance, salt and osmotic stress, chilling tolerance and growth and photosynthesis. Usually, it is used to enhance the vase life of cut flowers. Scientifically, it is proven that salicylic acid is the active component of aspirin that triggers a plant’s defence mechanism against diseases caused by fungi, bacteria and viruses. Researchers suggest that salicylic acid behaves like a hormone and might trigger other processes in plants.

Garlic extract is a substance that contains vitamins, flavonoids, minerals, sulphur, and ascorbic acid. In addition, it also has nearly about seventeen amino acids. It also possesses many antioxidants, antimicrobial, antifungal and antibacterial properties that provides protection to cuttings from pathogens.

Aloe vera gel is a clear gel obtained from leaves of Aloe plant. It contains nearly about 75 biologically active ingredients, including various types of minerals, sugar, vitamins, saponins, lignins, salicylic acid and amino acids. It also contains phytohormones like auxins and gibberellins that promote root growth in plants. It possesses some antibacterial and antifungal properties that protect the cuttings from soil-borne pathogens.

Hence, this research work aims at studying the effect of some potential natural plant extracts and common commercial synthetic rooting products as well as Aspirin which contains acetyl salicylic acid to compare their effects when used alone and in combinations on rooting of terminal cuttings of Chrysanthemum cv. Flirt with the objective to study to study the effect of IBA, Aspirin, Natural plant extract on rooting of cuttings of Chrysanthemum.

2. methodology

This investigation was carried out in form of pro-tray experiment in the Department of Floriculture and Landscaping, College of Agriculture, OUAT, Bhubaneswar during August – September 2021.

* 1. **Experimental site**

The experiment was conducted in form of pro-tray experiment under the polyhouse of the Department of Floriculture and Landscaping located in the premises of College of Agriculture, OUAT, Bhubaneswar.

**2.2 Geographical location of the experimental site**

Bhubaneswar is situated at 63 km away west of the Bay of Bengal at an altitude of 25.50 m above mean sea level. Geographically, it is located at sub-tropical region with 20**o**15**’** North latitude and 85**o**52**’** East latitude.

**2.3 Climate**

Bhubaneswar comes under sub-tropical climate. Above 85 % rainfall occurs from June to September and the rest is received within October to May. The average maximum temperature ranges from 38 – 42**o**C during May to June while the minimum temperature varies from 15 – 16**o**C during December to January. The relative humidity varies between 50 % in winter to 90 % in rainy season.

* 1. **Collection of cuttings for planting**

The mother plants were maintained in the garden of Department of Floriculture and Landscaping prior to experiment. Disease free, uniform and healthy mother plants were selected for obtaining cuttings. The terminal cuttings (5 – 7 cm) were taken from healthy mother plants and the basal leaves were removed. The prepared cuttings were arranged in 8 bundles by tying their bottom portion with a rubber band. Each bundle had 30 number of cuttings. Total 240 cuttings were collected from mother plants. The basal 2 – 3 cm portion of cuttings was dipped in treatment solutions.

**2.5 Experimental details**

The experiment was conducted to study the effect of IBA, Aspirin and Natural plant extracts on Rooting of Chrysanthemum. The experiment was carried out following the Completely Randomized Design (CRD) and the experimental details are as follows:

**Table 1 – Experimental Details**

|  |  |
| --- | --- |
| Year of planting | 2021 |
| Number of crops | 01 |
| Name of crop | *Dendranthema grandiflora* |
| Number of experiments | 01 |
| Number of treatments | 08 |
| Experimental design | CRD |
| Number of replications per treatment | 03 |
| Number of cuttings per replication | 10 |
| Total number of cuttings | 240 |

* 1. **Treatment details**

The following 8 treatments were followed for conducting the experiment:

**Table 2 – Treatment Details**

|  |  |  |
| --- | --- | --- |
| **Sl. No.** | **Treatments** | **Treatment Details** |
| 1. | T**1** | Control (Distilled water) |
| 2. | T**2** | IBA 750 ppm |
| 3. | T**3** | Aspirin (40mg/l of distilled water) |
| 4. | T**4** | IBA 750 ppm + Aspirin (40mg/l of distilled water) |
| 5. | T**5** | Diluted alcoholic leaf extract of *Ipomoea aquatica* |
| 6. | T**6** | 20 % water-soluble garlic cloves extract |
| 7. | T**7** | Gel from *Aloe vera* leaves |
| 8. | T**8** | Diluted alcoholic leaf extract of Ivy gourd |

* 1. **Preparation of IBA stock solution**

To prepare a stock solution of 750 ppm Indole Butyric Acid (IBA), 750 mg of IBA with 100 % purity was weighed accurately by an electrical weighing balance and dissolved in 2 ml of 50 % Ethyl alcohol in a 1000 ml glass beaker. Then the volume was made up to 1000 ml by adding distilled water to get a stock solution of 750 ppm.

* 1. **Preparation of Aspirin stock solution**

One Aspirin tablet of 40 mg was taken and dipped in 1000 ml of distilled water to get the stock solution of Aspirin.

* 1. **Preparation of Diluted alcoholic leaf extract of *Ipomoea aquatica***

Fresh and healthy leaves of *Ipomoea aquatica* were collected and crushed properly by using mortar and pestle. The crushed leaf material was taken in a 250 ml conical flask and 20 ml of Ethyl alcohol was added. Then the mouth of the flask was completely covered by using black polythene and rubber band and left in such for 24 hours. After 24 hrs, the mouth of the flask was opened, leaf extract was taken out and strained out properly to remove the crushed leaves. Then 30 ml of the strained liquid was taken and distilled water @ 20 times of the volume of this liquid (600 ml) was added for volume make-up. Finally, the diluted alcoholic leaf extract of *Ipomoea aquatica* was ready for dipping the basal end of the chrysanthemum cuttings.

**2.10** **Preparation of water-soluble garlic cloves extract**

A few numbers of fresh garlic cloves were taken, peeled and crushed properly by using mortar and pestle. Then 200 ml distilled water was added to the crushed garlic material left for 24 hrs at room temperature. Then it was properly strained to remove the crushed cloves and get the garlic extract. 20 ml of this garlic extract was taken and 80 ml of distilled water was added to get a 20 % stock solution of water-soluble garlic cloves extract for dipping the basal end of the chrysanthemum cuttings.

* 1. **Preparation of *Aloe vera* gel**

Fresh leaves of *Aloe vera* were taken and washed properly with water to remove the dirt. The leaves were cut opened length wise with a knife and scraped by using a spoon to take out the *Aloe vera* gel.

**2.12** **Preparation of Diluted alcoholic leaf extract of Ivy Gourd**

Fresh and healthy leaves of Ivy Gourdwere collected and crushed properly by using mortar and pestle. The crushed leaf material was taken in a 250 ml conical flask and 20 ml of Ethyl alcohol was added. Then the mouth of the flask was completely covered by using black polythene and rubber band and left as such for 24 hrs. After 24 hrs, the mouth of the flask was opened, leaf extracts were taken out and strained out properly to remove the crushed leaves. Then 20 ml of the strained liquid was taken and distilled water @ 20 times of the volume of this liquid (400 ml) was added for volume make-up. Finally, the diluted alcoholic leaf extract of Ivy Gourd was ready for dipping basal end of the chrysanthemum cuttings.

* 1. **Treatment of cuttings**

For T**1**, a bundle of 30 number of cuttings was dipped in 100 ml distilled water as control treatment for 30 minutes.

For T**2**, 100 ml of IBA solution was taken from 750 ppm stock solution and a bundle of 30 number of cuttings was dipped in it for 30 minutes.

For T**3,** 100 ml of Aspirin solution was taken from 40 mg/L stock solution and a bundle of 30 number of cuttings was dipped in it for 30 minutes.

For T**4,** 50 ml of IBA solution and 50 ml of Aspirin solution was taken together (1:1 v/v basis) and a bundle of 30 number of cuttings was dipped in it for 30 minutes.

For T**5,** 600 ml of diluted alcoholic leaf extracts of *Ipomoea aquatica* was taken and a bundle of 30 number of cuttings was dipped in it for 30 minutes.

For T**6,** 100 ml of 20 % water-soluble garlic cloves extract was taken and a bundle of 30 number of cuttings was dipped in it for 30 minutes

For T**7,** a bundle of 30 number of cuttings was dipped in pure Aloe vera gel for 30 minutes.

For T**8,** 400 ml of diluted alcoholic leaf extracts of Ivy Gourd was taken and a bundle of 30 number of cuttings was dipped in it for 24 hrs.

* 1. **Planting of cuttings**

The treated cuttings were planted immediately in pro-trays containing sand as the rooting medium. Planting was done manually. Holes were made at the centre of the medium using a stick and cuttings were planted in the holes. The bottom of the cuttings was covered properly by media and was followed by light watering using a rose can. Planting was done in August 2021.

* 1. **After care** 
     1. **Watering**

Watering was done during the morning hours using a rose can. Watering was provided daily depending on the moisture content of the medium.

* + 1. **Plant protection**

The cuttings were sprayed with 0.2 % of Blitox-50 solution (2 gm/l of water) at 7 DAP and 15 DAP as a preventive measure against soil-borne pathogens.

* 1. **Observations recorded**
     1. **Number of days to callus formation**

Number of days to which the cuttings started callusing from the day of planting in pro-trays was recorded according to the treatments and their mean was calculated per each replication. Callus is an irregular mass of parenchymatous cells that generally develop at the base portion of cuttings as dark brown colour.

* + 1. **Number of days for root initiation**

Number of days of which the cuttings started rooting from the day of planting in pro-trays was recorded according to the treatments and their mean was calculated considering ten number of cuttings per replication.

* + 1. **Number of roots per cutting**

Three cuttings were randomly selected from each treatment. They were uprooted with due care to avoid any damage to root system followed by proper washing of roots to remove sand. Then the total number of roots on each cutting was recorded. Number of roots per cutting was calculated by dividing the total number of roots by 10 and their mean was

calculated for each replication. This observation was recorded at 10, 15 and 20 DAP of cuttings in pro-trays.

* + 1. **Number of secondary roots per cutting**

Three randomly selected cuttings were taken from each treatment by carefully uplifting and dipping them in water to remove sand particles. The number of secondary roots arising from primary roots of selected cuttings were noted down. Number of secondary roots per cutting was calculated by dividing the total number of secondary roots by 10 and their mean was calculated for each replication. This observation was recorded at 20 DAP of cuttings in pro-trays.

* + 1. **Length of longest root (mm)**

The roots of three randomly selected cuttings of each treatment were measured with the help of a measuring scale and the length of longest root was recorded. This observation was also recorded at 10, 15 and 20 DAP of cuttings in pro-trays.

* + 1. **Fresh weight of roots per cutting (g)**

Three cuttings were randomly selected from each treatment; they were carefully uplifted followed by washing. Then the fresh weight of roots was recorded by using an electronic balance after wiping away the moisture with a tissue paper. The fresh weight of roots per cutting was obtained by dividing the total fresh weight of roots by 10 and their mean was calculated for each replication. This observation was recorded at 15 and 20 DAP of cuttings in pro-trays.

* + 1. **Senescence of leaves in cuttings**

The leaves which have their lost chlorophyll content and became yellow and dried were counted in each cutting and their mean was calculated for each replication. This observation was recorded at 20 DAP of cuttings in pro-trays.

* + 1. **Rooting Percentage of cuttings**

Rooting percentage was recorded on the basis of presence or absence of roots in all cuttingsandtheir mean was calculated for each replication.





**Fig.1** **Treatment details for rooting of Chrysanthemum cuttings**



**Fig.2 Treated cuttings planted in pro-trays**



**Fig.3 Labelled Pro-trays with Chrysanthemum cuttings**

* 1. **Statistical Analysis**

The data recorded in the experiment was subjected for single factor ANOVA in Completely Randomized Design (CRD) and each treatment was replicated thrice. The variance was tested at 5 % level of significance.

3. resultS

The results obtained in the research work on rooting of Chrysanthemum (*Dendranthema grandiflora* L.) cv. Flirt under the polyhouse brings about following analysis:

**3.1. Number of days to callus formation**

Days to callus formation was recorded for all chrysanthemum cuttings as per the treatments which has been presented in Table 3. From the perusal of Table 3, it was found that there was no significant difference among the treatments with respect to number of days taken for callus formation. However, among all the treatments, the highest number of days to callus formation was recorded in T8 (2.77 days) viz., diluted alcoholic leaf extract of Ivy gourd, while the least number of days to callus formation in chrysanthemum cuttings was recorded in T4 (2.40 days) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water, followed by T1 (2.42 days) viz., Control. It was also found that cuttings of T2 (IBA 750 ppm) and T5 (Diluted alcoholic leaf extract of *Ipomoea aquatica*) recorded same number of days for callusing, i.e., 2.50 days. Similarly, cuttings of T6 (20 % water-soluble garlic cloves extract) and T7 (Gel from *Aloe vera* leaves) also took same number of days for callusing i.e., 2.47 days.

**Table 3 – Effect of IBA, Aspirin and Natural plant extracts on number of days to callus formation**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Treatment Details** | **Number of days for callus formation** |
| T1 | Control (Distilled water) | 2.42 |
| T2 | IBA 750 ppm | 2.50 |
| T3 | Aspirin (40mg/l of distilled water) | 2.53 |
| **T4** | **IBA 750 ppm + Aspirin (40mg/l of distilled water)** | **2.40** |
| T5 | Diluted alcoholic leaf extract of *Ipomoea aquatica* | 2.50 |
| T6 | 20 % water-soluble garlic cloves extract | 2.47 |
| T7 | Gel from *Aloe vera* leaves | 2.47 |
| T8 | Diluted alcoholic leaf extract of Ivy gourd | 2.77 |
|  | CD (5 %) | NS |

**3.2. Number of days for root initiation**

Number of days for root initiation recorded for all chrysanthemum cuttings as per the treatments has been presented in Table 4 which revealed that there was significant difference among the treatments with respect to number of days for root initiation. The minimum number of days for root initiation was observed in T4 (6.83 days) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water. This was followed by T7 (6.99 days) viz., Gel from *Aloe vera* leaves, whereas the maximum number of days for root initiation was found in T8 (14.97 days) viz., Diluted alcoholic leaf extract of Ivy gourd, followed by T3 (7.43 days) viz., Aspirin 40mg/l of distilled water.

**Table 4 – Effect of IBA, Aspirin and Natural plant extracts on number of days for root initiation**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Treatment Details** | **Number of days for root initiation\*** |
| T1 | Control (Distilled water) | 7.20 |
| T2 | IBA 750 ppm | 7.03 |
| T3 | Aspirin (40mg/l of distilled water) | 7.43 |
| **T4** | **IBA 750 ppm + Aspirin (40mg/l of distilled water)** | **6.83** |
| T5 | Diluted alcoholic leaf extract of *Ipomoea aquatica* | 7.13 |
| T6 | 20 % water-soluble garlic cloves extract | 7.02 |
| T7 | Gel from *Aloe vera* leaves | 6.99 |
| T8 | Diluted alcoholic leaf extract of Ivy gourd | 14.97 |
|  | SE (m) + | 0.322 |
|  | CD (5 %) | 0.68 |

\* Significant at 5%

**4.3. Number of roots per cutting at 10 DAP**

Number of roots per cutting at 10 DAP was recorded for all chrysanthemum cuttings as per the treatments and has been presented in Table 5. From the perusal of Table 5, it was found that there was significant difference among the treatments with respect to number of roots per cutting at 10 DAP. The highest number of roots per cutting (15.10) at 10 DAP was found in cuttings treated with T4 viz., IBA 750 ppm + Aspirin 40mg/l of distilled water, which is followed by T7 (10.20) viz., Gel from *Aloe vera* leaves. The lowest number of roots per cutting at 10 DAP was found in T3 (6.57) viz., Aspirin 40mg/l of distilled water. On the other hand, no roots were formed at 10 DAP in cuttings treated with T8 viz., Diluted alcoholic leaf extract of Ivy gourd.

**Table 5 – Effect of IBA, Aspirin and Natural plant extracts on number of roots per cutting at 10 DAP**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Treatment Details** | **Number of roots per cutting\*** |
| T1 | Control (Distilled water) | 6.07 |
| T2 | IBA 750 ppm | 9.30 |
| T3 | Aspirin (40mg/l of distilled water) | 6.57 |
| **T4** | **IBA 750 ppm + Aspirin (40mg/l of distilled water)** | **15.10** |
| T5 | Diluted alcoholic leaf extract of *Ipomoea aquatica* | 8.17 |
| T6 | 20 % water-soluble garlic cloves extract | 9.97 |
| T7 | Gel from *Aloe vera* leaves | 10.20 |
| T8 | Diluted alcoholic leaf extract of Ivy gourd | 0 (0.707) |
|  | SE (m) + | 0.124 |
|  | CD (5 %) | 0.26 |

\* Significant at 5%

Data in parenthesis are square root transformed data.

**4.4.** **Number of roots per cutting at 15 DAP**

Number of roots per cutting at 15 DAP was recorded for all chrysanthemum cuttings as per the treatments which has been presented in Table 6. From the perusal of Table 6, it was found that significant difference was observed among the treatments with respect to number of roots per cutting at 15 DAP. The highest number of roots per cutting(33.93) at 15 DAP was recorded in cuttings under treatment T4 viz., IBA 750 ppm + Aspirin 40mg/l of distilled water, which was followed by T7 (33.13 ) viz., Gel from *Aloe vera* leaves, whereas the lowest number of roots per cutting at 15 DAP was recorded in T8 (2.23) viz., Diluted alcoholic leaf extract of Ivy gourd and it was followed by T1 (7.63) viz., Control.

**4.5.** **Number of roots per cutting at 20 DAP**

Number of roots per cutting at 20 DAP was recorded for all the chrysanthemum cuttings as per the treatments and has been presented in Table 7. From the perusal of Table 7, it was found that there was significant difference among the treatments with respect to number of roots per cutting at 20 DAP. The highest number of roots per cutting (45.83) at 20 DAP was recorded in T4 viz., IBA 750 ppm + Aspirin 40mg/l of distilled water. This was followed by T7 (42.13) viz., Gel from *Aloe vera* leaves. The lowest number of roots per cutting at 20 DAP was recorded in T8 (3.90) viz., Diluted alcoholic leaf extract of Ivy gourd, followed by T1 (16.07) viz., control.

**Table 6 – Effect of IBA, Aspirin and Natural plant extracts on number of roots per cutting at 15 DAP**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Treatment Details** | **Number of roots per cutting\*** |
| T1 | Control (Distilled water) | 7.63 |
| T2 | IBA 750 ppm | 14.50 |
| T3 | Aspirin (40mg/l of distilled water) | 10.43 |
| **T4** | **IBA 750 ppm + Aspirin (40mg/l of distilled water)** | **33.93** |
| T5 | Diluted alcoholic leaf extract of *Ipomoea aquatica* | 10.57 |
| T6 | 20 % water-soluble garlic cloves extract | 30.27 |
| T7 | Gel from *Aloe vera* leaves | 33.13 |
| T8 | Diluted alcoholic leaf extract of Ivy gourd | 2.23 |
|  | SE (m) + | 0.778 |
|  | CD (5 %) | 1.65 |

\* Significant at 5%

**Table 7 – Effect of IBA, Aspirin and Natural plant extracts on number of roots per cutting at 20 DAP**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Treatment Details** | **Number of roots per cutting\*** |
| T1 | Control (Distilled water) | 16.07 |
| T2 | IBA 750 ppm | 21.73 |
| T3 | Aspirin (40mg/l of distilled water) | 18.73 |
| **T4** | **IBA 750 ppm + Aspirin (40mg/l of distilled water)** | **45.83** |
| T5 | Diluted alcoholic leaf extract of *Ipomoea aquatica* | 21.03 |
| T6 | 20 % water-soluble garlic cloves extract | 29.00 |
| T7 | Gel from *Aloe vera* leaves | 42.13 |
| T8 | Diluted alcoholic leaf extract of Ivy gourd | 3.90 |
|  | SE (m) + | 1.603 |
|  | CD (5 %) | 3.39 |

\* Significant at 5%

**4.6. Number of secondary roots per cutting at 20 DAP**

Number of secondary roots per cutting at 20 DAP recorded for all chrysanthemum cuttings as per the treatments has been presented in Table 8 which revealed that there was significant difference among the treatments with respect to number of secondary roots per cutting at 20 DAP. At 20 DAP, the maximum number of secondary roots per cutting was obtained in T4 (6.17) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water while the minimum number of secondary roots per cutting was obtained in T8 (2.13) viz., Diluted alcoholic leaf extract of Ivy gourd.

**Table 8 – Effect of IBA, Aspirin and Natural plant extracts on number of secondary roots per cutting at 20 DAP**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Treatment Details** | **Number of secondary roots per cutting at 20 DAP\*** |
| T1 | Control (Distilled water) | 3.57 |
| T2 | IBA 750 ppm | 5.73 |
| T3 | Aspirin (40mg/l of distilled water) | 3.67 |
| **T4** | **IBA 750 ppm + Aspirin (40mg/l of distilled water)** | **6.17** |
| T5 | Diluted alcoholic leaf extract of *Ipomoea aquatica* | 5.23 |
| T6 | 20 % water-soluble garlic cloves extract | 5.93 |
| T7 | Gel from *Aloe vera* leaves | 6.10 |
| T8 | Diluted alcoholic leaf extract of Ivy gourd | 2.13 |
|  | SE (m) + | 0.183 |
|  | CD (5 %) | 0.38 |

\* Significant at 5%

**Table 9 – Effect of IBA, Aspirin and Natural plant extracts on length of longest root per cutting (mm) at 10 DAP**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Treatment Details** | **Length of longest root per cutting (mm) at 10 DAP\*** |
| T1 | Control (Distilled water) | 4.20 |
| T2 | IBA 750 ppm | 7.67 |
| T3 | Aspirin (40mg/l of distilled water) | 6.50 |
| **T4** | **IBA 750 ppm + Aspirin (40mg/l of distilled water)** | **9.15** |
| T5 | Diluted alcoholic leaf extract of *Ipomoea aquatica* | 6.53 |
| T6 | 20 % water-soluble garlic cloves extract | 7.87 |
| T7 | Gel from *Aloe vera* leaves | 8.77 |
| T8 | Diluted alcoholic leaf extract of Ivy gourd | 0 (0.707) |
|  | SE (m) + | 0.133 |
|  | CD (5 %) | 0.28 |

\* Significant at 5%

Data in parenthesis are square root transformed data.

**4.7. Length of longest root per cutting (mm) at 10 DAP**

Length of longest root per cutting (mm) at 10 DAP was recorded for all chrysanthemum cuttings as per the treatments and has been presented in Table 9. The data presented in Table 9 revealed that there was significant difference among the treatments with respect to length of longest root per cutting (mm) at 10 DAP. It was found that the maximum length of longest root per cutting at 10 DAP was obtained in T4 (9.15 mm) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water and it was followed by T7 (8.77 mm) viz., Gel from *Aloe vera* leaves and T6 (7.87 mm) viz., 20 % water-soluble garlic cloves extract. The minimum length of longest root per cutting (mm) at 10 DAP was recorded in T1 (4.20 mm) viz., Control, followed by T3 (6.50 mm) viz., Aspirin 40mg/l of distilled water. On the other hand, no roots were formed in cuttings till 10 DAP under T8 viz., Diluted alcoholic leaf extract of Ivy gourd.

**4.8. Length of longest root per cutting (mm) at 15 DAP**

Length of longest root per cutting (mm) at 15 DAP recorded for all chrysanthemum cuttings as per the treatments has been presented in Table 10 and it revealed that significance difference was observed among the treatments with respect to length of longest root per cutting (mm) at 15 DAP. The maximum length of longest root per cutting at 15 DAP was recorded in T4 (19.58 mm) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water, followed by T7 (16.87 mm) viz., Gel from *Aloe vera* leaves and T6 (14.47 mm) viz., 20 % water-soluble garlic cloves extract. And the minimum length of longest root per cutting (mm) at 15 DAP was found in T8 (5.8 mm) viz., Diluted alcoholic leaf extract of Ivy gourd, followed by T1 (8.52 mm) viz., Control.

**4.9. Length of longest root per cutting (mm) at 20 DAP**

Length of longest root per cutting (mm) at 20 DAP was recorded for all chrysanthemum cuttings as per the treatments and has been presented in Table 11. From the perusal of Table 11, it was found that there was significant difference among the treatments with respect to length of longest root per cutting (mm) at 20 DAP. The maximum length of longest root per cutting at 20 DAP was recorded in T4 (28.90 mm) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water, which was followed by T7 (26.43 mm) viz., Gel from *Aloe vera* leaves and T6 (26.13 mm) viz., 20 % water-soluble garlic cloves extract. And the minimum length of longest root per cutting (mm) at 15 DAP was found in T8 (11.03 mm) viz., Diluted alcoholic leaf extract of Ivy gourd, followed by T1 (12.55 mm) viz., Control.

**Table 10 – Effect of IBA, Aspirin and Natural plant extracts on length of longest root per cutting (mm) at 15 DAP**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Treatment Details** | **Length of longest root per cutting (mm) at 15 DAP\*** |
| T1 | Control (Distilled water) | 8.52 |
| T2 | IBA 750 ppm | 14.15 |
| T3 | Aspirin (40mg/l of distilled water) | 10.50 |
| **T4** | **IBA 750 ppm + Aspirin (40mg/l of distilled water)** | **19.58** |
| T5 | Diluted alcoholic leaf extract of *Ipomoea aquatica* | 13.05 |
| T6 | 20 % water-soluble garlic cloves extract | 14.47 |
| T7 | Gel from *Aloe vera* leaves | 16.87 |
| T8 | Diluted alcoholic leaf extract of Ivy gourd | 5.80 |
|  | SE (m) + | 2.090 |
|  | CD (5 %) | 4.43 |

\* Significant at 5%

**Table 11 – Effect of IBA, Aspirin and Natural plant extracts on length of longest root per cutting (mm) at 20 DAP**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Treatment Details** | **Length of longest root per cutting (mm) at 20 DAP\*** |
| T1 | Control (Distilled water) | 12.55 |
| T2 | IBA 750 ppm | 22.57 |
| T3 | Aspirin (40mg/l of distilled water) | 15.03 |
| **T4** | **IBA 750 ppm + Aspirin (40mg/l of distilled water)** | **28.90** |
| T5 | Diluted alcoholic leaf extract of *Ipomoea aquatica* | 21.73 |
| T6 | 20 % water-soluble garlic cloves extract | 26.13 |
| T7 | Gel from *Aloe vera* leaves | 26.43 |
| T8 | Diluted alcoholic leaf extract of Ivy gourd | 11.03 |
|  | SE (m) + | 1.409 |
|  | CD (5 %) | 2.98 |

\* Significant at 5%

**4.10. Fresh weight of roots per cutting (g) at 15 DAP**

Fresh weight of roots per cutting (gm) at 15 DAP recorded for all chrysanthemum cuttings as per the treatments has been presented in Table 12 which revealed that significance difference was observed among the treatments with respect to fresh weight of roots per cutting at 15 DAP. It was found that the highest fresh weight of roots per cutting at 15 DAP was obtained in T4 (0.23 gm) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water, which was followed by T7 (0.19 gm) viz., Gel from *Aloe vera* leaves and T6 (0.18 gm) viz., 20 % water-soluble garlic cloves extract. While the lowest fresh weight of roots per cutting at 15 DAP was found in T8 (0.03 gm) viz., Diluted alcoholic leaf extract of Ivy gourd, followed by T1 (0.05) viz., Control.

**Table 12 – Effect of IBA, Aspirin and Natural plant extracts on fresh weight of roots per cutting (g) at 15 DAP**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Treatment Details** | **Fresh weight of roots per cutting (g) at 15 DAP\*** |
| T1 | Control (Distilled water) | 0.05 |
| T2 | IBA 750 ppm | 0.11 |
| T3 | Aspirin (40mg/l of distilled water) | 0.07 |
| **T4** | **IBA 750 ppm + Aspirin (40mg/l of distilled water)** | **0.23** |
| T5 | Diluted alcoholic leaf extract of *Ipomoea aquatica* | 0.12 |
| T6 | 20 % water-soluble garlic cloves extract | 0.18 |
| T7 | Gel from *Aloe vera* leaves | 0.19 |
| T8 | Diluted alcoholic leaf extract of Ivy gourd | 0.03 |
|  | SE (m) + | 0.0026 |
|  | CD (5 %) | 0.005 |

\* Significant at 5%

**4.11. Fresh weight of roots per cutting (g) at 20 DAP**

Fresh weight of roots per cutting at 20 DAP recorded for all chrysanthemum cuttings as per the treatments has been presented in Table 13. The data in the Table 11 revealed that significance difference was observed among the treatments with respect to fresh weight of roots per cutting at 20 DAP. It was found that the highest fresh weight of roots per cutting at 20 DAP was obtained in T4 (0.34 gm) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water, which was followed by T7 (0.19 gm) viz., Gel from *Aloe vera* leaves and T6 (0.24 gm) viz., 20 % water-soluble garlic cloves extract. And the lowest fresh weight of roots per cutting at 20 DAP was found in T8 (0.07 gm) viz., Diluted alcoholic leaf extract of Ivy gourd, and is followed by T1 (0.12) viz., Control.

**Table 13 – Effect of IBA, Aspirin and Natural plant extracts on fresh weight of roots per cutting (g) at 20 DAP**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Treatment Details** | **Fresh weight of roots per cutting (g) at 20 DAP\*** |
| T1 | Control (Distilled water) | 0.12 |
| T2 | IBA 750 ppm | 0.19 |
| T3 | Aspirin (40mg/l of distilled water) | 0.14 |
| **T4** | **IBA 750 ppm + Aspirin (40mg/l of distilled water)** | **0.34** |
| T5 | Diluted alcoholic leaf extract of *Ipomoea aquatica* | 0.20 |
| T6 | 20 % water-soluble garlic cloves extract | 0.22 |
| T7 | Gel from *Aloe vera* leaves | 0.24 |
| T8 | Diluted alcoholic leaf extract of Ivy gourd | 0.07 |
|  | SE (m) + | 0.0031 |
|  | CD (5 %) | 0.006 |

\* Significant at 5%

**4.12. Number of senescence leaves per cutting at 10 DAP**

Number of senescence leaves per cutting at 10 DAP was recorded for all chrysanthemum cuttings as per the treatments and has been presented in Table 14. The data presented in the table revealed that there was significant difference among the treatments with respect to number of numbers of senescence leaves per cutting at 10 DAP. The maximum leaf senescence at 10 DAP was found in cuttings of T8 (0.97) viz., Diluted alcoholic leaf extract of Ivy gourd. This was significantly followed by T1 (0.63) viz., Control. While the minimum leaf senescence at 10 DAP was recorded in T4 (0.33) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water, which was equally followed by T7 (0.43) viz., Gel from *Aloe vera* leaves and T6 (0.43) viz., 20 % water-soluble garlic cloves extract.

**4.13. Number of senescence leaves per cutting at 20 DAP**

Number of senescence leaves per cutting at 20 DAP recorded for all chrysanthemum cuttings as per the treatments has been presented in Table 15. From the perusal of Table 15, it was revealed that there was significant difference among the treatments with respect to number of senescence leaves per cutting at 20 DAP. The maximum leaf senescence at 20 DAP was recorded in cuttings treated with T8 (0.17) viz., Diluted alcoholic leaf extract of Ivy gourd, followed by T1 (0.13) viz., Control. While the minimum leaf senescence at 20 DAP was recorded in T4 (0.03) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water, which was equally followed by T7 (0.10) viz., Gel from *Aloe vera* leaves and T6 (0.10) viz., 20 % water-soluble garlic cloves extract.

**Table 14 – Effect of IBA, Aspirin and Natural plant extracts on number of senescence leaves per cutting at 10 DAP**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Treatment Details** | **Number of senescence leaves per cutting at 10 DAP\*** |
| T1 | Control (Distilled water dip) | 0.63 |
| T2 | IBA 750 ppm | 0.60 |
| T3 | Aspirin (40mg/l of distilled water) | 0.57 |
| **T4** | **IBA 750 ppm + Aspirin (40mg/l of distilled water)** | **0.33** |
| T5 | Diluted alcoholic leaf extracts of *Ipomoea aquatica* | 0.50 |
| T6 | 20 % water-soluble garlic cloves extract | 0.43 |
| T7 | Gel from *Aloe vera* leaves | 0.43 |
| T8 | Diluted alcoholic leaf extracts of Ivy gourd | 0.97 |
|  | SE (m) + | 0.155 |
|  | CD (5 %) | 0.32 |

\* Significant at 5%

**Table 15 – Effect of IBA, Aspirin and Natural plant extracts on number of senescence leaves per cutting at 20 DAP**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Treatment Details** | **Number of senescence leaves per cutting at 20 DAP** |
| T1 | Control (Distilled water dip) | 0.13 (0.78) |
| T2 | IBA 750 ppm | 0.13 (0.78) |
| T3 | Aspirin (40mg/l of distilled water) | 0.10 |
| **T4** | **IBA 750 ppm + Aspirin (40mg/l of distilled water)** | **0.03 (0.72)** |
| T5 | Diluted alcoholic leaf extracts of *Ipomoea aquatica* | 0.10 |
| T6 | 20 % water-soluble garlic cloves extract | 0.10 (0.76) |
| T7 | Gel from *Aloe vera* leaves | 0.10 |
| T8 | Diluted alcoholic leaf extracts of Ivy gourd | 0.17 (0.80) |
|  | CD (5 %) | NS |

Data in parenthesis are square root transformed data.

**Table 16 – Effect of IBA, Aspirin and Natural plant extracts on rooting percentage (%) of cuttings**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Treatment Details** | **Rooting Percentage (%)** |
| T1 | Control (Distilled water) | 80 |
| T2 | IBA 750 ppm | 90 |
| T3 | Aspirin (40mg/l of distilled water) | 83.33 |
| **T4** | **IBA 750 ppm + Aspirin (40mg/l of distilled water)** | **96.67** |
| T5 | Diluted alcoholic leaf extract of *Ipomoea aquatica* | 93.31 |
| T6 | 20 % water-soluble garlic cloves extract | 89.6 |
| T7 | Gel from *Aloe vera* leaves | 93.33 |
| T8 | Diluted alcoholic leaf extract of Ivy gourd | 70 |

**4.14. Rooting percentage (%) of cuttings**

The rooting percentage (%) of cuttings of chrysanthemum as per the different treatments has been presented in Table 16. From the perusal of Table 16, it was clearly revealed that the chrysanthemum cuttings under T4 (IBA 750 ppm + Aspirin 40mg/l of distilled water showed the highest rooting percentage with 96.67 %. This was closely followed by T7 (Gel from *Aloe vera* leaves) with 93.33 %. While the cuttings under T8 (Diluted alcoholic leaf extracts of Ivy gourd) recorded the lowest rooting percentage with 70 %.



**Fig. 5 – Secondary roots formation in T4 cuttings**

**Fig 4. Callus formation in cuttings**



**Fig. 6 Rooted cuttings respectively from T1 to T8**

4. DISCUSSION

**4.1 Effect of IBA, Aspirin and Natural plant extracts on number of days to callus formation in chrysanthemum cuttings**

Callus is an irregular mass of parenchymatous cells that are generally formed at wounded portion of plant parts with the purpose of healing of wounded portions in plant body. Callus formation is the first step towards root initiation in cuttings. The callus mass then dedifferentiates towards formation of adventitious roots in cuttings taken from plants. Further callus differentiation occurs depending on the auxin concentration in the wounded site as well as polarity of cuttings. In the present research work, it was found that no significant difference was observed in the chrysanthemum cuttings with respect to number of days to callus formation. Among all the treatments, the highest number of days to callus formation in cuttings (2.77) was recorded in T8 (Diluted alcoholic leaf extract of Ivy gourd) while the least number of days for callus formation in cuttings (2.40) was seen in T4 (IBA 750 ppm + Aspirin 40mg/l of distilled water). The reason may be due to the effect of Aspirin that contains salicylic acid. Salicylic acid has a synergistic role on auxins, that helps in callusing and rooting in cuttings. The above findings are corroborated with Sardoei *et al*. (2014) in Poinsettia.

**4.2 Effect of IBA, Aspirin and Natural plant extracts on number of days for root initiation in chrysanthemum cuttings**

Number of days for root initiation refers to number of days at which the cuttings started rooting from the day of planting in sand in protrays. The least number of days taken by a treatment for rooting than other treatments show its success over others. In this investigation carried out with 8 number of treatments, it was found that the cuttings recorded the least number of days for root initiation with 6.83 days when treated with T4 (IBA 750 ppm + Aspirin 40mg/l of distilled water). The rooting in cuttings taken from plants is directly dependent in age of cuttings, environmental conditions and endogenous level of auxins present as well as exogenous application of auxins. The cuttings taken from chrysanthemum plants were terminal in nature, thus the endogenous level of auxin was almost similar. But better rooting was recorded in T4 (IBA 750 ppm + Aspirin 40mg/l of distilled water) as compared to T2 (IBA 750 ppm) and the other treatments. This may be due to the effect of Aspirin used in conjunction with IBA which were applied exogenously. Aspirin that contains salicylic acid which is considered to be a phytohormone and has a positive effect in formation of adventitious roots in cuttings. Aspirin when used in combination with auxins produce a synergistic effect and promote rooting very rapidly. This is in close conformity with the findings of Bojarczuk and Jankiewicz (1975) who reported that salicylic acid in combination with NAA synergistically promoted rooting very rapidly in cuttings of several *Populus* sp.

After T4, the cuttings treated with T7 (Gel from *Aloe vera* leaves) also took minimum number of days for root formation, i.e., 6.99 days. *Aloe vera* gel contains IAA and it could be used as an alternative rooting hormone. Also, it contains growth hormones like gibberellin and salicylic acid which promotes quick rooting and overall growth of the plant. Similar views have been reported by El-Sherif (2017) in *Populus* trees.

4.3 **Effect of IBA, Aspirin and Natural plant extracts on number of roots per cutting of chrysanthemum at 10, 15 and 20 DAP**

The data pertaining to the present investigation revealed that different treatments given to the terminal cuttings of chrysanthemum had a significant effect with respect to the number of roots per cutting at 10, 15 and 20 DAP.

Based on the observations of the research study, it was found that the highest number of roots per cutting was seen in cuttings of T4 (IBA 750 ppm + Aspirin 40mg/l of distilled water) at 10, 15 and 20 DAP with 15.10, 33.93 and 45.83 roots respectively. This was followed by the treatment of T7 (Gel from *Aloe vera* leaves) with 10.20, 33.13 and 42.13 number of roots per cutting respectively at 10, 15 and 20 DAP. The presence of salicylic acid in aspirin caused a positive effect on rooting of chrysanthemum cuttings, since salicylic acid is known to be a plant hormone and it regulates the plant response to many biotic and abiotic stress, thus promoting root growth and development. This is in close conformity with the findings of Sakhanokho and Kelley (2009) in *Hibiscus sp.* Aloe vera gel is known to contain natural growth regulators such as auxins and gibberellins as well as other plant nutrients. These natural auxins and gibberellins stimulate and accelerate the formation of roots and improve the quality of roots. Aloe vera gel is well known for its medicinal properties which is attributed to its anti-fungal and anti-bacterial properties. Thus, the chrysanthemum cuttings treated with Aloe gel were well protected from soil borne pathogens and had not only a better chance of survival but also exhibited better rooting as compared to the other treatments. This has been supported by the research findings of Owusu and Kuavedzi (2020) in Croton cuttings.

Also, the T6 (20 % water-soluble garlic cloves extract) treated cuttings recorded a good number of roots per cutting at 10, 15 and 20 DAP with 9.97, 30.27 and 29.00 roots respectively. This might be due to the reason that garlic is rich in antioxidant phytochemicals and its extract has a positive influence in root growth and development. It is a well-known fact that garlic has several medicinal properties due the compounds present in its cloves. It is a very powerful anti-oxidant. Thus, chrysanthemum cuttings treated with 20% garlic extract provided the basal portion of the cuttings a better protection from pathogens present in growing media and enhance the chances of survival as well as rooting characteristics. This fact has been supported by Abbasifar *et al*. (2020) in cuttings of rose.

On the other hand, the chrysanthemum cuttings under T8 (Diluted alcoholic leaf extract of Ivy gourd) had produced no roots formed at 10 DAP. But 2.23 and 3.90 number of roots per cutting were formed at 15 and 20 DAP respectively, which was the minimum among all the treatments. This may be due to the inhibitory action of compounds present in Ivy gourd leaves.

**4.4 Effect of IBA, Aspirin and Natural plant extracts on number of secondary roots per cutting of chrysanthemum at 20 DAP**

Based on the data recorded in the present research, it was found that the highest number of secondary roots per cutting at 20 DAP (6.17 roots) was in T4 (IBA 750 ppm + Aspirin 40mg/l of distilled water). This was followed by T7 (Gel from *Aloe vera* leaves) and T6 (20 % water-soluble garlic cloves extract) i.e., 6.10 and 5.93 roots respectively. This trend may be due to the fact that early rooting in T4 (IBA 750 ppm + Aspirin 40mg/l of distilled water)resulted in better sprouts i.e., opening of terminal leaves which added to the endogenous levels of auxins as well cytokinins which triggered the formation of secondary adventitious roots. The success of survival of cuttings as well as their establishment is directly proportional to the root mass produced. A similar effect occurred when chrysanthemum cuttings were treated with 20% garlic extract which also was found to cause early rooting next to T4 (IBA 750 ppm + Aspirin 40mg/l of distilled water), as reported by Al-Mayahi and Fayadh (2015) in *Solanum tuberosum*, cv. Latonia. Likewise, *Aloe vera* gel contains IAA which could be the alternative root hormone, as reported by El-Sherif (2017) in *Populus* trees.

**4.5 Effect of IBA, Aspirin and Natural plant extracts on length of longest root per cutting of chrysanthemum (mm) at 10, 15 and 20 DAP**

The data pertaining to the present investigation revealed that different treatments given to the terminal cuttings of chrysanthemum had a significant effect with respect to the length of longest root per cutting at 10, 15 and 20 DAP.

In this research work, the maximum length of the longest root per cutting was recorded in cuttings of T4 (IBA 750 ppm + Aspirin 40mg/l of distilled water) with 9.15 mm at 10 DAP, 19.58 mm at 15 DAP and 28.90 mm at 20 DAP. The presence of salicylic acid in Aspirin was the main factor affecting growth of roots. Salicylic acid is a phenolic compound and encourages root growth as well as protects the cuttings from infections, when used in combination with IBA and other auxins. This has been supported by Sardoei *et al*., 2013 in cuttings of Henna.

Likewise, T7 (Gel from *Aloe vera* leaves) treated cuttings produced longer roots per cutting at 10, 15 and 20 DAP with 8.77, 16.87 and 26.43 mm long roots respectively). Aloe have been reported to be a source of nearly 75 biologically active ingredients, including various types of salicylic acid, minerals, sugar, vitamins, saponins, lignins, and amino acids, that promotes cell preservation and proliferation. It has auxins and gibberellins which helps in rooting of cuttings. This has been supported by Jamal Uddin *et al*., (2020) who studied the effect of natural substances in comparison to synthetic hormone in grapevine cutting and found that in Aloe vera gel treatment, longest root length (12.9 cm) was observed followed by IBA (10.9 cm).

Also, the chrysanthemum cuttings under T6 (20 % water-soluble garlic cloves extract) produced longer roots, i.e. 7.87 mm, 14.47 mm and 26.43 mm at 10, 15and 20 DAP respectively. These results are in line with the findings of Abbasifar *et al*. (2020) who gave the report of using garlic extract on rooting of cuttings in grape. He found the highest root length (19.67 cm) was obtained from 50 g/L garlic extract application than the highest root length (12 cm) of control. He arrived at a conclusion that garlic extract is having significant impact on rooting and root length of grapevine.

In successful rooting of cuttings not only the number of roots is of significance but also the presence of secondary roots as well as root length are of primary importance. The presence of long roots influences directly the ability of roots to proliferate the medium in search of nutrients, moisture and for anchorage. So, the length of roots in chrysanthemum cuttings are of primary importance.

**4.6. Effect of IBA, Aspirin and Natural plant extracts on fresh weight of roots per cutting of chrysanthemum (gm) at 15 and 20 DAP**

Based on the findings of the present investigation, the maximum fresh weight of roots per cutting at 15 DAP and 20 DAP was obtained in T4 (IBA 750 ppm + Aspirin 40mg/l of distilled water) i.e., 0.23 gm and 0.34 gm respectively. This was closely followed by T7 (Gel from *Aloe vera* leaves) with 0.19 gm at 15 DAP and 0.24 gm at 20 DAP. Aspirin, due to salicylic acid present in it, synergistically combined with IBA and resulted in maximum root formation in cuttings, thus increasing the overall root weight. The results are in line with the findings of Murat and Elmas (2008) in a study of rooting of *Olea europaea* cuttings. Similarly, aloe vera is rich in essential amino acids, mono-and polysaccharides, lignin, macronutrients, micronutrients, vitamins, gibberellins and salicylic acid, thus, help in improving the root parameters. This has been supported by Sumantra and Widnyana (2010) while experimenting on seed germination of Dendrobium orchid.

The fresh weight of roots in a cutting signifies the ability of the chrysanthemum cuttings to put forth vegetative growth of above ground plant parts. This is due to the fact that the root mass is involved in absorption of moisture and nutrients which are directed towards growth in height and number of leaves sprouted. Thus, T4 (IBA 750 ppm + Aspirin 40mg/l of distilled water) and T7 (Gel from *Aloe vera* leaves) provided better opportunity to the cuttings for survival and further growth.

**4.7. Effect of IBA, Aspirin and Natural plant extracts on number of leaves senescence per cutting of chrysanthemum at 10 and 20 DAP**

In this research work, the number of leaves that got senescence and withered away was recorded for all the 8 treatments at 10 DAP and 20 DAP. According to the results, it was found that maximum number of leaf senescence (0.97 and 0.17) was in cuttings treated with T8 (Diluted alcoholic leaf extracts of Ivy gourd) at both 10 and 20 DAP respectively. Similarly, the minimum number of leaf senescence (0.33 and 0.03) was seen in cuttings treated with T4 (IBA 750 ppm + Aspirin 40mg/l of distilled water) at both 10 and 20 DAP respectively. This is because of the presence of aspirin that contains salicylic acid as an active component. It triggers a defense mechanism in plants against many fungal, bacterial and viral diseases, thus, promoting better growth and survival of plants. Salicylic acid is having antisenescence property and supports leaf growth and development.

Similarly, T6 (20 % water-soluble garlic cloves extract) and treated cuttings also showed minimum leaf senescence at both 10 DAP and 20 DAP (0.43and 0.10 respectively), which is very significantly close to the T4 treatment. It may be due to the reason that garlic extract contains many allelopathic chemicals with a known antimicrobial and antibacterial agent, thus preventing the cuttings from infections. The results are in line with Wang *et al*. (2015) in eggplant.

Also, the T7 (Gel from *Aloe vera* leaves) treated cuttings showed minimum leaf senescence, 0.43 at 10 DAP and 0.10 at 20 DAP, statistically similar to T6 (20 % water-soluble garlic cloves extract). Aloe vera gel contains essential amino acids, macronutrients, micronutrients, vitamins, gibberellins and salicylic acid and had stimulating effect on plant growth and development as reported by Hamouda *et al*. (2012) in Basil.

Terminal stem cuttings are plant parts that have been detached from the mother plant and possess higher levels of endogenous auxins, as not only the tips but also the leaves produce them. Thus, the rate of senescence of leaves is directly related to the success of rooting in cuttings which has been confirmed in the present study.

**4.8. Effect of IBA, Aspirin and Natural plant extracts on rooting percentage of chrysanthemum cuttings**

The experimental results of the present investigation revealed that the terminal cuttings of chrysanthemum subjected to different treatments showed significant effect on rooting percentage of cuttings.

Results showed that the highest rooting percentage was exhibited in cuttings under treatment T4 (IBA 750 ppm + Aspirin 40mg/l of distilled water) with 96.67 %, followed by the treatment of T7 (Gel from *Aloe vera* leaves) where 93.33 % rooting was recorded in cuttings of chrysanthemum. While the lowest rooting percentage was recorded in T8 (Diluted alcoholic leaf extracts of Ivy gourd) and T1 (Control), 70 % and 80 % respectively.

Aspirin is nothing but acetylsalicylic acid (ASA), very similar to the salicylic acid that plants themselves produce during stressful conditions. Salicylic acid acts as a synergist for auxins and helps in adventitious rooting. Salicylic acid had synergistically acted with IAA and promoted the root formation in mung bean cuttings, resulting in highest root percentage than other treatments, as mentioned in the findings of Kling and Meyer (1983).

*Aloe vera* gel is also having salicylic acid which helps in rooting of cuttings. Aloe Vera is showed to be the best treatment in combination with coconut water in rooting of *Vitex diversifolia* semi hardwood cuttings than the commercially available synthetic rooting hormone IBA, where 80 % rooting was seen in cuttings, as reported by Shidiki *et al*., (2019).

**CONCLUSION**

From the research study, it was observed that there was significant effect among the treatments. T4 (IBA 750 ppm + Aspirin 40mg/l of distilled water) proved to be the best

treatment for rooting in cuttings, followed by T7 (Gel from *Aloe vera* leaves) and T6 (20 %

water-soluble garlic cloves extract) in comparison to other treatments as well as control, since it exhibited the best results on cuttings, viz., minimum number of days to callus formation with 2.40 (2.42 in control, 2.47 in both T7 and T6), least number of days for root initiation with 6.83 days (7.20 in control, 6.99 in T7, 7.02 in T6), highest number of roots per cutting at 10 DAP with 15.10 (6.07 in control, 10.20 in T7, 9.97 in T6), at 15 DAP with 33.93 (7.63 in control, 33.13 in T7, 30.27 in T6), at 20 DAP with 45.83 (16.07 in control, 42.13 in T7, 29.00 in T6), highest number of secondary roots per cutting at 20 DAP with 6.17 (3.57 in control, 6.10 in T7, 5.93 in T6), maximum length of longest root per cutting at 10 DAP with 9.15 mm (4.20 mm in control, 8.77 mm in T7, 7.87 mm in T6), 19.58 mm at 15 DAP (8.52 mm in control, 16.87 mm in T7, 14.47 mm in T6), 28.90 mm at 20 DAP (12.55 mm in control, 26.43 mm in T7, 26.13 mm in T6), maximum fresh weight of roots per cutting with 0.23 g at 15 DAP (0.05 g in control, 0.19 g in T7, 0.18 g in T6 ), 0.34 g at 20 DAP (0.12 g in control, 0.24 gm in T7, 0.22 g in T6), lowest number of senescence leaves per cutting with 0.33 at 10 DAP (0.63 in control, 0.43 in both T7 and T6), 0.03 at 20 DAP (0.13 in control, 0.10 in T3, T5, T6, T7) and highest rooting percentage in cuttings with 96.67 % (80 % in control, 93.33 % in T7, 93.31 % in T5). From the present investigation, it can be concluded that the naturally obtained substances such as salicylic acid, *aloe vera* gel, garlic extract and leaf extract of *Ipomoea aquatica* were found to be better in comparison to commercial synthetic rooting hormone IBA (alone) as well as the control (distilled water) for rooting in cuttings. These natural rooting substances are organic in nature, readily available at very minimal cost and environment friendly. Also, they contain phytohormones and growth regulators which help in stimulating plant growth. On the other hand, the synthetic rooting substances are chemical in nature, available at high cost and are toxic to both the plants and environment at higher concentration. Hence, there is a lot of scope for use of plant extracts and natural products as a successful alternative to commercially available synthetic hormones for rooting of cuttings of many horticultural crops Therefore, their use can be recommended for the propagation of horticulture crops aiming in organic crop production and creating many opportunities for further research work in future.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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