Effect of IBA, Aspirin and Natural plant extracts on Rooting of Chrysanthemum (*Dendranthema grandiflora* L.) cv. Flirt

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By

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CERTIFICATE – I

This is to certify that entitled **"EFFECT OF IBA, ASPIRIN AND NATURAL PLANT EXTRACTS ON ROOTING OF CHRYSANTHEMUM (*Dendranthema grandiflora* L.) cv. Flirt"** submitted in partial fulfilment of the requirements for the award of degree of **MASTER OF SCIENCE IN AGRICULTURE (FLORICULTURE AND LANDSCAPING)** to the Odisha University of Agriculture and Technology is a faithful record of *bona fide* and original research work carried out by **TOSALI TRISHNA SAHOO, Admission No. 191221803** under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma.

It is further certified that the assistance and help received by her from various sources during the course of investigation has been duly acknowledged.

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13.09.2021

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CERTIFICATE – II

This is to certify that the thesis **"EFFECT OF IBA, ASPIRIN AND NATURAL PLANT EXTRACTS ON ROOTING OF CHRYSANTHEMUM (*Dendranthema grandiflora* L.) cv. Flirt"** submitted by **TOSALI TRISHNA SAHOO, Admission No. 191221803** to the Odisha University of Agriculture and Technology, Bhubaneswar in the partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE (FLORICULTURE AND LANDSCAPING)** has been approved/disapproved by the students' advisory committee and external examiner.

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ABBREVIATIONS AND SYMBOLS

IBA	:	Indole Butyric Acid
IAA	:	Indole Acetic Acid
NAA	:	Naphthalene Acetic Acid
ppm	:	Parts per million
cm	:	Centimetre
mm	:	Millimetre
m	:	Metre
gm	:	Gram
kg	:	Kilogram
mg	:	Milligram
ml	:	Milli litre
l	:	Litre
/	:	Per
T	:	Treatment
^{o}C	:	Degree Celsius
DAP	:	Days After Planting
et al.	:	Co-workers
i.e.	:	That is
e.g.	:	Example
viz.	:	Namely
etc.	:	Etcetera
%	:	Percent
No.	:	Number
Sp.	:	Species
cv.	:	Cultivar
Fig.	:	Figure
@	:	At the rate of
v/v	:	Volume/volume
NS	:	Non-significant
SE (m)	:	Standard Error Mean
CD	:	Critical Difference

Title of Thesis	**:**	**Effect of IBA, Aspirin and Natural plant extracts on Rooting of Chrysanthemum (*Dendranthema grandiflora* L.) cv. Flirt**
Name of the student	**:**	**Tosali Trishna Sahoo**
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ABSTRACT

The present investigation entitled **"Effect of IBA, 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, located in the premises of College of Agriculture, O.U.A.T., Bhubaneswar during August – September 2021 with the following objectives: (i) To study the effect of IBA on rooting of cuttings of chrysanthemum, (ii) To study the effect of Aspirin on rooting of cuttings of chrysanthemum and (iii) To study the effect of Natural plant extracts on rooting of cuttings of chrysanthemum. The research study was conducted as per the Completely Randomized Design (CRD) with 8 treatments and 3 replications. The 8 treatments were T_1 (control), T_2 (IBA 750 ppm), T_3 (Aspirin 40mg/l of distilled water), T_4 (IBA 750 ppm + Aspirin 40mg/l of distilled water), T_5 (Diluted alcoholic leaf extract of *Ipomoea aquatica*), T_6 (20 % water-soluble garlic cloves extract), T_7 (Gel from *Aloe vera* leaves) and T_8 (Diluted alcoholic leaf extract of Ivy gourd). The terminal cuttings of chrysanthemum variety, 'Flirt' were collected and subjected to different treatment solutions and planted in pro-trays with sand as the rooting medium. Different observations of rooting parameters were recorded at 10, 15 and 20 DAP.

The results obtained in the experiment revealed that there was significant effect among the treatments. The treatment T_4 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 as well as control, since it exhibited the best results on cuttings, viz., 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 senescenced leaves per cutting (0.33 at 10 DAP, 0.03 at 20 DAP) and highest rooting percentage in cuttings (96.67 %) as compared to T_1 i.e., Control (2.42 days for callus formation, 7.20 days for root initiation, 6.07 number of roots per cutting at 10 DAP, 7.63 number of roots per cutting at 15 DAP, 16.07 number of roots per cutting at 20 DAP, 3.57 number of secondary roots per cutting at 20 DAP, 4.20 mm length of longest root per cutting at 10 DAP, 8.52 mm length of longest root per cutting at 15 DAP, 12.55 mm length of longest root per cutting at 20 DAP, 0.05 gm of fresh weight of roots per cutting at 15 DAP, 0.12 gm of fresh weight of roots per cutting at 20 DAP, 0.63 number of senescenced leaves per cutting at 10 DAP, 0.13 number of senescenced leaves per cutting at 20 DAP and 80 % rooting in cuttings. Similarly, T_7 (Gel from *Aloe vera* leaves) and T_6 (20 % water-soluble garlic cloves extract) also recorded best results respectively next to T_4 (IBA 750 ppm + Aspirin 40mg/l of distilled water). Therefore, the conclusion from the research work drawn was that naturally available plant extracts and products are organic, non-toxic, readily available at low cost and contain phytohormones and active compounds which stimulate rooting in cuttings, prevents infections as well as support plant growth. Hence, they can be successfully used as effective alternatives of synthetic rooting hormones that are expensive but also toxic to plants and environment at high concentrations. So, the present study opens up many opportunities for further research in future for use of plant extracts and natural products in commercial propagation of floricultural crops.

Signature of the student

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).

Chrysanthemum can be propagated through both sexually and asexually (vegetative method). 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. 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. 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 IBA, NAA and 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. ASA is the active ingredient in aspirin and is derived from salicylic acid, which is naturally found in willow bark. 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 plants. 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 salicylic acid, minerals, sugar, vitamins, saponins, lignins, 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 the goal to study 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 following objectives:

1. To study the effect of IBA on rooting of cuttings of Chrysanthemum.
2. To study the effect of Aspirin on rooting of cuttings of Chrysanthemum.
3. To study the effect of Natural plant extracts on rooting of cuttings of Chrysanthemum.

REVIEW OF LITERATURE

2.1. CHRYSANTHEMUM

2.1.1. IBA

Bharmal *et al.,* 2004 conducted an experiment to study the effect of rooting hormone IBA on propagation of Chrysanthemum cv. Sonali Tara. IBA rooting hormone was used in 3 concentrations, i.e. 1000, 2000 and 3000 ppm along with a control. It was found that treating the cuttings in IBA @ 2000 ppm using quick-dip method followed by two sprays of IBA @ 10 ppm at the intervals of 30 DAP and 60 DP of cuttings resulted in maximum rooting as well as survival percentage as compared to other treatments as well as control. Maximum number of primary roots recorded was 920.85, and survival percentage was found to be 96.57 % after 30 days of planting of cuttings.

Sidhu and Singh, 2002 did a study to know about the impact of IBA on rooting of terminal cuttings of Chrysanthemum cv. Flirt. IBA hormone was applied at 0 ppm, 100 ppm, 150 ppm, 200 ppm, 250 ppm and 300 ppm and results showed that the maximum number of roots per cutting (24.49), maximum length of longest root (5.09 cm) and maximum rooting percentage (87.13 %) were seen in cuttings treated with IBA at 250 ppm.

Grewal *et al*., 2005 conducted an experiment to study the effect of different rooting hormones like IBA and NAA on propagation of Chrysanthemum terminal cuttings cv. Snowball. The rooting hormones were singly applied @ 0, 100, 200, 300 and 400 ppm as well as in different combinations (50 + 50 ppm, 50 + 100 ppm and 100 + 50 ppm) and finally it was found that the terminal cuttings treated with IBA @ 400 ppm performed well in terms of various rooting parameters as compared to other concentrations and control. The mean root number obtained was significantly more with IBA @ 400 ppm (8.67) than in the control (3). Moreover, mean plantlet weight was recorded the highest in IBA @ 400 ppm (5.37 gm) than in the control (2.93 gm) where cuttings were propagated without rooting hormone.

Ganjure *et al*., 2012 carried out a field trial to standardize the application of IBA hormone on propagation of Chrysanthemum, cv. Piwali Rewadi. IBA was used @ 500 ppm, 800 ppm and 1000 ppm and it was found that Chrysanthemum cuttings responded more positively at 1000 ppm of IBA than other concentrations and control where the days to sprouting (8.60), days to rooting (9.33) were found minimum in IBA @ 1000 ppm. Also, the

fresh weight of roots (1.87 gm) and dry weight of roots (0.16 gm) were high at 1000 ppm IBA.

Ranpise *et al*., 2004 studied the effect of rooting hormone IBA on rooting, growth and flower yield of Chrysanthemum cv. Sonali Tara by application of IBA @ 200 ppm, 600 ppm, 1000 ppm, 2000 ppm and 3000 ppm and found that 200 ppm of IBA performed well followed by 1000 ppm of IBA on the basis of number of roots, root length, rooting and survival percentage of cuttings.

Surekha *et al*., 2014 conducted a field trial to study the effect of IBA rooting hormone on propagation of Chrysanthemum cuttings. IBA was used @ 100 ppm, 200 ppm, 300 ppm, 400 ppm, 500 ppm and 600 ppm and it was found that the cuttings treated with IBA @ 500 ppm resulted in maximum number of roots (8.67) and rooting percentage (88.3 %) than the cuttings treated with other IBA concentrations and the control.

Honfi, 2004 studied on the impact of IBA rooting hormone on propagation of Chrysanthemum. He experimented the rooting potential of 43 varieties and the effects of various rooting hormones. Finally, he found that treatment of cuttings with IBA rooting hormone @ 0.5 – 1 ppm resulted in large number of roots and root quality per cuttings.

Natarajan, 1995 conducted trials to study the effect of application of IBA rooting hormone at low concentration on propagation of some varieties of Chrysanthemum and found that treating the Chrysanthemum cuttings in 50 ppm IBA, either by spraying or dipping, stimulated better rooting in cuttings in comparison to the untreated cuttings.

Cuquel and Minami, 1994 conducted an experiment to study the effect of application of IBA rooting hormone on propagation of Chrysanthemum cuttings and finally reported that the cuttings treated with IBA @ 500 – 2000 ppm in talc performed well in terms of rooting and survival percentage as compared to lower and much higher concentrations than the range.

Dirr, 1992 investigated rooting in *Chrysanthemum morifolium* and found that roots were produced even in the absence of IBA rooting hormone. However, the trend showed that increase in the hormone concentration and dipping time influenced the rooting potential of Chrysanthemum. Although, NAA rooting hormone was superior to IBA rooting hormone but IBA @ 3000 ppm was recommended as the best concentration for better root number, average root length, fresh root weight and survival percentage parameters.

Amin and Hashim, 1992 conducted field trials to study about the standardization of the application of IAA and IBA rooting hormones on propagation of Chrysanthemum cuttings cv. Spider. The well-prepared terminal cuttings were treated with IBA and IAA @ 0, 100,

200, 300 and 400 ppm. Finally, he found that IBA @ 400 ppm performed well in terms of dry weight of roots and number of roots as compared with other treatments and control.

Lee *et al*., 1977 studied on the effect of IBA rooting hormone on propagation of Chrysanthemum and found that treating the cuttings with IBA @ 0.5 – 1 ppm resulted in larger number of roots and higher quality of roots per cuttings.

2.2. OTHER ORNAMENTAL CROPS

2.2.1. IBA

Seyedi *et al*., 2014 did an experiment to study the rooting in cuttings of *Bougainvillea glabra*. The cuttings were treated with IBA solution @ 0 ppm, 2000 ppm and 4000 ppm for 5 seconds and then planted on a medium containing sand and perlite. Results showed that cuttings treated with IBA @ 4000 ppm produced maximum rooting as compared to other treatments and the control. Also, the root number, root length and root fresh weight were highest in case of cuttings treated with IBA @ 4000 ppm.

Shahzad Akhtar *et al*., 2002 conducted an experiment to study the response of different rose species to different root promoting hormones. Rose stem cuttings were taken from two species i.e. *Rosa centifolia* and *Rosa damascena*. The basal portion of the cuttings were treated with two rooting hormones, NAA and IBA, @ 500 ppm and 1000 ppm by quick dip method in addition to a control. The experiment was laid out according to the randomized complete block design with factorial arrangement. Results showed that 1000 ppm produced significant results than 500 ppm and the control treatments in both the growth hormones. Also, *Rosa centifolia* produced more roots than *Rosa damascena* and IBA gave significantly better roots than NAA.

Prince *et al*., 2017 did a study on the effect of IBA on fifteen genotypes of Carnation (*Dianthus caryophyllus* L.). It was revealed that out of the fifteen genotypes used in the research experiment, the Guadina genotype produced highest rooting percentage (91.33 %) whereas, the IIHR genotype produced lowest rooting percentage (44.66 %). Moreover, IBA @ 500 ppm resulted in highest rooting percentage (72.48 %) as compared to IBA @ 200 ppm. Also, other rooting parameters like root length, days for root initiation and number of roots per cutting were recorded the best with IBA at 500 ppm.

Akhtar *et al*., 2015 did a research in *Rosa centifolia* cuttings and found that rooting percentage increased with use of plant growth regulators. Different growth regulators, i.e. IAA, IBA and NAA were used at various concentrations, i.e. 450 ppm, 700 ppm and 950 ppm alone and in combinations. Healthy and well-prepared stem cuttings were treated with PGR's

by quick dip method and planted in polythene bags. Results revealed that IBA at all the 3 concentrations used alone gave best result in all rooting parameters than other concentrations. Among the 3 concentrations of IBA, 450 ppm resulted in maximum number of roots (14.00), shoot length (10.67 cm), root length (11.90 cm), shoot dry weight (3.02 gm) and root dry weight (0.50 gm).

Radhari *et al*., 2014 conducted a trial on *Cordyline terminalis.* Two growth regulators, IBA and NAA were used @ 0, 1000, 2000 and 3000 mg/l, as alone as well as in different combinations. It was found that the fresh weight of roots, dry weight of roots, number of branches and average root length were maximum in cuttings treated with NAA (2000 mg/l) + IBA (1000 mg/l).

Sharma, 2014 conducted an experiment to observe the effect of rooting hormone IBA on propagation of Marigold. The well-prepared cuttings were treated with 0, 100, 200, 300, 400 and 500 ppm IBA. Results revealed that the root length (9.14 cm) and root spread (4.53 cm) were highest in 200 ppm of IBA, whereas, the number of roots (44.43), fresh roots weight (0.71 gm) and dry roots weight (0.079 gm) were highest in 400 ppm of IBA.

Renuka and Shekhar, 2014 did a research to study about the effect of NAA and IBA at different concentrations on rooting of Carnation (*Dianthus caryophllus* L.) cv. Dona under polyhouse conditions. He found that cuttings treated with IBA rooting hormone at 200 ppm resulted in maximum rooting percentage, least number of days for root initiation, greatest number of roots per cutting, maximum root length per cutting and highest percentage of rooted cuttings establishment as compared with those cuttings treated in combination of IBA @ 100 ppm + NAA @ 50 ppm. Thus, IBA rooting hormone recorded superior in all rooting parameters over NAA rooting hormone and an increase in IBA + NAA concentration resulted to an increase in various rooting parameters in cuttings.

Wazir, 2014 did a study on the effect of NAA and IBA on rooting of Camellia cuttings. Softwood, semi-hardwood cuttings and hardwood cuttings were taken and dipped for 5 minutes in NAA solution @ 250 ppm and 500 ppm and in IBA solution @ 500 ppm and 1000 ppm prior to planting. It was found that among all the treatments, IBA @ 1000 ppm was the best. However, type of cuttings had no effect on propagation.

Singh *et al*., 2014 did a research on *Morus alba* to study the effect of IBA and NAA on rooting of cuttings. The well-prepared stem cuttings were treated with IBA and NAA solutions at 1000 ppm, 1500 ppm and 2000 ppm by quick-dip method. Among all the treatments, IBA @ 2000 ppm resulted in highest rooting percentage, maximum number of sprouted cuttings, maximum length of roots per cutting and maximum length of longest roots.

Alshammary *et al*., 2013 did an experiment on *Bougainvillea peruviana* cv. Shubra and *Hamelia patens*. 60 number of hardwood cuttings of each species were taken and treated with IBA and NAA for 5 seconds as quick dip. It was reported that treating the cuttings of Bougainvillea and Hamelia with IBA @ 2000 ppm recorded the highest rooting percentage (53.6 % and 28.4 %), more number of roots per cutting (15.5 and 24.8), higher bud break percentage (73.9 % and 59.2 %), maximum root length per cutting (31.6 mm and 27.2 mm), higher fresh weight of roots (9.5 gm and 8.8 gm), higher dry weight of roots (6.6 gm and 6.4 gm), more number of branches per cutting (3.6 and 5.4), more number of leaves per cutting (59.0 and 50.1) and higher percentage of cutting establishment (60.3 % and 42.3 %) respectively.

Kumari *et al*., 2013 did a study on the effect of rooting in cuttings of *Jatropha curcas*. The semi hardwood cuttings were given treatments with IAA and IBA at concentrations of 100 ppm, 200 ppm and 300 ppm. Results revealed that the maximum rooting percentage (49.83 %), shoot length (10.57 cm), early shoots emergence (25.92 days), highest number of shoots per cutting (5.58), average shoot number (38.95) and sprouting (81.10 %) were the best when cuttings were treated with IBA @ 200 ppm.

Shahba and Alshammary, 2013 studied the effect of IBA on rooting of *Bougainvillea peruviana* cv. Shubra. The duo took 60 number of uniform hardwood cuttings and soaked in IBA and NAA for 12 hrs and 24 hrs. It was found that cuttings treated with IBA @ 500 ppm produced maximum rooting percentage, i.e. 59.4 % after 24 hours and 55.6 % after 12 hours of treatment, highest number of roots per cutting, i.e. 20.5 at 12 hours and 19.8 at 24 hours of treatment, higher root length per cutting, i.e. 46.6 cm and 49.2 cm and maximum cutting establishment percentage, i.e. 53.3 % after 24 hours and 68.3 % after 12 hours of treatment.

Susila and Reddy, 2013 conducted an experiment on *Adathoda vasica* to study the influence of IBA and NAA on rooting of cuttings. IBA and NAA rooting hormones were used at 250 ppm, 500 ppm, 1000 ppm and 1500 ppm singly as well as in combination. It was reported that cuttings treated with IBA @ 1500 ppm produced longest root length (22.18 cm) and highest percentage of rooting (67.50 %), whereas, cuttings treated with NAA @ 1500 ppm produced maximum number of roots per cutting (40.89), fresh roots weight (3.22 gm) and dry roots weight (1.12 gm).

Ullah *et al*., 2013 conducted an experiment to study the effect of IBA on propagation of Marigold. He found that IBA @ 400 ppm gave maximum number of branches per plant (6.8), IBA @ 100 ppm gave maximum number of leaves per plant (44.00), maximum plant

height and maximum root size (6.50). IBA @ 400 ppm produced maximum effect on roots per plant (84.4).

Bhatt and Chauhan, 2012 conducted a research to study the impacts of IBA and NAA rooting hormones on African Marigold (*Tagetes erecta*). IBA and NAA were at 0 ppm, 100 ppm, 150 ppm and 200 ppm as alone along with their combinations. Results showed that the average number of roots per cutting was 40.53 after 20 days and 58.79 after 30 days, which was maximum, when cuttings were treated with combination of IBA @ 150 ppm + NAA @ 150 ppm. The average root length was maximum (4.6 cm) in cuttings treated with 200 ppm NAA after 20 days and 5.51 cm in cuttings treated with IBA @ 150 ppm + NAA @ 150 ppm after 30 days.

Bhatt *et al*., 2008 did a research in *Lavendula officinalis* and found that the cuttings treating with 1000 ppm of IBA produced early rooting (21.66 days), highest number of roots per cutting (7.00), highest rooting percentage (86.66 %), maximum length of roots per cutting (10.30 cm) and high survival percentage (93.33 %).

Hashemabadi and Sedaghathoor, 2007 carried out a study on various concentrations of auxin treatment in cuttings of *Camellia japonica.* IBA and NAA were the two rooting hormones used. It was reported that treating the cuttings with IBA @ 4000 ppm resulted in highest number of roots, the cuttings treated with NAA @ 2000 ppm + IBA @ 4000 ppm resulted in maximum length of roots, whereas, highest rooting percentage was found in cuttings treated with IBA @ 4000 ppm.

Thorat *et al*., 2006 conducted a study on Nerium and found that treatment of cuttings in IBA at 100 ppm concentration for 24 hours recorded the best in terms of highest rooting, sprouting and survival percentage of plants transplanted in field.

Khewale *et al*., 2005 did a pot experiment on Carnation cv. Gaudina to study the effect of various conc. of IBA on different rooting parameters. They reported that highest rooting percentage, early root initiation, maximum number of roots and maximum root length was seen in cuttings treated with IBA @ 125 ppm.

Panahi and Morteza, 2000 did an experiment to study the effect of auxins on rooting of Carnation (*Dianthus caryophyllus* L.). Two rooting hormones IBA (0, 50, 100 and 200 ppm) and NAA (0, 25, 50 and 100 ppm) were used as single and in combination for treatment of cuttings. The results showed that the highest number of roots per cutting and maximum root length was seen at IBA @ 100 ppm treatment.

Gupta *et al*., 2005 conducted an experiment in *Buddlea asiatica* to study the effect of auxins on rooting of cuttings. 20 number of semi-hardwood cuttings were treated with IAA,

IBA and NAA at 1000 ppm, 2000 ppm, 3000 ppm, 4000 ppm and 5000 ppm for 10 seconds as quick-dip method. It was found that IBA @ 4000 ppm resulted in more longer root length, highest rooting percentage and survival of rooted cuttings.

El-Torky and El-Shennawy, 1993 did a study on *Ficus deltoidea* and reported that the highest rooting percentage was seen in cuttings treated with IBA at 3000 ppm conc.

Bhattacharjee and Balakrishna, 1992 conducted a study in *Hamelia patens* and found that IBA treatment of cuttings at 4000 ppm effectively improved the rooting percentage and number of roots and average root length per cutting.

Shirol *et al*., 1992 conducted a study in *Euphorbia pulcherimma* cv. Alba Hort and reported that highest rooting percentage (50.77%) and maximum length of longest root per cutting (8.33 cm) was obtained on cuttings treated with IBA at 3000 ppm + NAA at 3000 ppm.

Shahhoseini *et al*., 2015 did a study on Rosemary to know about the concentrations of IBA and NAA on rooting of semi-hardwood cuttings. The well-prepared cuttings were treated in IBA and NAA rooting hormone solutions for 1 minute prior to planting. Results showed that 4000 ppm IBA treatment had the best effect on quality and rooting of cuttings.

Singh *et al*., 2013 carried out an experiment on rooting of *Cestrum nocturnum*. The stem cuttings were soaked in IBA and NAA solutions at 100 ppm, 200 ppm and 300 ppm. Results showed that rooting percentage (76.53 %), root length per cutting (23.76 cm), roots fresh weight (6.06 gm) and roots dry weight (1.33 gm) were maximum in 100 ppm IBA.

Sao and Verma, 2021 carried out a research in dahlia to study the effect of rooting hormones IBA and NAA on rooting in stem cuttings. They reported that IBA at 1000 ppm produced maximum rooting percentage (69.82 %) while least days for root initiation (17.21 days) was recorded in combination treatment of 250 ppm IBA + 250 ppm NAA.

Singh *et al*., 2014 did an experiment in Duranta crop (*Duranta erecta* var. *golden*) under mist house conditions. The cuttings of about 15 cm long were taken from 2 to 4 year old mother plants and were treated in IBA solutions of 1, 2, 3, 4 and 5 g/l by quick-dip method. It was found that cuttings treated in 4 g/l IBA solution produced highest roots per cutting (43.00), length of roots per cutting (9.28 cm), diameter of root per cutting (1.67 mm), percentage of rooted cutting (88 %), number of sprouts per cuttings (4.34) and the minimum (20.66) days for callus formation.

Gupta *et al*., 1989 conducted an experiment on Dombeya plant. Healthy cuttings of 15 cm long were collected from 2 species *Dombeya natalensis* and *Dombeya tilliaceal* and treated with IAA, IBA and NAA rooting hormones, all @ 1000, 2000, 3000, 4000 and 5000

ppm. It was found that treatment of IBA at 4000 ppm produced maximum rooting (90 %), maximum number of roots (19.81), more root length (15.98 cm) per cutting and highest survival percentage of rooted cuttings (89 %) than other treatments.

2.2.2. ASPIRIN

Sardoei *et al*., 2014 conducted an experiment to determine an appropriate concentration of salicylic acid (SA) on rooting of Poinsettia (*Euphorbia pulcherimma*). The results showed that rooting percentage and mean root length was maximum in SA at 300 ppm. This study shows that plant growth regulators salicylic acid has a profound influence on rooting of Poinsettia.

Siahkamari *et al*., 2018 did an experiment to determine an appropriate concentration of salicylic acid (SA) on rooting of Oleander cuttings. It was found that rooting percentage was highest (85 % for White flowered oleander and 65 % for Red flowered oleander) in cuttings treated with 300 ppm SA. The study concluded that SA treatments have caused an increase in the percentage of rooting in cuttings over IBA treatments.

DaPing and Yan, 2012 did a study on *Viburunum opulus* to know the effect of different concentrations of Aspirin (Salicylic Acid) on rooting of cuttings. The results showed that cuttings treated in 0.7 % SA recorded maximum rooting percentage (83.3 %), highest number of roots per cutting (6) and maximum average root length (5.5 cm) as compared to other treatments and control.

Basu *et al.*, 1969 observed that tannic acid and gallic acid promoted rooting in leafy cutting of *Eranthemum tricolour* in combination with NAA and IBA. They also observed salicylic acid in combination with IAA, IBA and NAA greatly promoted rooting in the same species.

Fathi M *et al.*, 2018 conducted an experiment to study the effect of some natural compounds and human hormonal pills on rooting of Honeysuckle (*Lonicera japonica*) cuttings in comparison with the commercial chemical rooting hormone (IBA). They used natural honey and grape syrup, 0. 5 pill/L aspirin (40 mg/L) and 2 pill/L human LD (0. 36 mg/L) for study. It was reported that significant results were obtained by using such types of natural substances for rooting than the synthetic rooting hormone IBA and control.

2.2.3. GARLIC CLOVES EXTRACT

Abbasifar *et al*., 2020 did a study on Rose by taking garlic cloves extract at 3 concentrations of 0, 25 and 50 g/l for rooting in cuttings. Experimental results indicated that use of garlic clove extract at high concentration (50 g/l) produced higher root length, more

root number, fresh and dry weight of roots, whereas 0 and 25 g/l had no such positive effects on cuttings.

2.2.4. ALOE VERA GEL

Samuel Ebo Owusu and Reuben Nutefe Kuavedzi, 2020 carried out a field trial on the growth response of Croton (*Codiaeum variegatum pictum* L.) cuttings to different growth media (coco peat, sawdust, and topsoil) and plant growth hormones (*Aloe vera* gel and IBA). Results reported that cuttings grown on topsoil and treated with *Aloe vera* gel took minimum days to sprout and also the number of leaves and roots was higher in such cuttings. While the cuttings grown on sawdust had the least number of leaves and roots. Thus, it was concluded that Croton cuttings that were grown on a combination of topsoil and *Aloe vera* gel resulted in the earliest shoot response and a higher number of roots and leaves followed closely by those of IBA rooting hormone.

Boschi *et al*., 2017 experimented on Origanum. The base of cuttings was treated with IBA rooting hormone and *Aloe vera* gel and data on rooting parameters were recorded at 15, 30 and 60 DAP. Results showed that number of roots per cutting, average root length, rooting percentage and survival percentage of rooted cuttings were highest in *Aloe vera* gel treated cuttings, very closely followed by IBA treatment.

Shidiki *et al*., 2019 did a study to compare the effects of IBA, coconut water (CW) and *Aloe vera* (AV) gel on rooting of *Cordia milleneii* and *Vitex diversifolia*. Semi hardwood cuttings were used for this. Rooting percentage was highest (80 %) in AV+CW treatment, number of primary and secondary root and root length was high in AV treatment, followed by AV+CW treatment.

2.3. OTHER HORTICULTURAL CROPS

2.3.1. IBA

Siddiqua *et al*., 2018 did a research on Dragon fruit to know the effect of rooting hormones IBA and NAA and their combination on rooting of stem cuttings. The least number of days for root initiation (14.54), rooting percentage (57.75 %), length of the longest root (23.07 cm), average number of roots per cuttings (46.88), average length of roots per cuttings (12.41 cm), root volume (1.97 cc), root diameter (1.47 mm), fresh weight (2.28 gm) and dry weight of root (0.67 gm) was recorded in cuttings treated with IBA 7000 ppm.

Swathi, 2013 did an experiment on pomegranate to know the influence of IBA and NAA on rhizogenesis. 2 cultivars, i.e. Bhagwa and Ganesh were taken and IBA and NAA

were used at 2000 ppm and 4000 ppm each. She reported that IBA at 4000 ppm produced superior results than other treatments in terms of different rooting and shooting parameters. And cv. Bhagwa recorded superior results for majority of rooting and shooting parameters than cv. Ganesh.

2.3.2. ASPIRIN

Akbulut and Yigit, 2014 conducted an experiment to study the effects of Acetyl Salicylic Acid (ASA) and Indole-3-Acetic Acid (IAA) on rooting and pigmentation in *Amygdalus* cuttings and found that ASA in combination with IAA promoted maximum callus formation and rooting in treated cuttings.

2.3.3. GARLIC CLOVES EXTRACT

Abbasifar *et al*., 2020 experimented on influence of garlic cloves extract on rooting of grapevine cuttings and found that using garlic cloves extract at 25 g/l resulted in highest number of roots and highest length of roots (19.67 cm) in vine cuttings.

2.2.4. ALOE VERA GEL

Jamal Uddin *et al*., 2020 conducted an experiment on grapevine to study the effect of natural substances and synthetic hormones on rooting and vegetative growth of vines. Longest root length (12.9 cm) was seen in *Aloe vera* gel treatment followed by IBA (10.9 cm) whereas the smallest root length (5.2 cm) was in the control treatment. Hence, it was concluded that *Aloe vera* gel is the best natural substance which can be potentially used as an alternative rooting hormone for propagation of grapevine.

Mirihagalla and Fernando, 2020 experimented about the influence of IBA and *Aloe vera* gel on propagation of *Citrus aurantifolia*. Semi-hardwood cuttings were treated with *Aloe vera* gel for 2 minutes and 5 minutes and with 0.3 % of IBA. It was found that the mean root length was highest in IBA treatment (6.48 cm), but it was not significantly different from cuttings treated in aloe vera gel for 5 min (5.02 cm) and 2 min (3.58 cm). So, *Aloe vera* gel can be used instead of synthetic rooting hormones for inducing rooting in cuttings.

MATERIALS AND METHODS

The present investigation entitled "Effect of IBA, Aspirin and Natural plant extracts on Rooting of Chrysanthemum (*Dendranthema grandiflora* L.) cv. Flirt" was carried out in form of pro-tray experiment in the Department of Floriculture and Landscaping, College of Agriculture, O.U.A.T., Bhubaneswar during August – September 2021. The materials used and the techniques adopted during the course of investigation are described in this chapter.

3.1. 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, O.U.A.T., Bhubaneswar.

3.2. 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 20º15' North latitude and 85º52' East latitude.

3.3. 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 – 42ºC during May to June while the minimum temperature varies from 15 – 16ºC during December to January. The relative humidity varies between 50 % in winter to 90 % in rainy season.

3.4. Collection of cuttings for treatment

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.

3.5. 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

3.6. 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

3.7. 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. All the glass wares were well sterilized with alcohol before use.

3.8. 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.

3.9. 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 as such for 24 hours. After 24 hours, 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.

3.10. Preparation of 20 % 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 hours 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.

3.11. 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 with a knife and scraped by using a spoon to take out the *Aloe vera* gel.

3.12. Preparation of Diluted alcoholic leaf extract of Ivy Gourd

Fresh and healthy leaves of Ivy Gourd 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 as such for 24 hours. After 24 hours, the mouth of the flask was opened, leaf extract was 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.

3.13. 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 30 minutes.

3.14. 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.

3.15. After care

3.15.1. Watering

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

3.15.2. 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.

Fig. 1 – Treatment of cuttings

Fig. 2 – Planting of treated cuttings

Fig. 2.1. Filling of pro-trays with sand

Fig. 2.2. Holes made in the centre of sand medium for planting

Fig. 2.3. Treated cuttings planted in pro-trays

Fig. 2.4. Labelled pro-trays

3.16. Observations recorded

3.16.1. 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.

3.16.2. 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 per each replication.

3.16.3. 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.

3.16.4. Number of secondary roots per cutting

Three randomly selected cuttings were taken from each treatment by carefully uprooting and washing them. 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.

3.16.5. Length of longest root per cutting (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.

3.16.6. Fresh weight of roots per cutting (gm)

Three cuttings were randomly selected from each treatment, they were carefully uprooted 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.

3.16.7. 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.

3.16.8. Rooting Percentage of cuttings

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

3.17. 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.

3.17.1. ANOVA

Source of variation	Degree of Freedom	Sum of squares	Mean Sum of squares	F – Cal
Treatments	t – 1	TSS	TMS	$F = \frac{TMS}{EMS}$
Error	(n – t)	ESS	EMS	
Total	(n – 1)	TSS		

Where,

t = Number of treatments

r = Number of replications

TSS, RSS and ESS = Sum of squares of treatments, replications and error, respectively.

TMS and EMS = Mean sum of squares of treatments and error, respectively.

3.17.2. Standard Error of Mean (S. Em)

The values for S. Em (Standard error of mean) was calculated by the following formula:

$S.\ Em\ (\pm) = \sqrt{EMS - R}$

Where,

EMS = Error mean sum of squares

R = Number of replications

3.17.3. Critical Difference

To compare the means of various entries, a critical difference (CD) was calculated by using the formula:

CD (0.05) = t x $\sqrt{2}$ x S. Em ($\pm$)

Where, t = 't' value for error degrees of freedom at 5 % probability level.

EXPERIMENTAL RESULTS

The results obtained in the present research work entitled "Effect of IBA, Aspirin and Natural plant extracts on Rooting of Chrysanthemum (*Dendranthema grandiflora* L.) cv. Flirt" carried out under the polyhouse of the Department of Floriculture and Landscaping located in the premises of College of Agriculture, O.U.A.T., Bhubaneswar are presented in this chapter.

4.1. 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 T_8 (2.77) viz., Diluted alcoholic leaf extract of Ivy gourd, while the least number of days to callus formation in chrysanthemum cuttings was recorded in T_4 (2.40) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water, followed by T_1 (2.42) viz., Control. It was also found that cuttings of T_2 (IBA 750 ppm) and T_5 (Diluted alcoholic leaf extract of *Ipomoea aquatica*) recorded same number of days for callusing, i.e., 2.50. Similarly, cuttings of T_6 (20 % water-soluble garlic cloves extract) and T_7 (Gel from *Aloe vera* leaves) also took same number of days for callusing i.e., 2.47.

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

Treatments	Treatment Details	Number of days to callus formation
T_1	Control (Distilled water)	2.42
T_2	IBA 750 ppm	2.50
T_3	Aspirin (40mg/l of distilled water)	2.53
T_4	IBA 750 ppm + Aspirin (40mg/l of distilled water)	2.40
T_5	Diluted alcoholic leaf extract of *Ipomoea aquatica*	2.50
T_6	20 % water-soluble garlic cloves extract	2.47
T_7	Gel from *Aloe vera* leaves	2.47
T_8	Diluted alcoholic leaf extract of Ivy gourd	2.77
	CD (5 %)	NS

4.2. 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 T_4 (6.83) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water. This was followed by T_7 (6.99) viz., Gel from *Aloe vera* leaves, whereas the maximum number of days for root initiation was found in T_8 (14.97) viz., Diluted alcoholic leaf extract of Ivy gourd, followed by T_3 (7.43) 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*
T_1	Control (Distilled water)	7.20
T_2	IBA 750 ppm	7.03
T_3	Aspirin (40mg/l of distilled water)	7.43
T_4	IBA 750 ppm + Aspirin (40mg/l of distilled water)	6.83
T_5	Diluted alcoholic leaf extract of *Ipomoea aquatica*	7.13
T_6	20 % water-soluble garlic cloves extract	7.02
T_7	Gel from *Aloe vera* leaves	6.99
T_8	Diluted alcoholic leaf extract of Ivy gourd	14.97
	SE (m) $\pm$	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 at 10 DAP was found in cuttings treated with T_4 (15.10) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water, which is followed by T_7 (10.20) viz., Gel from *Aloe vera* leaves. The lowest number of roots per cutting at 10 DAP was found in T_3 (6.57) viz., Aspirin 40mg/l of distilled water. On the other hand, no roots were formed at 10 DAP in cuttings treated with T_8 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*
T_1	Control (Distilled water)	6.07
T_2	IBA 750 ppm	9.30
T_3	Aspirin (40mg/l of distilled water)	6.57
T_4	IBA 750 ppm + Aspirin (40mg/l of distilled water)	15.10
T_5	Diluted alcoholic leaf extract of *Ipomoea aquatica*	8.17
T_6	20 % water-soluble garlic cloves extract	9.97
T_7	Gel from *Aloe vera* leaves	10.20
T_8	Diluted alcoholic leaf extract of Ivy gourd	0 (0.707)
	SE (m) $\pm$	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 recorded for all chrysanthemum cuttings as per the treatments 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 at 15 DAP was recorded in cuttings under treatment T_4 (33.93) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water, which was followed by T_7 (33.13) viz., Gel from *Aloe vera* leaves, whereas the lowest number of roots per cutting at 15 DAP was recorded in T_8 (2.23) viz., Diluted alcoholic leaf extract of Ivy gourd and it was followed by T_1 (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 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 at 20 DAP was recorded in T_4 (45.83) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water. This was followed by T_7 (42.13) viz., Gel from *Aloe vera* leaves. The lowest number of roots per cutting at 20 DAP was recorded in T_8 (3.90) viz., Diluted alcoholic leaf extract of Ivy gourd, followed by T_1 (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*
T_1	Control (Distilled water)	7.63
T_2	IBA 750 ppm	14.50
T_3	Aspirin (40mg/l of distilled water)	10.43
T_4	IBA 750 ppm + Aspirin (40mg/l of distilled water)	33.93
T_5	Diluted alcoholic leaf extract of *Ipomoea aquatica*	10.57
T_6	20 % water-soluble garlic cloves extract	30.27
T_7	Gel from *Aloe vera* leaves	33.13
T_8	Diluted alcoholic leaf extract of Ivy gourd	2.23
	SE (m) $\pm$	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*
T_1	Control (Distilled water)	16.07
T_2	IBA 750 ppm	21.73
T_3	Aspirin (40mg/l of distilled water)	18.73
T_4	IBA 750 ppm + Aspirin (40mg/l of distilled water)	45.83
T_5	Diluted alcoholic leaf extract of *Ipomoea aquatica*	21.03
T_6	20 % water-soluble garlic cloves extract	29.00
T_7	Gel from *Aloe vera* leaves	42.13
T_8	Diluted alcoholic leaf extract of Ivy gourd	3.90
	SE (m) $\pm$	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 T_4 (6.17) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water while the minimum number of secondary roots per cutting was obtained in T_8 (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*
T_1	Control (Distilled water)	3.57
T_2	IBA 750 ppm	5.73
T_3	Aspirin (40mg/l of distilled water)	3.67
T_4	IBA 750 ppm + Aspirin (40mg/l of distilled water)	6.17
T_5	Diluted alcoholic leaf extract of *Ipomoea aquatica*	5.23
T_6	20 % water-soluble garlic cloves extract	5.93
T_7	Gel from *Aloe vera* leaves	6.10
T_8	Diluted alcoholic leaf extract of Ivy gourd	2.13
	SE (m) $\pm$	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*
T_1	Control (Distilled water)	4.20
T_2	IBA 750 ppm	7.67
T_3	Aspirin (40mg/l of distilled water)	6.50
T_4	IBA 750 ppm + Aspirin (40mg/l of distilled water)	9.15
T_5	Diluted alcoholic leaf extract of *Ipomoea aquatica*	6.53
T_6	20 % water-soluble garlic cloves extract	7.87
T_7	Gel from *Aloe vera* leaves	8.77
T_8	Diluted alcoholic leaf extract of Ivy gourd	0 (0.707)
	SE (m) $\pm$	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 (mm) at 10 DAP was obtained in T_4 (9.15 mm) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water and it was followed by T_7 (8.77 mm) viz., Gel from *Aloe vera* leaves and T_6 (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 T_1 (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 T_8 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 (mm) at 15 DAP was recorded in T_4 (19.58 mm) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water, followed by T_7 (16.87 mm) viz., Gel from *Aloe vera* leaves and T_6 (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 T_8 (5.8 mm) viz., Diluted alcoholic leaf extract of Ivy gourd, followed by T_1 (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 (mm) at 20 DAP was recorded in T_4 (28.90 mm) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water, which was followed by T_7 (26.43 mm) viz., Gel from *Aloe vera* leaves and T_6 (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 T_8 (11.03 mm) viz., Diluted alcoholic leaf extract of Ivy gourd, followed by T_1 (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*
T_1	Control (Distilled water)	8.52
T_2	IBA 750 ppm	14.15
T_3	Aspirin (40mg/l of distilled water)	10.50
T_4	IBA 750 ppm + Aspirin (40mg/l of distilled water)	19.58
T_5	Diluted alcoholic leaf extract of *Ipomoea aquatica*	13.05
T_6	20 % water-soluble garlic cloves extract	14.47
T_7	Gel from *Aloe vera* leaves	16.87
T_8	Diluted alcoholic leaf extract of Ivy gourd	5.80
	SE (m) $\pm$	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*
T_1	Control (Distilled water)	12.55
T_2	IBA 750 ppm	22.57
T_3	Aspirin (40mg/l of distilled water)	15.03
T_4	IBA 750 ppm + Aspirin (40mg/l of distilled water)	28.90
T_5	Diluted alcoholic leaf extract of *Ipomoea aquatica*	21.73
T_6	20 % water-soluble garlic cloves extract	26.13
T_7	Gel from *Aloe vera* leaves	26.43
T_8	Diluted alcoholic leaf extract of Ivy gourd	11.03
	SE (m) $\pm$	1.409
	CD (5 %)	2.98

* Significant at 5%

4.10. Fresh weight of roots per cutting (gm) 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 T_4 (0.23 gm) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water, which was followed by T_7 (0.19 gm) viz., Gel from *Aloe vera* leaves and T_6 (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 T_8 (0.03 gm) viz., Diluted alcoholic leaf extract of Ivy gourd, followed by T_1 (0.05) viz., Control.

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

Treatments	Treatment Details	Fresh weight of roots per cutting (gm) at 15 DAP*
T_1	Control (Distilled water)	0.05
T_2	IBA 750 ppm	0.11
T_3	Aspirin (40mg/l of distilled water)	0.07
T_4	IBA 750 ppm + Aspirin (40mg/l of distilled water)	0.23
T_5	Diluted alcoholic leaf extract of *Ipomoea aquatica*	0.12
T_6	20 % water-soluble garlic cloves extract	0.18
T_7	Gel from *Aloe vera* leaves	0.19
T_8	Diluted alcoholic leaf extract of Ivy gourd	0.03
	SE (m) $\pm$	0.0026
	CD (5 %)	0.005

* Significant at 5%

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

Fresh weight of roots per cutting (gm) at 20 DAP recorded for all chrysanthemum cuttings as per the treatments has been presented in Table 13. The data in the Table 4.11 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 T_4 (0.34 gm) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water, which was followed by T_7 (0.19 gm) viz., Gel from *Aloe vera* leaves and T_6 (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 T_8 (0.07 gm) viz., Diluted alcoholic leaf extract of Ivy gourd, and is followed by T_1 (0.12) viz., Control.

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

Treatments	Treatment Details	Fresh weight of roots per cutting (gm) at 20 DAP*
T_1	Control (Distilled water)	0.12
T_2	IBA 750 ppm	0.19
T_3	Aspirin (40mg/l of distilled water)	0.14
T_4	IBA 750 ppm + Aspirin (40mg/l of distilled water)	0.34
T_5	Diluted alcoholic leaf extract of *Ipomoea aquatica*	0.20
T_6	20 % water-soluble garlic cloves extract	0.22
T_7	Gel from *Aloe vera* leaves	0.24
T_8	Diluted alcoholic leaf extract of Ivy gourd	0.07
	SE (m) $\pm$	0.0031
	CD (5 %)	0.006

* Significant at 5%

4.12. Number of senescenced leaves per cutting at 10 DAP

Number of senescenced 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 number of senescenced leaves per cutting at 10 DAP. The maximum leaf senescence at 10 DAP was found in cuttings of T_8 (0.97) viz., Diluted alcoholic leaf extract of Ivy gourd. This was significantly followed by T_1 (0.63) viz., Control. While the minimum leaf senescence at 10 DAP was recorded in T_4 (0.33) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water, which was equally followed by T_7 (0.43) viz., Gel from *Aloe vera* leaves and T_6 (0.43) viz., 20 % water-soluble garlic cloves extract.

4.13. Number of senescenced leaves per cutting at 20 DAP

Number of senescenced 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 number of senescenced leaves per cutting at 20 DAP. The maximum leaf

senescence at 20 DAP was recorded in cuttings treated with T_8 (0.17) viz., Diluted alcoholic leaf extract of Ivy gourd, followed by T_1 (0.13) viz., Control. While the minimum leaf senescence at 20 DAP was recorded in T_4 (0.03) viz., IBA 750 ppm + Aspirin 40mg/l of distilled water, which was equally followed by T_7 (0.10) viz., Gel from *Aloe vera* leaves and T_6 (0.10) viz., 20 % water-soluble garlic cloves extract.

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

Treatments	Treatment Details	Number of senescenced leaves per cutting at 10 DAP*
T_1	Control (Distilled water dip)	0.63
T_2	IBA 750 ppm	0.60
T_3	Aspirin (40mg/l of distilled water)	0.57
T_4	IBA 750 ppm + Aspirin (40mg/l of distilled water)	0.33
T_5	Diluted alcoholic leaf extracts of *Ipomoea aquatica*	0.50
T_6	20 % water-soluble garlic cloves extract	0.43
T_7	Gel from *Aloe vera* leaves	0.43
T_8	Diluted alcoholic leaf extracts of Ivy gourd	0.97
	SE (m) $\pm$	0.155
	CD (5 %)	0.32

* Significant at 5%

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

Treatments	Treatment Details	Number of senescenced leaves per cutting at 20 DAP
T_1	Control (Distilled water dip)	0.13 (0.78)
T_2	IBA 750 ppm	0.13 (0.78)
T_3	Aspirin (40mg/l of distilled water)	0.10
T_4	IBA 750 ppm + Aspirin (40mg/l of distilled water)	0.03 (0.72)
T_5	Diluted alcoholic leaf extracts of *Ipomoea aquatica*	0.10
T_6	20 % water-soluble garlic cloves extract	0.10 (0.76)
T_7	Gel from *Aloe vera* leaves	0.10
T_8	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 (%)
T_1	Control (Distilled water)	80
T_2	IBA 750 ppm	90
T_3	Aspirin (40mg/l of distilled water)	83.33
T_4	IBA 750 ppm + Aspirin (40mg/l of distilled water)	96.67
T_5	Diluted alcoholic leaf extract of *Ipomoea aquatica*	93.31
T_6	20 % water-soluble garlic cloves extract	89.6
T_7	Gel from *Aloe vera* leaves	93.33
T_8	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 T_4 (IBA 750 ppm + Aspirin 40mg/l of distilled water showed the highest rooting percentage with 96.67 %. This was closely followed by T_7 (Gel from *Aloe vera* leaves) with 93.33 %. While the cuttings under T_8 (Diluted alcoholic leaf extracts of Ivy gourd) recorded the lowest rooting percentage with 70 %.

Fig. 3 – Callus formation in cuttings

Fig. 4 – Secondary roots formation in T_4 cuttings

Fig. 5 – Rooted cuttings respectively from T_1 to T_8

DISCUSSION

The experimental results of the present research work entitled "Effect of IBA, Aspirin and Natural plant extracts on Rooting of Chrysanthemum (*Dendranthema grandiflora* L.) cv. Flirt" presented in the preceding chapter revealed some useful information, which are discussed briefly in this chapter with proper supporting of scientific facts and the earlier research findings considering their research significance for future study and practical utility.

5.1. 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 the 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 then dedifferentiates towards formation of adventitious roots in cuttings taken from plants. Further callus differentiation occurs depending upon the auxin concentration in the wounded site as well as on polarity of auxins. 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 T_8 (Diluted alcoholic leaf extract of Ivy gourd) while the least number of days for callus formation in cuttings (2.40) was seen in T_4 (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 collaborated with Sardoei *et al*. (2014) in Poinsettia.

5.2. 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 pro-trays. The least number of days taken by a treatment for rooting than other treatments shows 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 when treated with T_4 (IBA 750 ppm + Aspirin 40mg/l of distilled water). The rooting in cuttings taken from plants is directly dependent on 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 T_4 (IBA 750 ppm + Aspirin 40mg/l of distilled water) as compared to T_2 (IBA 750 ppm) and 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 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 T_4, the cuttings treated with T_7 (Gel from *Aloe vera* leaves) also took minimum number of days for root formation, i.e. 6.99. *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.

5.3. 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 T_4 (IBA 750 ppm + Aspirin 40mg/l of distilled water) at 10, 15 and 20 DAP with 15.10, 33.93 and 45.83 respectively. This was followed by the treatment of T_7 (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 vera* 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 T_6 (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 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 enhanced 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 T_8 (Diluted alcoholic leaf extract of Ivy gourd) had 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.

5.4. 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) was in T_4 (IBA 750 ppm + Aspirin 40mg/l of distilled water). This was followed by T_7 (Gel from *Aloe vera* leaves) and T_6 (20 % water-soluble garlic cloves extract) i.e., 6.10 and 5.93 respectively. This trend may be due to the fact that early rooting in T_4 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 T_4, 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.

5.5. 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 T_4 (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 the 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, T_7 (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 T_6 (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 grapes. 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.

5.6. 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 T_4 (IBA 750 ppm + Aspirin 40mg/l of distilled water) i.e., 0.23 gm and 0.34 gm respectively. This was closely followed by T_7 (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 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 signify 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, T_4 and T_7 provided better opportunity to the cuttings for survival and further growth.

5.7. 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 senescenced 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 T_8 (Diluted alcoholic leaf extract 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 T_4 (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 defence 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, T_6 (20 % water-soluble garlic cloves extract) and treated cuttings also showed minimum leaf senescence at both 10 DAP and 20 DAP (0.43 and 0.10 respectively), which is very significantly close to the T_4 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 T_7 (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 T_6 (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.

5.8. 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 T_4 (IBA 750 ppm + Aspirin 40mg/l of distilled water) with 96.67 %, followed by the treatment of T_7 (Gel from *Aloe vera* leaves) where 93.33 % rooting was recorded in cuttings of chrysanthemum. While the lowest rooting percentage was recorded in T_8 (Diluted alcoholic leaf extract of Ivy gourd) and T_1 (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 honey suckle cuttings, resulting in highest root percentage than other treatments, as mentioned in the findings of Fathi M *et al.* (2018).

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).

SUMMARY AND CONCLUSION

The present investigation entitled "Effect of IBA, Aspirin and Natural plant extracts on Rooting of Chrysanthemum (*Dendranthema grandiflora* L.) cv. Flirt" was carried out under the polyhouse of the Department of Floriculture and Landscaping located in the premises of College of Agriculture, O.U.A.T., Bhubaneswar with the following objectives:

1. To study the effect of IBA on rooting of cuttings of Chrysanthemum.
2. To study the effect of Aspirin on rooting of cuttings of Chrysanthemum.
3. To study the effect of Natural plant extract on rooting of cuttings of Chrysanthemum.

The experiment was laid out in Completely Randomized Design (CRD). The research work was carried out with 8 treatments and each treatment had 3 replications. Each replication had 10 number of cuttings. So, a total of 240 number of cuttings were taken for the research. The 8 treatments consisted of Control (Distilled water), IBA 750 ppm, Aspirin (40mg/L of distilled water), IBA 750 ppm + Aspirin 40mg/L of distilled water, Diluted alcoholic leaf extract of *Ipomoea aquatica*, 20 % water soluble garlic cloves extract, Gel from *Aloe vera* leaves and Diluted alcoholic leaf extract of Ivy gourd.

The important findings from the present investigation are summarized below:

Effect of different treatments on number of days to callus formation per cuttings

- No significant difference was observed among the treatments with respect to number of days taken for callus formation.
- Maximum number of days to callus formation in cuttings (2.77) was recorded in T_8 (Diluted alcoholic leaf extract of Ivy gourd) while minimum number of days for callus formation in cuttings (2.40) was seen in T_4 (IBA 750 ppm + Aspirin 40mg/l of distilled water).
- T_2 (IBA 750 ppm) and T_5 (Diluted alcoholic leaf extract of *Ipomoea aquatica*) recorded same number of days for callusing, i.e., 2.50. Similarly, T_6 (20 % water-soluble garlic cloves extract) and T_7 (Gel from *Aloe vera* leaves) also took same number of days for callusing i.e., 2.47.

Effect of different treatments on number of days for root initiation in cuttings

- Significant difference was observed among the treatments with respect to number of days for root initiation.

- Least number of days for root initiation (6.83) days was observed in cuttings treated with T_4 (IBA 750 ppm + Aspirin 40mg/l of distilled water), followed by T_7 (Gel from *Aloe vera* leaves) with 6.99.
- Highest number of days for root initiation (14.97 days) was seen in T_8 (Diluted alcoholic leaf extract of Ivy gourd).

Effect of different treatments on number of roots per cutting at 10, 15 and 20 DAP

- Significant difference was observed among the treatments with respect to number of roots per cutting at 10, 15 and 20 DAP.
- Maximum number of roots per cutting was found in T_4 (IBA 750 ppm + Aspirin 40mg/l of distilled water) at 10, 15 and 20 DAP with 15.10, 33.93 and 45.83 respectively. This was followed by T_7 (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.
- No roots were formed at 10 DAP in cuttings of T_8 (Diluted alcoholic leaf extract of Ivy gourd). But at 15 and 20 DAP, 2.23 and 3.90 number of roots per cutting were obtained respectively, which was the minimum among all the treatments.

Effect of different treatments on number of secondary roots per cutting at 20 DAP

- Significant difference was observed among the treatments with respect to number of secondary roots per cutting at 20 DAP.
- Maximum number of secondary roots per cutting at 20 DAP (6.17) was obtained in T_4 (IBA 750 ppm + Aspirin 40mg/l of distilled water), followed by T_7 (Gel from *Aloe vera* leaves) and T_6 (20 % water-soluble garlic cloves extract) with 6.10 and 5.93 respectively.
- Minimum number of secondary roots per cutting was obtained in T_8 (Diluted alcoholic leaf extract of Ivy gourd) with 2.13.

Effect of different treatments on length of longest root per cutting at 10, 15 and 20 DAP

- Significant difference was observed among the treatments with respect to length of longest root per cutting at 10, 15 and 20 DAP.
- Maximum length of the longest root per cutting was recorded in T_4 (IBA 750 ppm + Aspirin 40mg/l of distilled water) at 10, 15 and 20 DAP with 9.15 mm, 19.58 mm and 28.90 mm respectively. This was closely followed by T_7 (Gel from *Aloe vera* leaves) with 8.77 mm, 16.87 mm and 26.43 mm long roots respectively at 10, 15 and 20 DAP.
- Minimum length of the longest root per cutting at 15 and 20 DAP was recorded in T_8 (Diluted alcoholic leaf extract of Ivy gourd) with 5.8 mm and 11.03 mm respectively.

Effect of different treatments on fresh weight of roots per cutting at 15 and 20 DAP

- Significant difference was observed among the treatments with respect to fresh weight of roots per cutting at 15 and 20 DAP.
- Highest fresh weight of roots per cutting at 15 and 20 DAP was seen in T_4 (IBA 750 ppm + Aspirin 40mg/l of distilled water) i.e. 0.23 gm and 0.34 gm respectively. This was closely followed by T_7 (Gel from *Aloe vera* leaves) with 0.19 gm and 0.24 gm at 15 and 20 DAP respectively.
- Lowest fresh weight of roots per cutting at 15 and 20 DAP was seen in T_8 (Diluted alcoholic leaf extract of Ivy gourd) with 0.03 gm and 0.07 gm respectively.

Effect of different treatments on number of senescenced leaves per cutting at 10 and 20 DAP

- Significant difference was observed among the treatments with respect to number of senescenced leaves per cutting at 10 DAP, while there was no such difference among the treatments at 20 DAP.
- Maximum number of leaf senescence (0.97 and 0.17) was recorded in T_8 (Diluted alcoholic leaf extract of Ivy gourd) at both 10 and 20 DAP respectively.
- Minimum number of leaf senescence (0.33 and 0.03) was seen in T_4 (IBA 750 ppm + Aspirin 40mg/l of distilled water) at both 10 and 20 DAP respectively.

Effect of different treatments on rooting percentage of cuttings

- The terminal cuttings of chrysanthemum subjected to different treatments showed significant effect on rooting percentage of cuttings.
- Maximum rooting percentage was recorded in T_4 (IBA 750 ppm + Aspirin 40mg/l of distilled water) with 96.67 % followed by T_7 (Gel from *Aloe vera* leaves) with 93.33 % rooting.
- Minimum rooting percentage was obtained in T_8 (Diluted alcoholic leaf extract of Ivy gourd) and T_1 (Control), 70 % and 80 % respectively.

CONCLUSION

From the research study, it was observed that there was significant effect among the treatments. T_4 (IBA 750 ppm + Aspirin 40mg/l of distilled water) proved to be the best treatment for rooting in cuttings, followed by T_7 (Gel from *Aloe vera* leaves) and T_6 (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 T_7 and T_6), least number of days for root initiation

with 6.83 days (7.20 in control, 6.99 in T_7, 7.02 in T_6), highest number of roots per cutting at 10 DAP with 15.10 (6.07 in control, 10.20 in T_7, 9.97 in T_6), at 15 DAP with 33.93 (7.63 in control, 33.13 in T_7, 30.27 in T_6), at 20 DAP with 45.83 (16.07 in control, 42.13 in T_7, 29.00 in T_6), highest number of secondary roots per cutting at 20 DAP with 6.17 (3.57 in control, 6.10 in T_7, 5.93 in T_6), maximum length of longest root per cutting at 10 DAP with 9.15 mm (4.20 mm in control, 8.77 mm in T_7, 7.87 mm in T_6), 19.58 mm at 15 DAP (8.52 mm in control, 16.87 mm in T_7, 14.47 mm in T_6), 28.90 mm at 20 DAP (12.55 mm in control, 26.43 mm in T_7, 26.13 mm in T_6), maximum fresh weight of roots per cutting with 0.23 gm at 15 DAP (0.05 gm in control, 0.19 gm in T_7, 0.18 gm in T_6), 0.34 gm at 20 DAP (0.12 gm in control, 0.24 gm in T_7, 0.22 gm in T_6), lowest number of senescenced leaves per cutting with 0.33 at 10 DAP (0.63 in control, 0.43 in both T_7 and T_6), 0.03 at 20 DAP (0.13 in control, 0.10 in T_3, T_5, T_6, T_7) and highest rooting percentage in cuttings with 96.67 % (80 % in control, 93.33 % in T_7, 93.31 % in T_5).

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 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 floricultural and other horticultural crops aiming in organic crop production and creating many opportunities for further research work in future.

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