EFFECT OF MEDIA AND NUTRIENTS ON THE GROWTH AND FLOWERING OF HYDRANGEA (*Hydrangea macrophylla* Thunb.Ser.)

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A

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(Floriculture and Landscaping)

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CERTIFICATE – I

This is to certify that the thesis entitled **"EFFECT OF MEDIA AND NUTRIENTS ON THE GROWTH AND FLOWERING OF HYDRANGEA** (***Hydrangea macrophylla*** **Thunb Ser*).*"** submitted in partial fulfilment of the requirements for the award of the degree of **MASTER OF SCIENCE IN AGRICULTURE(FLORICULTURE AND LANDSCAPING)** of the Orissa University of Agriculture and Technology, Bhubaneswar is a faithful record of *bona fide* and original research work carried out by **TEPPALA PAVANI Adm.no.11FLS/16** under my guidance and supervision. No part of this thesis has been submitted for the award of 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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Chairman
Advisory committee

CERTIFICATE – II

This is to certify that the thesis entitled "**EFFECT OF MEDIA AND NUTRIENTS ON THE GROWTH AND FLOWERING OF HYDRANGEA (*Hydrangea macrophylla* Tunb Ser).**" submitted by **TEPPALA PAVANI, Adm.no. 11FLS/16** to the Orissa University of Agriculture and Technology, Bhubaneswar in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE (FLORICULTURE AND LANDSCAPING)** has been approved by the students' advisory committee and the external examiner.

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ABBREVIATIONS AND SYMBOLS

v/v	volume by volume
N	Nitrogen
P	Phosphorus
K	Potassium
$Al_2 (SO_4)_3$	Aluminium sulphate
FYM	Farm Yard manure
%	Percentage
/	per
@	At the rate
^0C	Degree centigrade
cm	Centimetre
cv.	Cultivar
DAF	Days after first fertilizer application
EC	Electrical conductivity
eg.	Example
et al	And others
etc.	And so on
F-CRD	Factorial completely randomized design
gm	Gram
mm	Millimetre
MOP	Muriate of potash
P^H	measure of acidity or alkalinity of solution
SE(m)±	standard error mean
SPAD	soil plant analysis development
sq.cm	Square centimetre
SSP	Single super phosphate
viz	Videlicet (namely)

ABSTRACT

An investigation entitled “Effect of media and nutrients on the growth and flowering of Hydrangea (*Hydrangea macrophylla* Thunb. Ser.)” was conducted in the Department of Floriculture and Landscaping, College of Agriculture, Orissa University of Agriculture and Technology,Bhubaneswar during the year 2017-18 with the objectives-(i) To study the effect of nutrients and growing media on growth parameters of Hydrangea (ii) To study the flowering in Hydrangea as influenced by the growing media and nutrients (iii)To study the change in colour of flower heads in Hydrangea as influenced by nutrients specifically by the application of aluminium sulphate.

One year old *Hydrangea macrophylla* plants were grown in 25cm size clay pots under 75% agro shade net by using two types of media viz. soil+FYM+coco peat @ 1:1:1 v/v (M_1) and soil+FYM+coco peat @ 2:1:1 v/v (M_2) and with two levels of nutrients mixture viz. NPK @1:1:1(N_1) and NPK @ 2:1:1(N_2) applied at 30,60 and 90 days of potting. Aluminium sulphate at three levels viz. A_1 (0gm/plant), A_2 (4gm/plant) and A_3 (6gm/plant) was applied to the plants at 30,60 and 90 days of potting. There were 12 treatments with 3 replications and the experiment was laid out in factorial CRD. The materials and methods were followed as per standard procedure. The biometric observations were recorded at 30,60 and 90 days of potting w.r.t plant height, number of branches/plant, number of leaves/plant,number of sprouts/plant, stem girth, days taken for flower head appearance, days to first floret opening, days to full bloom, diameter of flower head and number of florets/flower head. The leaf area and chlorophyll content of 3rd leaf at flowering were also recorded.

The results obtained indicated that the vegetative characters recorded maximum values with M_2 x N_2 viz. plant height (55.74cm), number of branches/plant(16.00) and number of sprouts/plant (18.02) whereas number of leaves/plant(57.78) was recorded for M_1 x N_2 and the stem girth was highest (3.53cm) with M_1 x N_1 at 90 days of potting. As regards to the floral characters, the earliest flowering (97.00 DAF), shortest time for full bloom (11.33 days), largest diameter of flower head (17.04cm), more number of florets/flower head (53.48) was recorded in M_1 x N_1 whereas minimum number of days taken for first floret opening (5.17 days) was observed in N_2 x A_3.From the investigation it was observed that aluminium sulphate had no significant effect on vegetative and floral parameters especially change in colour of flower heads except influencing earlier first floret opening in the flower head. Thus, it was concluded that a potting mixture consisting of soil:FYM:coco peat (1:1:1 v/v) and nutrients (NPK@1:1:1) is best for pot culture of *Hydrangea macrophylla* .

CHAPTER 1

INTRODUCTION

INTRODUCTION

Next to trees, shrubs play a great role in enhancing beauty of a garden. Like trees they also have permanent characteristics but they can be converted to different shapes and sizes foe which shrubs are chosen for topiary work. Both deciduous and evergreen shrubs are grown in garden but flowering shrubs are very attractive when they are planted on roadside or around the lawn, many people grow flowering shrubs in large gardens and foliage shrubs in small gardens. Hydrangeas are considered the "Queen" of flowering shrubs. They are native to North and South America, Himalayas, Central and eastern Asia (Dirr, 2004). Although many hydrangeas are popular in temperate climate but they are also well distributed in many sub-tropical countries. The Hydrangea genus contains about 70-75 species of various flowering plants (Jones and Reeds, 2006). Most of the species are shrubs, some are small trees, while others are of climbing variety (Bailey, 1998). It is a beautiful, perennial bush with huge flower heads. These bushes profusely produce huge, round flower heads which have two kind of florets. The sterile or ray florets are male and form the large, colourful sepals on the outside of the flower head. The fertile florets bear the male and female parts and are usually found in the centre of the cluster (Mojahed *et al*., 1969). Hydrangeas normally grow at medium to high altitudes. At high elevations the shrubs grow very large and at medium elevations they are grown in pots. Hydrangeas are normally pruned after flowering to produce new growth that in turn produce flowers. They are easy to grow in well-drained soil in a sheltered position preferably in areas which receive plenty of morning sun. Normally hydrangeas bloom from spring to rainy season.

Hydrangea macrophylla (Thunb.Ser.) is a species of Hydrangea and it is the only species which is widely cultivated in many parts of the world in many climates (Jessica, 2008). Common name includes Big leaf Hydrangea, French Hydrangea, Penny Mac and Hortensia (Adkins and Dirr, 2003). The other species are *Hydrangea appuloides* and *Hydrangea hortensis*. All these species can be grown in medium elevations but are best in hill stations and places having cool climate like Kashmir valley, Kalimpong, Darjeeling, Himachal Pradesh, Shillong and hilly areas of Uttarakhand and Sikkim. At medium elevations they can be grown in 30 cm pots, their root system quickly fill up the pots and require free supply of water. Liquid manures can be applied frequently for good result since flower blooms are very large. Normally these flower heads are removed when they turn green. Suckers of Hydrangea need to be removed and utilized for obtaining new plants.

The colour of hydrangeas will vary considerably due to the pH of the soil they are growing in (Tilt, 2008). Kikelly (2006) reported that the blue hues are best in acid soil and the degree of blueness is controlled by the amount of available aluminium and the capacity of a particular variety to draw it up. The red and pinks enjoy an alkaline or neutral soil where aluminium is not actively absorbed. The whites stay white but usually enjoy the same conditions as the reds and pinks. Bailey (1992) found that to encourage "bluing" of the flowers the acidity level of soil should be between 5.5-6.0 on the pH scale. To initiate colour change from pink to blue, aluminium sulphate has to be applied several times at intervals till the desired colour is attained.

The sepals of Hydrangea possess an anthocyanin pigment that becomes blue upon reacting with aluminium. So, unless enough aluminium is present to react with all the anthocyanin completely, an intermediate colour will be produced instead of the desired clear blue colour. The colour of the sepals of hydrangea can also be influenced by the amount of N supplied to the plants (Link and Shanks, 1952). Low concentration of N produced a mauve colour whereas medium to high concentration of N produced intense pink colour.

India has the potential for growing good quality Hydrangea. At flowering Hydrangea are extraordinarily beautiful with large ball of florets. The flower head remains in good condition for 2-3 months and then turn to green. Hydrangea can also be used as a cut flower. In cut flower trade New Zealand is a major exporter of Hydrangea. Major importers are Japan (70%), the U.S.A (5%), the Netherlands (5%), Hong Kong (2%) and Taiwan (2%).

The present research project has been designed to grow Hydrangea under Bhubaneswar conditions which has not been reported earlier. However, there are reports that in Odisha hydrangea are grown in Pottangi and Sunabeda. It has been found that *Hydrangea macrophylla* can be grown in winter in Bhubaneswar conditions. However, under Bhubaneswar condition no work has been done in this crop regarding growing media and nutritional aspects. Therefore, several aspects are to be investigated namely, suitability of growing media and requirement of nutrients for successful growth and flowering in *Hydrangea macrophylla*. Water management is very important in growing hydrangeas. The crop is very sensitive to low moisture content in soil. The soil mixture need to have more moisture. FYM and cocopeat are easily available material to maintain water holding capacity in soil. Keeping in view these facts, the research project "Effect of media and nutrients on the growth and flowering of Hydrangea (*Hydrangea macrophylla* Thunb.Ser.)" was conducted at the Department of Floriculture and Landscaping,

College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar with the following objectives:

i. To study the effect of nutrients and growing media on growth parameters of Hydrangea.
ii. To study the flowering in Hydrangea as influenced by the growing media and nutrients.
iii. To study the change in colour of flower heads in Hydrangea as influenced by nutrients specifically by the application of Aluminium sulphate.

CHAPTER 2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

EFFECT OF MEDIA ON GROWTH AND FLOWERING

Hydrangea

Dilta *et al.* (2015) investigated the influence of various growing media and daminozide application on growth, flowering and pot presentability in *Hydrangea macrophylla* (Thunb) and reported that hydrangea plants be grown in growing medium comprising of rai forest soil + FYM + vermicompost (2:1:1, v/v) and sprayed with 5000 ppm dose of daminozide for producing most desirable and presentable potted hydrangea.

Other Crops

Waber *et al*. (1996) studied the growth of *Lilium longiflorum* var. 'Nellie white' plants in 40:0:20:40, 0:40:20:40, 0:57:14:28, 0:73:9:18 (v/v) Sphagnum peat: Coir dust :Loam: Perlite substrates .They observed that as proportion of the coir in the substrate increased height, root and shoot fresh weight increased .However, nodes to flower ,days to flower and number of flowers were not significantly affected by substrates.

Reshma (2002) conducted an experiment on the performance of two cultivars of chrysanthemum namely Snow ball and Glance in different growing media like leaf mould ,municipal solid waste (MSW) ,sawdust and soil + sand + FYM (1:1:1,v/v) sole or in all possible combinations .The findings revealed that among different growing media ,tallest plants with maximum number of longest side shoots and leaf number were obtained in leaf mould + MSW which also resulted in maximum plant spread in case of Snow ball (1239.0 cm^2). On the other hand maximum plant spread in cultivar Glance (1115 cm^2) was observed in MSW .Leaf mould + MSW +control were found close to leaf mould + MSW , resulting earliest flowering in both the cultivars. However, largest flowers of Snowball (11.76 cm^2) and Glance (6.63 cm^2) were recorded when MSW + leaf mould +control(1:1:1, v/v)and leaf mould, respectively were used as growing media. MSW+ leaf mould+ saw dust in case of Snowball (27.87 days)and leaf mould in cultivar Glance (22.87 days) resulted in

maximum duration of flowering .Pot presentability of both cultivars was also maximum when grown in leaf mould + MSW.

Singh (2002) conducted a study to standardize the growing media for the bulblet production in Lilium hybrids and their growth .Out of the four growing media, scales planted in vermiculite performed best in both the cultivars of Asiatic lily var. Sancerre and Oriental lily var. Stargazer. Outer scales planted in vermiculite resulted in maximum for all the characters under study. For growth of bulblets, coco peat was better as compared to soil mixture (Sand: Soil: FYM,1:1:1v/v).

Dhananjaya *et al.* (2003) carried out an experiment to assess the influence of different substrates, their chemical reaction, and nutrient reaction and nutrient status on growth of *Anthurium andreanum* var. Singapore hybrid particularly on important morphological characters. Among the four substrates evaluated in combination with varying levels of FYM, soil and sand, it was found that more number of suckers (6.1/plant) and early flower initiation (188.15 days after planting) were observed in the media of coffee cherry husk :FYM: Soil and Sand in the ratio of 2:1:1:1 respectively .This study found coffee cherry husk as an efficient alternate substrate for anthurium cultivation.

Dien (2003) evaluated different substrates such as coco peat, saw dust ,coco peat +saw dust (1:1,v/v), coco peat + saw dust + soil (1:1:1,v/v),coco peat+ sawdust + sand (1:1:1,v/v),sand+ soil + FYM (1:1:1,v/v) in cut gerbera production .With this aim the materials were used either alone or mixed with each other and the effect of the growing media on flower yield and the quality of Gerbera var. Gerbera No.1 were investigated .Looking upon the effect of growing media in general coco peat + sand + saw dust (1:1:1,v/v)was found to be the best with respect to days required for bud initiation (75days),flower diameter (9.47cm),flower stalk length(35.31cm),flower weight (15.3g/flower) ,number of flowers per plant (29.55 flower /plant),number of flowers per m^2 (21 flowers/m^2) and vase life (13.4days) of flowers.

Gupta *et al.* (2004) standardized growing media under protected environment for gerbera in mid hills of Himachal Pradesh and found that coco peat + saw dust + sand (1:1:1, v/v) was best with respect to number of days required for bud initiation (75.0), flower diameter (9.47 cm), flower stalk length (35.31cm), number of flowers per plant (29.55), number of flowers/ m^2 (210.0)and vase life (13.35days) of flowers.

Merhaut *et al.*(2005) revaluated the effects of four types of media viz. Coir and coco peat at 1:1 v/v, peat and sandy loam soil (1:2) on plant growth in the

production of Oriental lilies (*Lilium* sp.) 'Star fighter' and 'Casa Blanca'. Results indicated that the use of coir and peat did not significantly influence the plant growth (shoot dry weight) as compared to the use of sandy loam soil.

Thakur (2005) carried out an experiment on influence of growing media on growth and flowering of rose and recorded and studied all the combination of three soil based growing media namely ,Soil :FYM : Sand (G_1), soil: FYM: saw dust (G_2) and soil: FYM: sawdust (G_3) mixed each in 2:1:1(v/v).Study revealed that rose plants grown in a medium containing soil+ FYM+ saw dust resulted in maximum plant height (75.74cm) ,bud length (2.79cm),flower size (9.03cm),leaf area (87.02 m^2) ,earlier flower bud appearance and bud appearance to harvesting (14.13 days)

Singh *et al*. (2009) conducted an experiment to standardize the potting media for Anthurium var. Flame grown under protected conditions. The treatments were prepared by volumetric ratios of basic media viz. rice husk (2), sawdust (2), coco peat (2), soil (1), sand (1), FYM (1), brick pieces (1) and wooden charcoal (1). Results indicated that the combinations of growing media significantly influenced the vegetative growth, flowering pattern and flower production of Anthurium .The overall best performance was recorded in media composed of saw dust + brick pieces + wooden charcoal +soil + sand + FYM in the ratio of 2:1:1:1:1:1.

Basheer and Thekkayam (2012) carried out an investigation on the influence of various media treatments. Sand + coir pith compost was found to produce the maximum plant height (41.66cm) ,leaf area (574.48cm^2) and petiole length at the fourth week after emergence (16.29cm)and shortest phyllachron (39.94 days).in Anthurium

Kameswari *et al.* (2014) conducted an experiment for three consecutive years to study the suitability of different potting media for growing Chrysanthimum variety 'Punjab Anuradha'. Significant differential responses was observed among the treatments with respect to growth and floral characters. The result associated with plant growth parameters indicated maximum values for plant height, plant spread, number of branches per plant, duration of flowering ,flower weight, spray length and number of flowers per plant in the media containing Cocopeat +Sand+ FYM + Vermicompost. The maximum flower diameter, however, was found in T_3(Soil + Sand+FYM+ Vermicompost (2:1:0.5:0.5), where soil was replaced with coco peat in the above combination .Chemical analysis of the soil indicated that T_3 (Soil+ Sand

+FYM+ Vermicompost) was found to be superior over T_7 (Coco peat + Sand + FYM + Vermicompost) in terms of nutrient content. But with high pH & EC, this treatment showed next best results afterT_7.

Gupta and Dilta (2015) carried out an investigation to study the influence of seven growing substrates viz., Soil, FYM, Sand, Ban Oak , Leaf mould, spent mushroom compost, Coco peat on *Primula malacoides* Franch. The growing substrate comprising Coco peat: FYM : Sand(1:1:1,v/v), recorded the maximum values in terms of plant height ,plant spread, number of inflorescences per plant ,number of flowers per plant ,duration of flowering and highest pot present ability score .

Dilta *et al.* (2016) investigated the influence of various growing media and paclobutrazol on growth , flowering and pot presentability of Geranium and reported that geranium plants can be raised in growing medium comprising of rai soil+ FYM + Vermicompost (2:1:1, v/v) for producing the maximum number of shoots per plant (6.71), plant spread (24.27cm),number of flowers per inflorescence diameter(8.74cm), number of inflorescence per plant(14.10) and maximum number of inflorescence opened at a time (9.67).

EFFECT OF NITROGEN, PHOSPHORUS AND POTASSIUM ON GROWTH AND FLOWERING

Hydrangea

Shanks *et al.* (1950) carried out studies on the mineral nutrition of *Hydrangea cv. Gertrude Glatin* at Maryland Agricultural experiment station, Maryland. In this experiment, they used twelve fertilizer treatments. The treatments were based on three levels of N, P, K. The lowest or 1st level of each element was that which was present in the soil. The medium or 2nd level of each element was applied by fertilizing the soil with a solution of 7gm/gallon of sodium-di-hydrogen phosphate and 3-5 gm of potassium chloride. The high or 3rd level of each element was supplied by doubling the concentration of the fertilizer solutions used for the medium level. They found that plants with low nitrogen treatments had characteristically light and yellow green leaves while plants receiving high nitrogen treatments had very dark green leaves. The length of the stem of the current season growth was influenced almost exclusively by the level of nitrogen. The diameter of the inflorescence likewise was also influenced most by the nitrogen levels with several exceptions.

Link & Shanks (1952) also reported that growing plants of Hydrangea have a high demand for nutrients, especially nitrogen. However, on the contrary, Bailey (1989) reported that in florist hydrangea, excessive fertilization during the vegetative stage of production though resulted in vigorous growth but led to reduction in plant quality.

Asen *et al. (*1958) found that plants supplied with high concentrations of N and P during the summer had slightly redder sepals than similar plants supplied with low concentrations of these elements during this period. The slightly redder sepals due to high concentrations of available N and P during the summer and were attributed to the decreased absorption and accumulation of Al. Similar and more pronounced effects on colour resulted from applications of N and P during forcing. Variations in the concentrations of available K during the summer had a much more pronounced effect on sepal colour than variations in the concentrations of available N or P.

Bi *et al*. (2008) ascertained the effect of rate of nitrogen fertigation during vegetative growth and spray application of urea in the fall on growth and flowering of florist's hydrangea cv. 'Merritt's Supreme' and concluded that both vegetative growth and flowering parameters during forcing were influenced by both the nitrogen status before forcing and nitrogen supply during forcing. In this experiment, they observed that plants grown with 210 and 280 mg/l N during 2005 had the more growth (total plant biomass, height), flowering(number of flowers, flower size) and leaf quality (leaf area, chlorophyll content) than the forcing in 2006.

Bi and Scagel (2008) fertigated plants of hydrangea cv. Berlin with different rates of nitrogen from July to September in 2007 and spraying of leaves with 'N' labelled urea in late October to ascertain urea uptake and nitrogen translocation by hydrangea leaves in relation to nitrogen status. They reported that the hydrangea plants with lower nitrogen status in the fall absorbed and trans located nitrogen more efficiently from foliar urea than the plants with higher nitrogen status.

Thaneshwari (2014) carried out a study to investigate the influence of nitrogen (5 doses) and potassium (4 doses) along with a constant dose of phosphorous @30 g/m^2 on growth, flowering, cut flower yield and quality of hydrangea. She

reported that fertilization of hydrangea plants be carried out with NPK @80:30:50 g per meter square for obtaining better growth, flowering and yield of hydrangea cut flowers.

Other Crops

Natarajan *et al.* (1981**)** conducted the experiment on application of N and K each at 240 g per plant per year at bimonthly intervals was best for flower yield in *Jasminum sambac.*

Bhattacharjee (1981) reported that application of different levels of N, P and K increased flower spike length in gladiolus. The increased level of N advanced the time of flowering and greatly increased the flower spike length. The maximum number of flower per spike and largest flowers were obtained with 20g N m^{-2}.The application of P and K at higher levels improved the quality of flowers in gladiolus cv. Friendship.

Shah *et al*.(1984) conducted studies on effect of different levels of N and P on growth of gladiolus var. Vink's glory .They revealed that plants growing on 60/60 cm plots received N: P_2O_5 : K_2O at 12-24-12g/plot and by increasing N rates plant growth was augmented and number of leaves/plant increased.

Bankar (1988) reported that N improved vegetative growth, flowering and bulb production in Tuberose cv. 'Double'in the first year. P and K increased spike number, rachis length and duration of flowering only in the second year (the ratoon crop). The optimum fertilizer application rate was determined as 15 g N + 40 g P_2O_5 + 40 g K_2O/m^2.

Gowda *et al*.(1991) studied the effect of NPK on vegetative growth of Tuberose cv.' Double'. The experiment was tried with each of the nutrients at three different doses (viz,. N at 100,150 and 200 kg/ha, P_2O_5 at 50,75,and 100 kg/ha and K_2O at 100,125 and 150 kg/ha). They noticed that application of N had a significant effect on plant height which increased with increasing levels of N.

Singatkar *et al.* (1995) carried out an experiment at Pune to study the effect of different levels of N, P and K on growth and flower production of Gaillardia cv. Yellow Double and results indicated that phosphorus (125 kg ha-1) had significant and beneficial effects on size of flower and length of flower stalk over control but keeping quality of flowers was less under higher levels of phosphorus.

Chattopadhyay *et al.* (1995) conducted a nutritional study in Gladiolus cv. Tropic sea at Kalimpong with N (40,50,and 60g/m^2),P(10,20 and 30g/m^2) and K (20g/m^2) in a RBD design with 3 replications. Characters like plant height and spike length were increased with N_{60} P_{10} K_{20} followed by N_{50} P_{10} K_{20} but the former treatment delayed flowering and had lesser spike weight than the later .The number of flowers, size and number of flowers opening at a time in the former treatment were statistically at par with the later but superior to other treatments indicating the suitability of treatment for production of spikes intended for export.

Singh *et al*. (1996) carried out a fertilizer trial for studying the effect of NPK on flowering and flower quality of tuberose (*Polianthes tuberosa*) cv. Single was carried out at Haryana Agricultural University and they concluded that application of high doses of N, P and K delayed spike emergence and considerably prolonged the flowering period and shelf life of florets .Length of spike and rachis increased with increasing doses of N and P fertilizer application.

Grewal *et al*. (2004) carried out investigations on the nutrition of chrysanthemum cv. 'Flirt' under Ludhiana conditions and reported that application of nitrogen @ 40 g per meter square resulted in better growth, development and flowering. They also reported that the plants receiving higher dose of nitrogen took more time for flower bud formation than those receiving less doses of nitrogen.

Guarav *et al*. (2004) under Pune conditions reported the interaction of NPK applied @ 20:20:15g m^{-2} $month^{-1}$ to the gerbera cv. Sunway, the nutritional treatment significantly produced more number of flowers per plant with large flower diameter over other various nutritional levels investigated.

Abou - Dahab and Habib (2005) recorded better growth and flowering when plants of *Barleria cristata* were fertilized with ammonium sulphate @ 4 g per plant.

Qasim *et al*. (2005) studied the effects of nitrogen (0, 20, 30, 40 and 50 g N per plant) applied in two splits, first on 15th March 2003, before the onset of flowering and 60 days after application of first dose, on *Rosa chinensis* cv. 'Gruss-an-Teplitz' to observe the impact of nitrogen on plant growth, flower production and nitrogen contents in leaves at various stages of flowering as a means for achieving

better management, production and ascertaining nitrogen utilization by plants. Number of leaves per plant, leaf area, number of flowers and fresh weight of flowers per plant recorded highest values with the application of 30 g N per plant, whereas leaf N contents were maximum with 20 g N per plant. Moreover, number of leaves per plant, leaf area and leaf N contents were maximum in June whereas number of flowers and fresh weight of flowers per plant was highest in April followed by March as compared to May and June. Nitrogen application @ 30g N per plant in April produced maximum flower yield whereas vegetative growth was maximum with the application of same dose of N in June.

Zubair *et al*. (2006) conducted an experiment at Agricultural Research Farm, Department of Horticulture, NWFP Agricultural University, Peshawar during 2003-05. Eight cultivars of gladiolus namely, 'Deciso', 'Hong Kong', 'Jessica', 'Jester Ruffled', 'Madonna', 'Peters Pears', 'Rose Supreme' and 'White Friendship' were used to study the influence of potassium levels (0, 100 and 200 kg K/ha). They recorded that spike emergence was earlier at100 kg/ha and first floret opening was delayed with an increase in potassium levels. They also recommended gladiolus cvs. 'Rose Supreme' and 'Jessica' especially when fertilized with potassium @ 100 kg/ha for commercial cultivation in Peshawar (Pakistan).

Wang (2007) studied the effect of potassium nutrition on growth and flowering of Phalaenopsis. They found that K concentration increased, flower count and diameter of the flower also increased. Flower stems on plants in either medium became longer and thicker with increasing K concentrations.

Aruna *et al*. (2007) conducted an experiment at the Dept. of Vegetable Crops, Horticultural College and Research Institute, Periyakulam, T.N.A.U. India, to study the effect of N and micronutrients on growth and yield attributing characters in crossandra. The treatment N_4M_4 (*i.e.* application of N @ 180 kg/ha along with foliar spray of ZnSO4 @ 0.5 % + FeSO4@ 1.0 %) recorded highest values for plant height, number of branches, number of leaves, leaf area, number of spikes per plant, number of flowers per spike and flower yield in comparison to control. The increase in flower yield as a consequence of increase in the growth parameters and other yield attributing characters could be due to the application of increased levels of nitrogen and foliar spray of micronutrients.

Ahmad *et al*., (2007) studied the vegetative and floral characteristics of *Zinnia elegans* cv. 'Giant Dahlia Flowered' were studied at the Floriculture Research Farm,

Institute of Horticultural Sciences, University of Agriculture, Faisalabad, during 2002 in response to nitrogen applications (0, 33,67 and 100 kg/ha) under natural agro-climatic conditions of Faisalabad. Maximum growth rate, plant height, number of lateral shoots per plant, size of lateral shoots and leaf area was recorded in plants supplied with 100 kg N per ha. However, leaf N percentage, maximum number of flowers per plant and maximum flower diameter was recorded in those plants which received 67 kg N per ha. Application of nitrogen @ 100 kg/ha significantly delayed flower initiation in comparison to lower doses of nitrogen. Flowers of excellent quality were produced when fertilized with 67 and 100 kg N/ha. Nitrogen application @ 100 kg/ha promoted vegetative growth while moderate dose (67 kg N/ha) improved floral characteristics such as number of flowers per plant and flower diameter along with leaf N content.

Mohit *et al.* (2008) conducted a study during winter seasons of November 2004 to March 2005 to find out the effect of nitrogen and phosphorus doses on the performance of China aster cv.'Poornima' under Western Uttar Pradesh conditions. Three levels of nitrogen (100,200 and 300 kg/ha) and phosphorus (100, 150 and 200 kg/ha) along with a control were tested in Factorial R.B.D. with three replications. Application of nitrogen and phosphorus @300 kg N and 200 kg P, respectively, resulted in the production of tallest plants, maximum number of leaves, branches and flowers, thickest stems, largest size flowers, longest flowering duration, maximum fresh and dry weight of flowers and the highest yield of flowers.

Chavan *et.al.* (2010) conducted an experiment which revealed that application of nitrogen at 300 kg per ha significantly improved the plant growth parameters such as plant height (40.08 cm) and plant spread (31.93 cm) in china aster during Rabi season.

Pal and Ghosh (2010) conducted a field experiment on African marigold at Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal. The characters showed a positive response to different levels of potassium fertilizer application. Yield of flowers increased with increased quantity of potassium fertilizer from 0 to 200 kg/ha. Plant height, both primary and secondary branches, plant spread, flower size, nitrogen, phosphorus, potassium and chlorophyll content of leaf and anthocyanin content in petals were also directly related to potassium levels.

Aladakatti *et al.* (2012) conducted a field experiment in medium black, clayey soil under irrigated conditions to assess the response of stevia to levels of

nitrogen, phosphorus and potassium. Five cuttings (crops) were taken in a year. Pooled results indicated that significantly higher dry leaf yield was obtained with nitrogen @ 400 kg /ha (11.42 t/ha) and it was on par with 300 kg/ha (10.94 t/ha). Phosphorus @ 200 kg/ha recorded significantly highest dry leaf yield (11.14 t/ha) and it was on par with150 kg/ha (10.85 t/ha). Potassium @ 200 kg ha-1 recorded dry leaf yield of 10.78 t/ha and it was comparable with potassium @ 100 kg/ha (10.46 t/ha). The growth parameters *viz.*, plant height, number of branches /plant and number of leaves/plant were significantly higher with nitrogen, phosphorus and potassium @ 400 kg/ ha. Interactions of N, P and K were non-significant. Nutrient level of 300:150:100 kg ha-1.NPK applied in equal splits to five cuttings (crops) in a year and was considered as an economically optimum level of nutrients for stevia.

Khalaj *et al.* (2012) conducted the experiment on impact of nitrogen levels, plant density and their interaction on growth and yield of tuberose (*Polianthes tuberosa* L.) cv. 'Double' at the Mahall National Research Station on Ornamental plants, Iran. They concluded that maximum quality and quantity of flowers was obtained with application of N @ 200 kg/ha.

Khalaj and Edrisi (2012) conducted an experiment to investigate the effect of different levels of nitrogen (0, 50, 100, 150, 200, 250 kg/ha) in the form of ammonium nitrate and different plant spacings (10 x 10cm, 15 x 15cm, 20 x 20cm, 25 x 25cm) on growth and flowering of tuberose. They reported that application of nitrogen @ 200 kg/ha resulted in better growth and yield of tuberose especially when planted at a spacing of 25 × 25 cm apart.

EFFECT OF ALUMINIUM SULPHATE ON FLOWERING

Hydrangea

Asen *et al.* (1963) reported that hydrangea supplied with ammonium nitrogen were reddest and contained least aluminium and effect of nitrogen on sepal colour was due to its influence on the absorption of aluminium.

Guerin and Morel(1998) carried out an experiment for the better understanding of Aluminum resistance and toxicity mechanisms in *Hydrangea* which may contribute to overcome the problems in blueing of flowers and plant quality. To guarantee a blue

color, application of Aluminum is required at the end of the vegetative growth stage (to ensure a pH of 4.3-4.8) and at the beginning of forcing

Blom and Piott (1992) reported that application of Aluminum sulphate @12 and 16 gm/pot is commercially acceptable for blueing in Hydrangea.

Theo *et al.* (1992) observed that Al content was determined in roots, buds, and stems of dormant florists' hydrangeas *[Hydrangea macrophylla* subsp. *macrophylla* var. *macrophylla* (Thunb.)'Mathilda Gutges' and 'Brestenburg'] that were or were not treated in the field with aluminium sulfate. During the greenhouse forcing stage, previously non treated plants were subjected to four successive weekly sub irrigated applications of Aluminium sulphate totaling 4, 8, 12, or 16 g/pot. Applications were early (weeks 2, 3, 4, 5) or late (weeks6, 7, 8, 9), using the start of forcing as week = 0. The Al contents in stems and buds of dormant plants were about five to six times higher in field-treated than in non-treated plants. Roots were the primary location of Al accumulation (>70%). Aluminium sulphate applications of 12 to 16 g/pot during greenhouse forcing provided commercially acceptable blue plants.

Naumann and Horst (2003) determined the Aluminium content in roots, buds, and stems of dormant florists *Hydrangea macrophylla sub sp. macrophylla var. macrophylla (Thunb)Ser.'Mathilda Gutges' and Brestenburg)* that were or were not treated in the field with $Al_2 (SO_4)_3$. During the greenhouse forcing stage, previously non treated plants were subjected to four successive weekly sub irrigated applications of Aluminium sulphate totaling 4,8,12 or 16g/pot .Application time were early weeks (2, 3,4,0) or late weeks (6,7,8,9).The Aluminium contents in stems and buds of dormant plants were about 5 to 6 times higher in field treated than in non-treated plants .Aluminium sulphate applications of 12 to 16g/pot during greenhouse forcing provided commercially acceptable blue plants. There was a positive correlation between blueness ranking and the Aluminium foliar concentration of the two uppermost expanded leaves taken from flowering plants.

Schreiber *et al.* (2011) analysed the red, purple, and blue sepals on selected cultivars of *Hydrangea macrophylla* for their aluminum content. This content was determined to be a function of the sepal color with red sepals possessing 0–10 μg Al/g fresh sepal, purple sepals having 10–40 μg Al/g fresh sepal, and blue sepals containing greater than 40 μg Al/g fresh sepal. Accordingly, the threshold aluminum

content needed to change *H. macrophylla* sepals from red to blue was about 40 μg Al/g fresh sepal. Higher aluminum concentrations were incorporated into the sepals, but this additional aluminum did not affect the intensity or hue of the blue color. These observations agreed with a chemical model proposing that the concentration of the blue Al^{3+}-anthocyanin complex reached a maximum when a sufficient excess of aluminum was present. In addition, the visible absorbance spectra of harvested red, purple, and blue sepals were duplicated by Al^{3+} and anthocyanin (delphinidin-3-glucoside) mixtures in this model chemical system.

CHAPTER 3

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation entitled “Effect of media and nutrients on the growth and flowering of Hydrangea (*Hydrangea macrophylla* Thunb.Ser.)” was carried out in the form of pot experiment in the Department of Floriculture and Landscaping ,College of Agriculture ,OUAT, Bhubaneswar during November 2017 - May2018.The materials used and the techniques adopted during the course of investigation are described in this chapter.

3.1. Geographical location of the experimental site

Bhubaneswar is situated at 63km away west of the Bay of Bengal at an altitude of 25.50 m above mean sea level .Geographically it is located at sub- tropical region with 20^0 15’ North latitude and 85^0 52’East longitude.

3.2. Climate

Bhubaneswar comes under sub- tropical climate .About 85% rainfall occurs from June to September and the rest is received within October to May. The average maximum temperature ranges from 38-42^0 C during May to June while the minimum temperature varies from 15-16^0 C during December to January The relative humidity varies between 50% in winter to 90% in rainy season The details of the weather data during the period of investigation from November 2017 to April 2018 have been shown in Appendix-1 as per the metrological data recorded at the university observatory close to the experimental site .Besides a comparative weather data has been presented in Table -1 for Bhubaneswar, Sunabeda of Odisha and Shillong (Meghalaya) where Hydrangea bloom well .The blooming period of hydrangeas was July-August at high altitude areas like Shillong, whereas early spring at Sunabeda but it was February-May under Bhubaneswar condition.

3.3. Collection of plants

Hydrangea plants were maintained in the Department of Floriculture and Landscaping, College of Agriculture, OUAT, Bhubaneswar prior to the experiment.

Uniform and healthy one year old plants were selected for the pot experiment. Plants having lengthy branches and having adventitious roots were discarded.

3.4. Media used for potting of plants

Two types of media were used for potting of the plants .The media were collected from the Department of Floriculture and Landscaping , College of Agriculture ,OUAT Bhubaneswar. Before filling the media in the pot they were uniformly mixed to avoid clods and other materials .The old soil adhering to plant roots was removed. Clay pots of 25 cm size were filled with media as per the treatments. The pots were filled with two types of media viz. M_1 i.e. Soil+ FYM + Coco peat @ 1:1:1 v/v and M_2 i.e. Soil+ FYM + Coco peat @ 2:1:1v/v. The pots were lightly watered to enable the media to settle down properly. All the pots were kept under 75% agro shade nets .The characteristics of different media has been described in Table-2.

3.5. Planting

Healthy and uniform plants were selected and watered one hour before potting. The plants were lifted carefully with a ball of earth and the adhering old soil was removed and potted in the earthen pots previously filled with requisite media as per the treatments followed by light watering with a rosecane.

3.6. Preparation and application of nutrients

Two types of nutrient mixtures were prepared viz. N_1 by taking one part N, one part of P_2O_5 and one part of K_2O and N_2 by taking two parts of N, one part of P_2O_5 and one part of K_2O. The source of nutrients were Urea, Single super phosphate and Muriate of potash. The quantity of fertilizer was calculated on basis of nutrient contents in the commercial grade. Approximately 500gm of NPK mixture was prepared at a time just before application and 5gm of it was applied to per pot as per the treatments followed by copious watering with a rosecane. Aluminium sulphate was applied at three levels viz. A_1 (0gm), A_2 (4gm) and A_3 (6gm) per pot. The requisite amount of Aluminium sulphate as per the treatments were weighed by balance and applied to the pots one week after fertilizer application.

Table – 1 Weather data per month of Bhubaneswar, Sunabeda, and Shillong (2017)

Months	Temperature (◦C)									Precipitation		
	Average			Minimum			Maximum			Rainfall (mm)		
	BBSR	Sunabeda	Shillong	BBSR	Sunabeda	Shillong	BBSR	Sunabeda	Shillong	BBSR	Sunabeda	Shillong
January	22.1	18.7	10.4	15.7	12.3	4.9	28.6	25.1	15.0	12	7	13
February	24.9	21.2	12.3	18.7	14.5	7.3	31.2	27.9	17.4	25	3	17
March	28.9	24.5	16.4	22.3	17.8	11.2	34.6	31.2	21.6	26	19	70
April	30.8	27	18.9	25.1	20.9	14.4	36.6	33.1	23.5	26	55	180
May	31.7	28.1	19.6	26.5	22.7	15.9	37	33.6	23.4	62	93	403
June	30.6	20.3	20.8	26.2	22.4	17.9	35.1	30.3	23.7	190	107	851
July	28.6	23.2	21.2	25.4	20.6	18.5	31.8	25.8	23.9	353	387	696
August	28.3	22.9	21.1	25.2	20.4	18.2	31.5	25.5	24.1	344	347	480
September	28.6	23.3	20.5	25.1	20.2	17.3	32.1	20.5	23.7	257	239	337
October	27.7	22.7	18.1	23.4	18.7	14.1	32	26.8	22.2	168	131	234
November	24.7	19.8	14.4	19.3	14.2	9.3	30.1	25.4	19.5	38	30	37
December	21.9	18	11.4	15.6	11.7	5.9	28.3	24.4	16.9	4	6	8

3.7. Experiment details

The experiment was conducted to study the effect of media and nutrients on growth and flowering of hydrangea. During the experiment the pots were filled with two types of media i.e. M_1 (Soil + FYM +Coco peat @ 1:1:1 v/v) and M_2 (Soil + FYM +Coco peat @ 2:1:1 v/v) which were treated with two levels of nutrients viz. N_1 (NPK @ 1:1:1) and N_2 (NPK @ 2:1:1) and three levels of aluminium sulphate viz. A_1(0gm), A_2(4gm) and A_3 (6gm) as per the design of the experiment.

3.7.1. Experimental design: Factorial CRD

3.7.2. Number of treatments: 12

3.7.3. Number of replications: 3

3.7.4. Number of plants: 72

T_1= Soil: FYM: Coco peat (1:1:1) +N,P,K (1:1:1)+ $Al_2(SO_4)_3$(0 gm)

T_2= Soil: FYM: Coco peat (1:1:1)+ N,P,K (1:1:1)+ $Al_2(SO_4)_3$(4gm)

T_3= Soil: FYM: Coco peat (1:1:1)+N,P,K (1:1:1) + $Al_2(SO_4)_3$ (6gm)

T_4= Soil: FYM : Coco peat (1:1:1) + N,P,K (2:1:1)+$Al_2(SO_4)_3$ (0gm)

T_5= Soil: FYM: Coco peat (1:1:1) +N,P,K (2:1:1)+ $Al_2(SO_4)_3$ (4gm)

T_6= Soil : FYM : Coco peat (1:1:1) + N,P,K (2:1:1) + $Al_2(SO_4)_3$(6gm)

T_7= Soil : FYM : Coco peat (2:1:1) + N,P,K (1:1:1)+$Al_2(SO_4)_3$(0 gm)

T_8= Soil : FYM : Coco peat (2:1:1) + N,P,K(1:1:1)+$Al_2(SO_4)_3$ (4gm)

T_9= Soil : FYM : Coco peat(2:1:1)+N,P,K(1:1:1) +$Al_2(SO_4)_3$ (6gm)

T_{10}= Soil : FYM : Coco peat(2:1:1) + N,P,K (2:1:1)+ $Al_2(SO_4)_3$ (0gm)

T_{11}= Soil : FYM : Coco peat(2:1:1)+N,P,K(2:1:1) + $Al_2(SO_4)_3$ (4gm)

T_{12}= Soil: FYM : Coco peat(2:1:1,)+N,P,K(2:1:1) +$Al_2(SO4)_3$ (6gm)

3.8. After care

After planting the pots were kept under agro shade net (75%).The pots were arranged in such a way that they received uniform sunlight

3.8.1. Irrigation

Irrigation was given by a rose cane in the morning hours .Watering was provided daily depending upon the moisture content in the media and the season.

Table 2- Characteristics of media

CHARECTERISTICS	SOIL	FYM	COCOPEAT
1.Formation	The result of weathering of different rocks	De composted material derived from cattle waste	Derived from coconut fibre
2. Particle size	0.002-0.05 mm	_	0.5-3mm
3. pH	7.15	7.38	6.45
4. EC	$0.4dsm^{-1}$	$0.46dsm^{-1}$	$0.038dsm^{-1}$
5. Moisture %	2.0%	5.33%	11.73%
6. C:N ratio	25:1	6.4: 1	44.0:1
7. Total N %	188.1	1.30	0.88
13.Total P_2O_5 %	120	0.79	0.30
14.Total K_2O %	327.04	0.36	0.49
15.Total S	0.015	0.024	0.006

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3.8.2 Plant protection

The plants were sprayed with 0.1% solution of SAFAYA(Carbendazim + Mancozeb) at 15 days after planting as a preventive measure against soil borne diseases .Second spraying was done one month after first spraying .Third spraying was done with Blitox 50 Ec .0.1% /lit to prevent the dry rot disease at flowering.

3.8.3 Application of nutrients

The fertilizer mixture and aluminium sulphate was applied to the pots as per the design of the experiment at 30, 60, 90 days of potting followed by watering.

3.8.4. Staking

Staking was necessary to keep plants and flower heads erect and to maintain the shape of the flower head. Staking was provided after flower head emergence with sticks to give support to the plant. The stakes were inserted in the soil and tied with a thread to the plant carefully, without damaging the flower head and florets. The stakes used were greater in length than the plants.

3.8.5. Weeding

Weeding was done in the pots manually and regularly throughout the period of experiment.

3.9. Observational Techniques

3.9.1. Plant height (cm)

The height of the plants were measured by a scale from the base the plant to the top of the plant at 30,60, and 90 days after first fertilizer application, recorded and expressed in cm

3.9.2. Number of branches /plant

Number of branches produced per plant at 30, 60 and 90 days after first fertilizer application were counted and recorded.

3.9.3. Number of leaves / plant

The number of leaves produced per plant at 30, 60 and 90 days after first fertilizer application were counted and recorded.

3.9.4.Number of new sprouts /plant

The number of new sprouts produced /plant was counted at 30, 60 and 90 days after first fertilizer application and recorded

3.9.5. Stem girth (cm)

The diameter of the stem of each plant was measured by using a Vernier callipers and recorded .From the diameter (d) the girth of the individual plants was calculated by using the formula girth or circumference $C = \Pi d$ and expressed in cm.

3.9.6. Leaf area (sq.cm)

The leaf area of 3^{rd} leaf from top of the upper most flower head /plant was recorded by using leaf area meter at flowering and expressed in sq. cm .

3.9.7. Chlorophyll content of leaves (SPAD value)

Chlorophyll content of 3^{rd} leaf from the top of flower head was calculated by using SPAD meter.

3.9.8. Days to first flower head initiation

Days to flower head initiation was calculated the from the time of first fertilizer application to flower head appearance

3.9.9. Days to first floret opening in first flower head

Days to first floret opening was calculated from the time of flower head appearance to the opening of the first floret in the flower head.

3.9.10. Number of florets in first flower head

The number of florets present in the first flower head in the plant was counted and recorded.

3.9.11. Diameter of first flower head (cm)

The diameter of flower head was measured with a scale at the centre of the flower head in both directions from which the average was taken and expressed in cm.

3.9.12. Colour of flower

Colour of the flower heads were observed visually at the time of flowering and any change in their colour was recorded.

3.10. Statistical analysis

Factorial CRD was employed for studying the effect of media and nutrients on growth and flowering of hydrangea with respect to different vegetative and flowering parameters during the investigation to analyse the data.

Mean, standard error, analysis of variance and critical variances were calculated for different characters in the experiment. Significant data for F values were found out from F table.

Standard error mean = $\sqrt{\frac{EMS}{\mathrm{r}}}$

SE (m)± for type of media = $\sqrt{\frac{\mathrm{EMS}}{\mathrm{r}\times\mathrm{nutrients}\times\mathrm{aluminium\ sulphate}}}$

SE (m)± for type of nutrients = $\sqrt{\frac{\mathrm{EMS}}{\mathrm{r}\times\mathrm{media}\times\mathrm{aluminium\ sulphate}}}$

SE (m)± for Aluminium sulphate = $\sqrt{\frac{EMS}{\mathrm{r}\times\mathrm{media}\times\mathrm{nutrients}}}$

Interactions

SE (m)± for type of media × nutrients = $\sqrt{\frac{\mathrm{EMS}}{\mathrm{r}\times\mathrm{aluminium\ sulphate}}}$

SE (m)± for type of media × Aluminium sulphite = $\sqrt{\frac{\mathrm{EMS}}{\mathrm{r}\times\mathrm{nutrients}}}$

SE (m)± for type of nutrients × Aluminium sulphite = $\sqrt{\frac{\text{EMS}}{\text{r}\times\text{media}}}$

C.D. = SE(m) ×$\sqrt{2}$ × ‘t’ value at (0.05) error d.f

SE(m) = Error mean of Square

C.D. = Critical difference

r= Replication

d.f = Degree of freedom

CHAPTER 4

EXPERIMENTAL RESULTS

EXPERIMENTAL RESULTS

The results of the experiment entitled "Effect of media and nutrients on the growth and flowering of Hydrangea (*Hydrangea macrophylla Thunb.Ser.)"* conducted at Department of Floriculture and Landscaping, College of Agriculture, OUAT, Bhubaneswar have been presented in Table-3 to Table-24 covering various characters recorded for their values under different treatments.

4.1. Plant height (cm) at 30 days after first application of fertilizer

The observations on plant height were recorded after 30 DAF and were statistically analysed and presented in Table- 3.

The treatment types of media did not exhibit any significant difference. However, the highest plant height was recorded for M_2 (49.05 cm) followed by M_1 (48.72 cm). Highly significant difference was observed for the different levels of nutrients for the character plant height. The highest plant height was recorded for N_2 (49.37 cm) followed by N_1 (48.41 cm). Application of aluminium sulphate did not exhibit any significant difference among the treatments. The highest plant height was observed for the treatment A_2 (49.05 cm) followed by A_3 (48.94 cm) and A_1 (48.67 cm).

The interaction between media x nutrients was non-significant. However, the highest plant height was observed in the treatment $M_2 \times N_2$ (49.70 cm) followed by $M_1 \times N_2$ (49.03 cm). The lowest plant height were recorded in the treatments M_1N_1 (48.41 cm) and $M_2 \times N_1$ (48.40 cm). Media x $Al_2(SO_4)_3$ interaction was found to be non-significant. However, the highest plant height was recorded for the treatment $M_2 \times A_3$ (49.25 cm) followed by $M_2 \times A_2$ (49.15 cm), $M_1 \times A_2$ (48.95 cm) and $M_2 \times A_1$ (48.75 cm). The lowest plant height was recorded with $M_1 \times A_3$ (48.63 cm) followed by $M_1 \times A_1$ (48.58 cm). The interaction nutrient x $Al_2(SO_4)_3$ was non-significant. The highest plant height was recorded for $N_2 \times A_2$ (49.58 cm) followed by $N_2 \times A_3$ (49.27 cm) and $N_2 \times A_1$ (49.25 cm). The lowest plant height was recorded for the treatment $N_1 \times A_3$ (48.62 cm) followed by $N_1 \times A_2$ (48.5 cm) and $N_1 \times A_1$ (48.08 cm). Media x nutrients x $Al_2(SO_4)_3$ interaction was found to be non-significant. However, the highest plant height was recorded for $M_2 \times N_2 \times A_2$ (49.90 cm) followed by $M_2 \times N_2 \times A_3$ (49.67 cm), $M_2 \times N_2 \times A_1$ (49.53 cm) and $M_1 \times N_2 \times A_2$ (49.27 cm). The lowest plant heights were observed in $M_1 \times N_2 \times A_1$ (48.97 cm), $M_1 \times N_2 \times A_3$ (48.87 cm),

$M_2 \times N_1 \times A_3$ (48.83 cm) and $M_2 \times N_1 \times A_2$ (48.63 cm). The minimum plant height was recorded in the treatment $M_2 \times N_1 \times A_1$ (47.97 cm).

Table3-Effect of media, nutrients and aluminium sulphate on plant height (cm) at 30 DAF

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1(0gm)	A_2(4gm)	A_3(6gm)		
M_1 (1:1:1)	N_1 (1:1:1)	48.20	48.63	48.40	**48.41**	
	N_2 (2:1:1)	48.97	49.27	48.87	**49.03**	
	Mean	**48.58**	**48.95**	**48.63**		**48.72**
M_2 (2:1:1)	N_1 (1:1:1)	47.97	48.40	48.83	**48.40**	
	N_2 (2:1:1)	49.53	49.90	49.67	**49.70**	
	Mean	**48.75**	**49.15**	**49.25**		**49.05**
N_1(1:1:1)		48.08	48.52	48.62		**48.41**
N_2 (2:1:1)		49.25	49.58	49.27		**49.37**
Grand mean		**48.67**	**49.05**	**48.94**		

Effects	**F test**	**SE(m) ±**	**CD at 5%**
Types of Media	NS	0.17	_
Nutrients	**	0.17	0.50
Aluminium sulphate	NS	0.21	_
Interactions			
Media × Nutrients	NS	0.349	_
Media × $Al_2(SO_4)_3$	NS	0.427	_
Nutrients × $Al_2(SO_4)_3$	NS	0.427	_
Media × Nutrients $Al_2(SO_4)_3$	NS	.0.604	_

*= Significant at 5% level ** Significant at 1% level

4.2. Number of branches per plant at 30 days after first application of fertilizer

Observations on number of branches per plant were recorded at 30 DAF and the data so obtained were statistically analysed and presented in Table -4.

From perusal of Table-4 it was found that the data did not show any significant difference for production of number of branches at 30 DAF due to the treatments under types of media. However, the highest number of branches was recorded for M_2 (8.22) followed by M_1 (7.67).The levels of nutrients showed highly significant difference for the character number of branches per plant. The highest number of branches was observed in N_2 (8.67) and the lowest number of branches for N_1 (7.22). $Al_2(SO_4)_3$ treatment did not

show any significant difference at different levels. However, the highest number of branches per plant was recorded for A_2 (8.0) followed by A_1 (7.9) and A_3 (7.9).

Table 4- Effect of media, nutrients and aluminium sulphate on number of branches per plant at 30 DAF

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1(0gm)	A_2(4gm)	A_3(6gm)		
M_1 (1:1:1)	N_1 (1:1:1)	7.00	7.67	7.00	**7.22**	
	N_2 (2:1:1)	8.00	8.00	8.33	**8.11**	
	Mean	**7.50**	**7.83**	**7.67**		**7.67**
M_2 (2:1:1)	N_1 (1:1:1)	7.67	7.00	7.00	**7.22**	
	N_2 (2:1:1)	9.00	9.33	9.33	**9.22**	
	Mean	**8.33**	**8.17**	**8.17**		**8.22**
N_1 (1:1:1)		7.33	7.33	7.00		**7.22**
N_2 (2:1:1)		8.50	8.67	8.83		**8.67**
Grand mean		**7.9**	**8.0**	**7.9**		

Effects	**F test**	**SE(m) ±**	**CD at 5%**
Types of Media	NS	0.22	_
Nutrients	**	0.22	0.64
Aluminium sulphate	NS	0.27	_
Interactions			
Media × Nutrients	NS	0.31	_
Media × $Al_2(SO_4)_3$	NS	0.38	_
Nutrients × $Al_2(SO_4)_3$	NS	0.38	_
Media × Nutrients × $Al_2(SO_4)_3$	NS	0.54	_

*= Significant at 5% level ** = Significant at 1% level

The interaction between media and nutrients was found to be non-significant. However, the highest number of branches was recorded in the treatment M_2 x N_2 (9.22) followed by M_1 x N_2 (8.11). The lowest number of branches were recorded in M_1 x N_1 (7.22) and M_2 x N_1 (7.22). There was no significant difference found in the interaction media x $Al_2(SO_4)_3$. The highest number of branches per plant was recorded for M_2 x A_1 (8.33) followed by M_2 x A_2 (8.17) and M_2 x A_3 (8.17). The least number of branches were observed in M_1 x A_2 (7.83) followed by M_1 x A_3 (7.67) and M_1 x A_1 (7.50). The interaction nutrients x $Al_2(SO_4)_3$ was non-significant. However, the highest number of branches per plant were observed in the treatment N_2 x A_3 (8.83) followed by N_2 x A_2 (8.67) and N_2 x A_1 (8.50). The lowest number of branches per plant were recorded in N_1A_1 (7.33) and N_2A_2 (7.33) followed by N_1 x A_3 (7.00). Media x nutrients x $Al_2(SO_4)_3$ interactions were found to be non-significant. The highest number of branches per plant were recorded in the

treatments M_2 x N_2 x A_2 (9.33) and M_2 x N_2 x A_3 (9.33) followed by M_2 x N_2 x A_1 (9.00). The lowest number of branches per plant were recorded in the treatments M_1 x N_1 x A_2 (7.67), M_2 x N_1 x A_1 (7.67) followed by M_1 x N_1 x A_1, M_1 x N_1 x A_3, M_2 x N_1 x A_2 and M_2 x N_1 x A_3 (7.00)

4.3. Number of leaves per plant at 30 days after first application of fertilizer

Observations on the number of leaves per plant were recorded at 30 DAF and data so obtained were statistically analysed and presented in Table- 5.

From the Table-5, it was found that the data showed no significant difference for production of leaves at 30 days due to treatments under types of media. The number of leaves per plant were found to be highest in M_2 (47.78) followed by M_1 (47.28). There was highly significant difference due to levels of nutrients among the different treatments. The highest number of leaves per plant were recorded in N_2 (49.72) and the lowest in N_1 (45.33). $Al_2(SO_4)_3$ did not exhibit any significant difference at different levels. However, the highest number of leaves per plant were recorded for A_2 (47.75) followed by A_1 (47.58) and the lowest was observed for A_3 (47.25).Media x nutrients interaction exhibited no significant difference. However, the highest number of leaves per plant were produced in M_2 x N_2 (49.78) followed by M_1 x N_2 (49.67). The lowest number of leaves were produced with M_2 x N_1 (45.78) followed by M_1 x N_1 (44.89). No significant difference was found in media x $Al_2(SO_4)_3$ interactions. However, the highest number of leaves per plant were produced in M_2 x A_1 (48.33) followed by M_1 x A_2 (48.00). The lowest number of leaves per plant were produced by M_2 x A_2 (47.50) and M_2 x A_3 (47.50) followed by M_1 x A_3 (47.00).

The interaction M_1 x A_1 recorded the lowest number of leaves per plant (46.83). The interaction nutrients x $Al_2(SO_4)_3$ exhibited no significant difference. However, the highest number of leaves per plant were produced by N_2 x A_1 (50.00) followed by N_2 x A_2 (49.67) and N_2 x A_3 (49.50). No significant difference was observed for media x nutrients x $Al_2(SO_4)_3$interaction. However, the highest number of leaves were produced by M_2 X N_2 x A_1 (51.00) followed by M_1 x N_2 x A_2 (50.33) and M_1 x N_2 x A_3 (49.67). The lowest number of leaves per plant was produced under M_1 x N_1 x A_3 (44.33).

Table-5 Effect of media, nutrients and aluminium sulphate on the number of leaves per plant at 30 DAF

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1(0gm)	A_2(4gm)	A_3(6gm)		
M_1 (1:1:1)	N_1(1:1:1)	44.67	45.67	44.33	**44.89**	
	N_2 (2:1:1)	49.00	50.33	49.67	**49.67**	
	Mean	**46.83**	**48.00**	**47.00**		**47.28**
M_2 (2:1:1)	N_1(1:1:1)	45.67	46.00	45.67	**45.78**	
	N_2 (2:1:1)	51.00	49.00	49.33	**49.78**	
	Mean	**48.33**	**47.50**	**47.50**		**47.78**
N_1 (1:1:1)		45.17	45.83	45.00		**45.33**
N_2 (2:1:1)		50.00	49.67	49.50		**49.72**
Grand mean		**47.58**	**47.75**	**47.25**		

Effects	**F test**	**SE(m) ±**	**CD at 5%**
Types of Media	NS	0.52	-
Nutrients	**	0.52	1.51
Aluminium sulphate	NS	0.64	-
Interactions			
Media × Nutrients	NS	0.74	-
Media × $Al_2(SO_4)_3$	NS	0.90	-
Nutrients × $Al_2(SO_4)_3$	NS	0.90	-
Media × Nutrients × $Al_2(SO_4)_3$	NS	1.28	-

* = Significant at 5% level. ** = Significant level at 1% level.

4.4. Stem girth (cm) of the plants at 30 days after first application of fertilizer

Observations on the stem girth of plants (cm) were recorded at 30 DAF and data so obtained were statistically analysed and presented in Table-6.

From perusal of data presented in Table-6 it was found that there was no significant difference for girth of the stems at 30 days due to treatments under types of media. However, the highest stem girth was observed in M_1 (2.95 cm) followed by M_2 (2.62 cm). There was no significant difference among the treatments for different levels of nutrients. The highest stem girth was produced by N_1 (2.93 cm) followed by N_2 (2.63 cm). Levels of $Al_2(SO_4)_3$ exhibited no significant difference at different levels. The highest stem girth was produced by A_3 (2.92 cm) followed by A_2 (2.75 cm) and A_1 (2.68 cm).

Table -6 Effects of media, nutrients and aluminium sulphate on stem girth (cm) at 30 DAF

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1(0gm)	A_2(4gm)	A_3(6gm)		
M_1 (1:1:1)	N_1(1:1:1)	3.10	2.90	3.03	**3.01**	
	N_2 (2:1:1)	2.73	2.97	2.97	**2.89**	
	Mean	**2.92**	**2.93**	**3.00**		**2.95**
M_2 (2:1:1)	N_1 (1:1:1)	2.57	2.83	3.17	**2.86**	
	N_2 (2:1:1)	2.33	2.30	2.50	**2.38**	
	Mean	**2.45**	**2.57**	**2.83**		**2.62**
N_1 (1:1:1)		2.83	2.87	3.10		**2.93**
N_2 (2:1:1)		2.53	2.63	2.73		**2.63**
Grand mean		**2.68**	**2.75**	**2.92**		

Effects	**F test**	**SE(m) ±**	**CD at 5%**
Types of Media	NS	0.17	_
Nutrients	NS	0.17	_
Aluminium sulphate	NS	0.21	_
Interactions			
Media × Nutrients	NS	0.24	_
Media × $Al_2(SO_4)_3$	NS	0.29	_
Nutrients × $Al_2(SO_4)_3$	NS	0.29	_
Media× Nutrients× $Al_2(SO_4)_3$	NS	0.41	_

* = Significant at 5% level. ** = Significant level at 1% level.

Media x nutrients interaction exhibited no significant difference. However, the highest stem girth was recorded in M_1 x N_1 (3.01 cm) and the lowest was recorded for M_2 x N_2 (2.38 cm). Media x $Al_2(SO_4)_3$ interactions were found to be non-significant. However, the highest girth of stem was produced by M_1 x A_3 (3.00 cm) followed by M_1 x A_2 (2.93 cm) and M_1 x A_1 (2.92 cm). The lowest stem girth was observed in M_2 x A_1 (2.45 cm). There was no significant difference with nutrient x $Al_2(SO_4)_3$ interaction. The highest stem girth was produced by N_1 x A_3 (3.10 cm) followed by N_1 x A_2 (2.87 cm). The lowest stem girth was observed for N_2 x A_1 (2.53 cm). Media x nutrients x $Al_2(SO_4)_3$ interaction exhibited no significant difference. However, the greatest stem girth was produced by M_2 x N_1 x A_1 (3.17 cm) followed by M_1 x N_1 x

A_1 (3.10 cm). The smallest stem girth was recorded for the treatment M_2 x N_2 x A_1 (2.33 cm) followed by M_2 x N_2 x A_2 (2.30 cm).

4.5. Number of sprouts per plant at 30 after first application of fertilizer

Observations on the number of sprouts/plant were recorded at 30 DAF and data so, obtained were statistically analysed and presented inTable-7.

Table 7- Effect of media, nutrients and aluminium sulphate on the number of sprouts per plant at 30 DAF

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1(0gm)	A_2(4gm)	A_3(6gm)		
M_1 (1:1:1)	N_1 (1:1:1)	9.10	9.67	8.87	**9.21**	
	N_2 (2:1:1)	10.17	9.97	10.53	**10.22**	
	Mean	**9.63**	**9.82**	**9.70**		**9.72**
M_2 (2:1:1)	N $(1:1:1)_1$	9.83	8.87	8.83	**9.18**	
	N_2(2:1:1)	11.33	11.90	11.90	**11.71**	
	Mean	**10.58**	**10.38**	**11.22**		**10.44**
N_1(1:1:1)		9.47	9.27	8.85		**9.19**
N_2(2:1:1)		10.75	10.93	11.22		**10.97**
Grand mean		**10.11**	**10.10**	**10.03**		

Effects	**F test**	**SE(m) ±**	**CD at 5%**
Types of Media	NS	0.27	-
Nutrients	**	0.27	0.80
Aluminium sulphate	NS	0.34	-
Interactions			
Media × Nutrients	NS	0.39	- _
Media × Al $_2(SO_4)_3$	NS	0.48	_
Nutrients × Al $_2(SO_4)_3$	NS	0.48	_
Media×Nutrients×$Al_2(SO_4)_3$	NS	0.67	_

* = Significant at 5% level. ** = Significant level at 1% level.

From the perusal of data in Table-7 it was found that there was no-significant difference for production of sprouts/plant at 30 days due to treatments under types of media.M_2produced highest number of sprouts/plant (10.44) whereas the lowest number of sprouts/plant were produced by M_1 (9.72). Level of nutrients exhibited

highly significant difference for sprouts production at 30 days. The highest number of sprouts were produced by the level of nutrients N_2 (10.97) followed by N_1 (9.19). Levels of $Al_2 (SO_4)_3$ exhibited no significant difference among the treatments. However, the highest number of sprouts were produced by A_1 (10.11) and the lowest number of sprouts in A_3 (10.03).

Media × nutrient interaction was found to be non-significant .The highest number of sprouts were produced by the treatment $M_2 \times N_2$ (11.71) and the lowest number of sprouts by$M_2 \times N_1$ (9.18) No significant difference was exhibited by media × $Al_2 (SO_4)_3$ interaction. However, the highest number of sprouts was produced by $M_2 \times A_3$ (11.22) followed by $M_2 \times A_1$ (10.58). The lowest number of sprouts were produced by $M_1 \times A_1$ (9.63).Nutrients × $Al_2 (SO_4)_3$ interaction exhibited no significant difference. The highest number of sprouts were produced by $N_2 \times A_3$ (11.22) whereas the lowest number of sprouts were produced by $N_1 \times A_3$ (8.85).There was no significant difference in the interaction media × nutrient × $Al_2 (SO_4)_3$.However, the highest number of sprouts was produced by $M_2 \times N_2 \times A_2$ and $M_2 \times N_2 \times A_3$ (11.90) .The lowest number of sprouts was produced by $M_2 \times N_1 \times A_3$ (8.83).

4.6. Height of the plants (cm) at 60 days after first application of fertilizer

Observations on the height of plant were recorded at 60 DAF and data so obtained were statistically analysed and presented inTable-8.

From the perusal of data in Table-8 it was found that the types of media showed highly significant difference for height of the plants. M_2 produced the highest plant height (52.75cm) followed by M_1 (51.47cm).Highly significant difference was also found among levels of nutrients. The highest plant height was produced by N_2 (53.21cm) followed by N_1 (51.28cm).The different levels of $Al_2 (SO_4)_3$ did not exhibit significant difference among them. However, the highest plant height was produced by A_3 (52.50cm) followed by A_2 (52.32cm).The lowest plant height was produced by A_1 (51.92cm).

Media × nutrient exhibited highly significant difference .The highest plant height was produced by $M_2 \times N_2$ (54.19cm) followed by $M_1 \times N_2$ (52.23cm).The lowest plant height was produced by $M_1 \times N_2$ (51.31cm) and $M_1 \times N_1$ (51.26cm) which were at par with each other .The interaction media × $Al_2 (SO_4)_3$ exhibited no significant difference .However, the highest plant height was produced by $M_2 \times A_3$

(53.02cm) followed by $M_2 \times A_2$ (52.88cm) .The lowest plant height was produced by $M_1 \times A_1$ (51.50cm).No significant difference was observed for nutrients × $Al_2(SO_4)_3$ interaction .However, the highest plant height was produced by $N_2 \times A_3$ (57.37cm)followed by $N_2 \times A_2$ (53.25cm) and $N_2 \times A_1$ (53.02cm).The lowest plant height was produced by $N_1 \times A_1$ (50.83cm).Non significant difference was observed for the interaction media × nutrient × $Al_2(SO_4)_3$. However, the highest height of plants was produced by $M_2 \times N_2 \times A_3$ (54.40cm) followed by $M_2 \times N_2 \times A_2$ (54.37cm) .The lowest plant height was produced for $M_1 \times N_1 \times A_1$ (50.77cm).

Table 8 -Effect of media, nutrients and aluminium sulphate on height of plants (cm) at 60 DAF

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1 (0gm)	A_2 (4gm)	A_3 (6gm)		
M_1 (1:1:1)	N_1 (1:1:1)	50.77	51.37	51.63	**51.26**	
	N_2 (2:1:1)	52.23	52.13	52.33	**52.23**	
	Mean	**51.50**	**51.75**	**51.98**		**51.47**
M_2 (2:1:1)	N $(1:1:1)_1$	50.90	51.40	51.63	**51.31**	
	N_2 (2:1:1)	53.80	54.37	54.40	**54.19**	
	Mean	**52.35**	**52.88**	**53.02**		**52.75**
N_1 (1:1:1)		50.83	51.38	51.63		**51.28**
N_2(2:1:1)		53.02	53.25	53.37		**53.21**
Grand mean		**51.92**	**52.32**	**52.50**		

Effects	**F test**	**SE(M)$^{\pm}$**	**CD at 5%**
Types of Media	**	0.18	0.53
Nutrients	**	0.18	0.53
Aluminium sulphate	NS	0.22	_
Interactions			
Media × Nutrients	**	0.26	0.74
Media × $Al_2(SO_4)_3$	NS	0.32	_
Nutrients × $Al_2(SO_4)_3$	NS	0.32	_
Media× Nutrients× $Al_2(SO_4)_3$	NS	0.45	_

* = Significant at 5% level. ** = Significant level at 1% level

4.7. Number of branches per plant at 60 days after first application of fertilizer

Observations on number of branches per plant were recorded at 60 DAF and data so obtained were statistically analysed and presented in Table -9

From the perusal of Table -9 it was found that the data showed no significant difference for production for number of branches at 60 DAF due to treatments under types of media .However, the highest plant height was produced by M_2 (11.78)followed by M_1 (11.11).Highly significant difference was observed for the level of nutrients. Highest number of branches was produced by N_2 (13.11) followed by N_1(9.78) .No significant difference was observed for different levels of $Al_2(SO_4)_3$ .However, the highest number of branches was produced by A_2 (11.58) followed by A_1 (11.42)and A_3 (11.33). The interaction media × nutrient exhibited no significant difference. The highest number of branches were produced by $M_2 \times N_2$ (13.67) followed by $M_1 \times N_2$ (12.56).The lowest number of branches were produced by $M_2 \times N_1$ (9.89) followed by $M_1 \times N_1$ (9.67).

Table 9 Effect of media, nutrients and aluminium sulphate on number of branches per plant at 60 DAF

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1 (0gm)	A_2 (4gm)	A_3(6gm)		
M_1 (1:1:1)	N_1 (1:1:1)	9.67	10.33	9.00	**9.67**	
	N_2 (2:1:1)	12.00	12.67	13.00	**12.56**	
	Mean	**10.83**	**11.50**	**11.00**		**11.11**
M_2 (2:1:1)	N_1 (1:1:1)	10.33	9.67	9.67	**9.89**	
	N_2 (2:1:1)	13.67	13.67	13.67	**13.67**	
	Mean	**12.00**	**11.67**	**11.67**		**11.78**
N_1 (1:1:1)		10.00	10.00	9.33		**9.78**
N_2 (2:1:1)		12.83	13.17	13.33		**13.11**
Grand mean		**11.42**	**11.58**	**11.33**		

Effects	**F test**	**SE(m) ±**	**CD at 5%**
Types of Media	NS	0.29	_
Nutrients	**	0.29	0.84
Aluminium sulphate	NS	0.35	_
Interactions			
Media × Nutrients	NS	0.41	_
Media × $Al_2(SO_4)_3$	NS	0.50	_
Nutrients × $Al_2(SO_4)_3$	NS	0.50	_
Media ×Nutrients × $Al_2(SO_4)_3$	NS	0.71	_

* = Significant at 5% level. ** = Significant level at 1% level.

Media × $Al_2(SO_4)_3$. interaction exhibited no significant difference However, the highest number of branches were produced by $M_2 \times A_1$ (12.00) followed by $M_2 \times$

A_2 and $M_2 \times A_3$ (11.67).The lowest number of branches was produced by $M_1 \times A_2$ (10.83) . Nutrients × $Al_2(SO_4)_3$ interaction was found to be non significant. However, the highest number of branches were produced by $N_2 \times A_3$ (13.33) followed by $N_2 \times A_2$ (13.17) and $N_2 \times A_1$ (12.83) .The lowest number of branches was produced by $N_1 \times A_3$ (9.33).No significant difference was observed for the interaction media × nutrient × $Al_2(SO_4)_3$.However, the highest number of branches were produced by $M_2 \times N_2 \times A_1$, $M_2 \times N_2 \times A_2$ and $M_2 \times N_2 \times A_3$ (13.67). The lowest number of branches was produced by $M_1 \times N_2 \times A_1$ (9.67) followed by $M_1 \times N_1 \times A_3$ (9.00)

4.8. Number of leaves per plant at 60 days after first application of fertilizer

Observations on number of leaves per plant were recorded at 60 DAF and the data so, obtain were statistically analysed and presented in Table-10.

From the perusal of data presented in Table -10 it was found that types of media showed no significant difference for production of leaves at 60 DAF. However, the highest number of leaves were produced by M_1 (53.20) followed by M_2 (52.37).Highly significant difference was exhibited for production of leaves at 60 days due to levels of nutrients .The highest number of leaves were produced for N_2 (54.35) followed by N_1 (51.22).The levels of $Al_2(SO_4)_3$ exhibited no significant difference among the treatments. However, the highest number of leaves were produced by A_2 (52.88) followed by A_1 (52.83) and A_3 (52.64).

Media × nutrient interaction exhibited significant difference. The highest number of leaves were produced by $M_1 \times N_2$ (55.67) followed by $M_2 \times N_2$ (53.03). The lowest number of leaves were produced by $M_2 \times N_1$ (51.70) followed by $M1 \times N_1$ (50.73) which were at par. Media × $Al_2(SO_4)_3$ interaction was found to be non-significant. However, the highest number of leaves were produced by $M_1 \times A_2$ (53.87) followed by $M_1 \times A_3$ (53.23).The lowest number of leaves were produced by $M_1 \times A_2$ (51.88). The interaction nutrients × $Al_2(SO_4)_3$ was found to be non-significant .The highest number of leaves were produced by $N_2 \times A_1$ (54.83) followed by $N_2 \times A_3$ (54.50) and $N_2 \times A_2$ (53.72) .The lowest plant height was produced by $N_1 \times A_3$ (50.78). No significant difference was observed for the interaction media × nutrient × $Al_2(SO_4)_3$.However, the highest number of leaves were produced by $M_1 \times N_2 \times A_3$ (56.33) followed by $M_1 \times N_2 \times A_1$ and $M_1 \times N_2 \times A_2$ (55.33) . The lowest number of leaves were produced by $M_1 \times N_1 \times A_1$ (49.67).

Table-10 Effect of media, nutrients and aluminium sulphate on number of leaves per plant at 60 DAF

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A1(0gm)	A2(4gm)	A3(6gm)		
M_1 (1:1:1)	N_1(1:1:1)	49.67	52.40	50.13	**50.73**	
	N_2(2:1:1)	55.33	55.33	56.33	**55.67**	
	Mean	**52.50**	**53.87**	**53.23**		**53.20**
M_2 (2:1:1)	N $(1:1:1)_1$	52.00	51.67	51.43	**51.70**	
	N_2(2:1:1)	54.33	52.10	52.67	**53.03**	
	Mean	**53.17**	**51.88**	**52.05**		**52.37**
N_1 (1:1:1)		50.83	52.03	50.78		**51.22**
N_2(2:1:1)		54.83	53.72	54.50		**54.35**
Grand mean		**52.83**	**52.88**	**52.64**		

Effects	**F test**	**SE(M)±**	**CD at 5%**
Types of Media	NS	0.60	_
Nutrients	**	0.60	1.74
Aluminium sulphate	NS	0.73	_
Interactions			
Media × Nutrients	*	0.85	2.46
Media × Al $_2(SO_4)_3$	NS	1.04	_
Nutrients × Al $_2(SO_4)_3$	NS	1.04	_
Media×Nutrients×$Al_2(SO_4)_3$	NS	1.47	_

* = Significant at 5% level. ** = Significant level at 1% level.

4.9. Stem girth (cm) of the plant at 60 days after first application of fertilizer

Observations on stem girth (cm) of plant were recorded at 60 DAF and the data so obtained were statistically analysed and presented in Table-11.

From the perusal of Table -11 it was found that the data showed no significant difference for increase in stem girth at 60 DAF due to treatments under types of media .However, the highest stem girth was observed in M_1(3.22cm) followed by M_2 (2.87cm) . The level of nutrients exhibited no significant difference for the character stem girth .The highest stem girth was recorded in N_1(3.23cm)followed by N_2 (2.86cm).No significant difference was observed for different levels of $Al_2 (SO_4)_3$ .However, the highest stem girth was produced by A_3 (3.19cm)followed by A_2(3.19cm) and A_1 (2.97cm)

The interaction of media × nutrient exhibited no significant difference. However, the highest stem girth was produced by $M_1 \times N_1$ (3.32cm) followed by $M_2 \times N_1$ (3.14cm)

and M_1 × N_2 (3.12cm).The lowest stem girth was recorded for M_2 × N_2 (2.60cm).Types of media × $Al_2(SO_4)_3$ interaction . Also exhibited no significant difference .However, the highest stem girth was produced by M_1 × A_3 (3.28cm) followed by M_1 × A_1 (3.20cm) and M_1 × A_2 (3.18cm).The lowest stem girth was observed in M_2 × A_3 (3.10cm)followed by M_2 × A_2 (2.78cm) and M_2 × A_1(2.73cm).The level of nutrients × $Al_2(SO_4)_3$ interaction exhibited no significant difference**.** The highest stem girth was produced by N_1× A_3 (3.42cm) followed by N_1× A_2 (3.17cm) and N_1× A_1 (3.12cm).The lowest plant stem girth was produced by N_2× A_2 (2.80cm). No significant difference was exhibited by type of media × nutrient × $Al_2(SO_4)_3$ interaction. However, the highest stem girth was produced by M_1× N_2× A_3 (3.50cm) followed by M_1×N_2× A_1 (3.37cm).The lowest stem girth was observed in M_2×N_2× A_1 (2.60cm) followed M_2×N_2× A_2 (2.50cm).

Table 11 - Effect of media, nutrients and aluminium sulphate on stem girth (cm) of plants at 60 DAF

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1(0gm)	A_2(4gm)	A_3(6gm)		
M_1 (1:1:1)	N_1(1:1:1)	3.37	3.27	3.33	**3.32**	
	N_2 (2:1:1)	3.03	3.10	3.23	**3.12**	
	Mean	**3.20**	**3.18**	**3.28**		**3.22**
M_2 (2:1:1)	N $(1:1:1)_1$	2.87	3.07	3.50	**3.14**	
	N_2(2:1:1)	2.60	2.50	2.70	**2.60**	
	Mean	**2.73**	**2.78**	**3.10**		**2.87**
N_1 (1:1:1)		3.12	3.17	3.42		**3.23**
N_2 (2:1:1)		2.82	2.80	2.97		**2.86**
Grand mean		**2.97**	**2.98**	**3.19**		

Effects	**F test**	**SE(m)±**	**CD at 5%**
Types of Media	NS	0.17	-
Nutrients	NS	0.17	-
Aluminium sulphate	NS	0.20	-
Interactions			
Media × Nutrients	NS	0.23	-
Media × $Al_2(SO_4)_3$	NS	0.29	-
Nutrients × $Al_2(SO_4)_3$	NS	0.29	-
Media × Nutrients × $Al_2(SO_4)_3$	NS	0.41	_

* = Significant at 5% level. ** = Significant level at 1% level.

4.10. Number of new sprouts per plant at 60 days after first application of fertilizer

Observations on the number of new sprouts per plant were recorded at 60 DAF and data so obtained were statistically analysed and presented in Table -12.

From the perusal of data presented in Table -12 it was found that there was no significant difference for production of new sprouts at 60 days due to treatments under types of media .However, the highest number of new sprouts was produced by M_2 (13.18) followed by M_1 (13.06). Highly significant difference was observed for the treatments under levels of nutrients .The highest number of sprouts was produced by N_2 (15.34) followed by N_1 (11.53). Aluminium sulphate treatments exhibited non-significant difference for production of number of sprouts per plant at 60 days.

Table 12-Effect of media, nutrients and aluminium sulphate on number of sprouts per plant at 60 DAF

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1(0gm)	A_2(4gm)	A_3(6gm)		
M_1 (1:1:1)	N_1(1:1:1)	11.37	12.17	10.77	**11.43**	
	N_2 (2:1:1)	14.07	14.63	15.33	**14.68**	
	Mean	**12.72**	**13.40**	**13.05**		**13.06**
M_2 (2:1:1)	N_1 (1:1:1)	12.20	11.40	11.27	**11.62**	
	N_2 (2:1:1)	16.07	15.93	16.00	**16.00**	
	Mean	**14.13**	**13.67**	**13.63**	_	**13.81**
N_1 (1:1:1)		11.78	11.78	11.02		**11.53**
N_2 (2:1:1)		15.07	15.28	15.67		**15.34**
Grand mean		**13.42**	**13.53**	**13.34**		

Effects	**F test**	**SE(m)±**	**CD at 5%**
Types of Media	NS	0.34	_
Nutrients	**	0.34	0.98
Aluminium sulphate	NS	0.42	_
Interactions			
Media × Nutrients	NS	0.48	_
Media × $Al_2(SO_4)_3$	NS	0.59	_
Nutrients × $Al_2(SO_4)_3$	NS	0.59	_
Media× Nutrients × $Al_2(SO_4)_3$	NS	0.83	_

* = Significant at 5% level. ** = Significant level at 1% level

The highest number of sprouts was produced by A_2 (13.53) followed by A_1 (13.42) and A_3 (13.34)

Types of media × nutrient interaction exhibited no significant difference .However, the highest number of sprouts was produced by $M_2 \times N_2$ (16.00) followed by $M_1 \times N_2$ (14.68) .The lowest number of sprouts was recorded for $M_2 \times N_1$ (11.62) followed by $M_1 \times N_1$ (11.43)No significant difference was observed for types of media × $Al_2 (SO_4)_3$ interaction. .However, the highest number of sprouts was produced by $M_2 \times A_1$ (14.13) followed by $M_2 \times A_2$ (13.67) and $M_2 \times A_3$ (13.63).The lowest number of sprouts was produced by $M_2 \times A_3$ (13.05) followed by $M_1 \times A_1$ (12.72).Levels of nutrients × $Al_2 (SO_4)_3$ interaction exhibited no significant difference. However, the highest number of sprouts was produced by $N_2 \times A_3$ (15.67) followed by $N_2 \times A_2$ (15.28) and $N_2 \times A_1$ (15.07).The lowest number of sprouts were produced by $N_1 \times A_1$ and $N_1 \times A_2$ (11.78) followed by $N_1 \times A_3$ (11.02) . Types of media × nutrient × $Al_2 (SO_4)_3$ interaction was found to be non-significant .The highest number of sprouts was produced by $M_2 \times N_2 \times A_1$ (16.07) followed by $M_2 \times N_2 \times A_3$ (16.00) and $M_2 \times N_2 \times A_2$(15.93).The lowest number of sprouts was produced by $M_1 \times N_1 \times A_1$ (11.37)followed by $M_2 \times N_1 \times A_3$ (11.27) and $M_1 \times N_1 \times A_3$ (10.77).

.4.11. Height of the plants (cm) at 90 days after first application of fertilizer

Observations on height of the plants (cm) were recorded at 90 DAF and data so obtained were statistically analysed and presented in Table-13.

From the Table-13 it was found that the data showed highly significant difference for height of the plants at 90 days due to treatments under types of media .M_2 produced the highest plant height (54.04cm) followed by M_1 (52.74cm). Highly significant difference was also observed for the level of nutrients .The highest plant height was produced by N_2 (54.45cm) followed by N_1 (52.33cm). The levels of $Al_2 (SO_4)_3$ exhibited no significant difference for the character plant height. The maximum height was produced by A_3 (53.69cm) followed by A_2 (53.37cm).The lowest plant height was observed in A_1 (53.11cm).

Types of media × nutrient interaction exhibited highly significant difference .The highest plant height was produced $M_2 \times N_2$ (55.74cm) followed by $M_1 \times N_2$

(53.16cm).The lowest height of plant was produced by $M_2 \times N_1$ (52.33cm) which was par with $M_1 \times N_1$ (52.32cm).

The interaction between media × $Al_2(SO_4)_3$ was found to be non-significant. However, the highest plant height was produced by $M_2 \times A_3$ (54.47cm) followed by $M_2 \times A_2$ (54.05cm) and $M_2 \times A_1$ (53.06cm).The lowest plant height was produced by $M_1 \times A_2$ (52.68cm) followed by $M_1 \times A_1$ (52.62cm).Level of nutrients × $Al_2(SO_4)_3$ exhibited no significance difference among the treatments .However, the maximum height of plants was produced by $N_2 \times A_3$ (54.78cm) followed by $N_2 \times A_2$ (54.35cm) and $N_1 \times A_1$ (52.00cm). Types of media × nutrient × $Al_2(SO_4)_3$ interaction was found to be non-significant .However, the maximum plant height was produced by $M_2 \times N_2 \times A_3$ (56.30cm) followed by $M_2 \times N_2 \times A_2$ (55.73cm) and $M_2 \times N_2 \times A_1$ (55.20cm).The lowest plant height was produced by $M_2 \times N_1 \times A_1$ and $M_1 \times N_1 \times A_1$ (52.00cm).

Table-13 Effect of media, nutrients and aluminium sulphate on the height of plants (cm) at 90 DAF

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1(0gm)	A_2(4gm)	A_3(6gm)		
M_1 (1:1:1)	N_1 (1:1:1)	52.00	52.40	52.57	**52.32**	
	N_2 (2:1:1)	53.23	52.97	53.27	**53.16**	
	Mean	**52.62**	**52.68**	**52.92**		**52.74**
M_2 (2:1:1)	N_1(1:1:1)	52.00	52.37	52.63	**52.33**	
	N_2(2:1:1)	55.20	55.73	56.30	**55.74**	
	Mean	**53.60**	**54.05**	**54.47**		**54.04**
N_1 (1:1:1)		52.00	52.38	52.60		**52.33**
N_2 (2:1:1)		54.22	54.35	54.78		**54.45**
Grand mean		**53.11**	**53.37**	**53.69**		

Effects	**F test**	**SE(m)±**	**CD at 5%**
Types of Media	**	0.19	0.54
Nutrients	**	0.19	0.54
Aluminium sulphate	NS	0.23	_
Interactions			
Media × Nutrients	**	0.27	0.77
Media × $Al_2(SO_4)_3$	NS	0.32	_
Nutrients × $Al_2(SO_4)_3$	NS	0.32	_
Media × Nutrients × $Al_2(SO_4)_3$	NS	0.46	_

* = Significant at 5% level. ** = Significant level at 1% level.

4.12. Number of branches per plant at 90 days after first application of fertilizer

Observations on number of branches per plant were recorded at 90 DAF and data so obtained were statistically analysed and presented in Table-14.

From the perusal of data presented in Table-14 it was found that there was significant difference for production of number of branches at 90 days due to treatments under types of media. The highest number of branches was produced by M_2 (14.17) followed by M_1 (13.17).Highly significant difference was observed for the treatments under level of nutrients. N_2 produced the highest number of branches (15.50) followed by N_1 which produced the lowest number of branches (11.83).No significant difference was found for treatments under levels of $Al_2 (SO_4)_3$ .However, similar number of branches were produced by A_1, A_2 and A_3 (13.67).

Table-14 Effect of media, nutrients and aluminium sulphate on number of branches per plant at 90 DAF

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1(0gm)	A_2(4gm)	A_3(6gm)		
M_1 (1:1:1)	N_1 (1:1:1)	11.33	11.67	11.00	**11.33**	
	N_2 (2:1:1)	14.67	14.67	15.67	**15.00**	
	Mean	**13.00**	**13.17**	**13.33**		**13.17**
M_2 (2:1:1)	N_1 (1:1:1)	12.67	12.33	12.00	**12.33**	
	N_2 (2:1:1)	16.00	16.00	16.00	**16.00**	
	Mean	**14.33**	**14.17**	**14.00**		**14.17**
N_1 (1:1:1)		12.00	12.00	11.50		**11.83**
N_2(2:1:1)		15.33	15.33	15.83		**15.50**
Grand mean		**13.67**	**13.67**	**13.67**		

Effects	**F test**	**SE(M)$^{\pm}$**	**CD at 5%**
Types of Media	*	0.34	0.99
Nutrients	**	0.34	0.99
Aluminium sulphate	NS	0.42	_
Interactions			
Media × Nutrients	NS	0.48	_
Media × $Al_2(SO_4)_3$	NS	0.59	_
Nutrients × $Al_2(SO_4)_3$	NS	0.59	_
Media × Nutrients × $Al_2(SO_4)_3$	NS	0.84	_

* = Significant at 5% level. ** = Significant level at 1% level.

Types of media × nutrient interaction exhibited no significant difference. However, $M_2 \times N_2$ produced highest number of branches (16.00) followed by $M_1 \times N_2$ (15.00) .The minimum number of branches was produced by $M_2 \times N_1$ (12.33) followed by $M_1 \times N_1$ (11.33). No significant difference was observed for types of media × $Al_2(SO_4)_3$ interaction. However, the highest number of branches were produced by $M_2 \times A_1$ (14.33) followed $M_2 \times A_2$ (14.17) and $M_2 \times A_3$ (14.00). $M_1 \times A_2$ produce the lowest number of branches (13.17) followed by $M_1 \times A_1$ (13.00).Level of nutrient × $Al_2(SO_4)_3$ exhibited no significant difference for the treatments. However, the highest number of branches was produced by $N_2 \times A_3$ (15.83) where as the lowest number of branches was produced by $N_1 \times A_3$ (11.50). No significant difference was observed types of media × nutrient × $Al_2(SO_4)_3$ interaction .The highest number of branches was produced by $M_2 \times N_2 \times A_1$, $M_2 \times N_2 \times A_2$ and $M_2 \times N_2 \times A_3$(16.00) .The lowest number of branches was produced by $M_2 \times N_2 \times A_1$ (11.43) followed by $M_2 \times N_2 \times A_3$ (11.00).

4.13. Number of leaves per plant at 90 days after first application of fertilizer

Observations on number of leaves per plant were recorded at 90 DAF and data so obtained were analysed and presented in Table -15.

From the perusal of Table-15 it was found that the data showed non-significant difference for production of number of leaves at 90 days due to treatment under level of media .However, M_2 produced the highest number of leaves (56.00) followed by M_1 (55.89).Significant difference was observed for treatments under level of nutrients. N_2 produced the highest number of leaves (57.11) were as N_1 produced the lowest number of leaves (54.78). No significant difference was exhibited by levels of $Al_2(SO_4)_3$ for the treatments. However, the highest number of leaves were produced byA_2 (56.50) followed by A_1 (56.00) and A_3 produced the lowest number of leaves (55.33). Types of media × nutrient interaction exhibited no significant. The difference in highest number of leaves were produced by $M_1 \times N_2$ (57.78) followed by $M_2 \times N_2$ (56.44) and $M_2 \times N_1$ (55.56).

$M_1 \times N_1$ produce the lowest number of leaves (54.00). No significant difference was observed for types of media × $Al_2(SO_4)_3$ interaction .However, the highest number of leaves were produced by $M_1 \times A_2$ (57.00) followed by $M_2 \times A_1$ (56.33). $N_1 \times A_3$ produced lowest number of leaves (55.00) level of nutrient × Al_2

$(SO_4)_3$ exhibited no significant difference .The highest number of leaves was produced by $N_1\times A_1$ (57.83) followed by $N_2\times A_2$ (57.00).The lowest number of leaves was recorded for $N_1\times A_1$ and $N_1\times A_3$ (54.17).No significant difference was observed for types of media × nutrient × $Al_2(SO_4)_3$ interaction. However, $M_1\times N_2\times A_1$ and $M_1\times N_2\times A_2$ produced the highest number of leaves (58.33) followed by $M_2\times N_2\times A_1$ (57.33). $M_1\times N_1\times A_1$ produced the lowest number of leaves (53.00).

Table-15 Effect of media, nutrients and aluminium sulphate on number of leaves per plant at 90 DAF

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1(0gm)	A_2 (4gm)	A_3(6gm)		
M_1 (1:1:1)	N_1 (1:1:1)	53.00	55.67	53.33	**54.00**	
	N_2 (2:1:1)	58.33	58.33	56.67	**57.78**	
	Mean	**55.67**	**57.00**	**55.00**		**55.89**
M_2 (2:1:1)	N_1 (1:1:1)	55.33	56.33	55.00	**55.56**	
	N_2 (2:1:1)	57.33	55.67	56.33	**56.44**	
	Mean	**56.33**	**56.00**	**55.67**		**56.00**
N_1 (1:1:1)		54.17	56.00	54.17		**54.78**
N_2 (2:1:1)		57.83	57.00	56.50		**57.11**
Grand mean		**56.00**	**56.50**	**55.33**		

Effects	**F test**	**SE(m)±**	**CD at 5%**
Types of Media	NS	0.64	_
Nutrients	*	0.64	1.85
Aluminium sulphate	NS	0.78	_
Interactions			
Media × Nutrients	NS	0.90	_
Media × $Al_2(SO_4)_3$	NS	1.10	_
Nutrients × $Al_2(SO_4)_3$	NS	1.10	_
Media × Nutrients × $Al_2(SO_4)_3$	NS	1.56	_

* = Significant at 5% level. ** = Significant level at 1% level.

4.14. Number of sprouts per plant at 90 days after first application of fertilizer

Observations on number of sprouts per plant were recorded at 90 DAF and data so obtained were statistically analysed and presented in Table-16

From the Table-16 it was found that the data showed non-significant difference for production of number of sprouts at 90 days due to treatments under

levels of media .However, the highest number of sprouts was produced by M_2(16.03) followed by M_1 (14.88).Highly significant difference was exhibited by levels of nutrients for treatments . N_2 produced the highest number of sprouts (17.44) were as N_1 produced the lowest number of sprouts (13.47).No significant difference was observed due to levels of $Al_2(SO_4)_3$. All plants produced same number of sprouts .However, A_3 produced the highest number of sprouts (15.54) followed by A_2 (15.42) and A_1 (15.41).

Table-16 Effect of media, nutrients and aluminium sulphate on number of sprouts per plant at 90 DAF

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1(0gm)	A_2(4gm)	A_3(6gm)		
M_1 (1:1:1)	N_1 (1:1:1)	12.87	13.30	12.53	**12.90**	
	N_2 (2:1:1)	16.33	16.53	17.73	**16.87**	
	Mean	**14.60**	**14.92**	**15.13**		**14.88**
M_2 (2:1:1)	N_1 (1:1:1)	14.50	13.97	13.63	**14.03**	
	N_2 (2:1:1)	17.93	17.87	18.27	**18.02**	
	Mean	**16.22**	**15.92**	**15.95**		**16.03**
N_1 (1:1:1)		13.68	13.63	13.08		**13.47**
N_2 (2:1:1)		17.13	17.20	18.00		**17.44**
Grand mean		**15.41**	**15.42**	**15.54**		

Effects	**F test**	**SE(m)±**	**CD at 5%**
Types of Media	NS	0.40	_
Nutrients	**	0.40	1.16
Aluminium sulphate	NS	0.49	_
Interactions			
Media × Nutrients	NS	0.56	_
Media × Al $_2(SO_4)_3$	NS	0.69	_
Nutrients × Al $_2(SO_4)_3$	NS	0.69	_
Media × Nutrients × $Al_2(SO_4)_3$	NS	. 0.98	

* = Significant at 5% level. ** = Significant level at 1% level.

Types of media × nutrient interaction exhibited no significant difference. $M_2 \times N_2$ produced the highest number of sprouts (18.02) followed by $M_1 \times N_2$ (16.87).The lowest number of sprouts was produced by $M_1 \times N_1$ (12.90). The types of media × $Al_2(SO_4)_3$ interaction was found to be non-significant .However, $M_2 \times A_1$ produced the highest number of sprouts (16.22) followed by $M_2 \times A_3$ (15.95). $M_1 \times A_1$ produced the lowest number of leaves (14.60). There was no significant difference due to level of nutrient × $Al_2(SO_4)_3$ interaction. However $N_2 \times A_3$ produce the highest

number of sprouts (18.00).were as N_1× A_3 produce the lowest number of sprouts (13.08). Types of media × nutrient × $Al_2(SO_4)_3$ interaction was non-significant. The highest number of sprouts was produced by M2×N_2×A_3 (18.27) whereas the lowest number of sprouts was produced by M_1× N_1×A_1 (12.87) followed by M_1×N_1×A_3 (12.53).

4.15. Stem girth of plant (cm) at 90 days after first application of fertilizer

Observations on stem girth (cm) of plant were recorded at 90 DAF and data so obtained were statistically analysed and presented in Table-17

Table -17 Effect of media, nutrients and aluminium sulphate on stem girth of plants (cm) at 90 DAF

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1(0gm)	A_2 (4gm)	A_3 (6gm)		
M_1 (1:1:1)	N_1(1:1:1)	3.63	3.60	3.70	**3.64**	
	N_2 (2:1:1)	3.33	3.57	3.37	**3.42**	
	Mean	**3.48**	**3.58**	**3.53**		**3.53**
M_2 (2:1:1)	N_1 (1:1:1)	3.17	3.13	3.67	**3.32**	
	N_2 (2:1:1)	2.93	2.73	2.80	**2.82**	
	Mean	**3.05**	**2.93**	**3.23**		**3.07**
N_1 (1:1:1)		3.40	3.37	3.68		**3.48**
N_2 (2:1:1)		3.13	3.15	3.08		**3.12**
Grand mean		**3.27**	**3.26**	**3.38**		

Effects	**F test**	**SE(m)±**	**CD at 5%**
Types of Media	*	0.18	0.52
Nutrients	NS	0.18	_
Aluminium sulphate	NS	0.22	_
Interactions			
Media × Nutrients	NS	0.26	_
Media × Al $_2(SO_4)_3$	NS	0.31	_
Nutrients × Al $_2(SO_4)_3$	NS	0.31	_
Media×Nutrients ×$Al_2(SO_4)_3$	NS	. 0.44	_

* = Significant at 5% level. ** = Significant level at 1% level.

From the perusal of data presented in Table -17 it was found that there was significant difference for stem girth of the plants at 90 days due to treatments under types of media. M_1 produced the highest stem girth (3.53cm) whereas M_2 produced the lowest stem girth (3.07cm).

No significant difference was observed among the treatments under levels of nutrients. However, N_1 produced the largest stem girth (3.12cm) .Levels of $Al_2(SO_4)_3$ exhibited non-significant difference .The stem girth was similar in all the treatments, the highest stem girth was produced by A_3 (3.38) followed by A_2 (3.26).

Types of media × nutrient interaction exhibited no significant difference. However, the highest stem girth was produced by M_1× N_1 (3.64cm) and lowest stem girth was recorded for M_2×N_2 (2.82cm).There was no significant difference due to media × $Al_2(SO_4)_3$ interaction .However, M_1 × A_2 produced the highest stem girth (3.58cm) whereas M_2 × A_2 produced the lowest stem girth (2.93cm) .Nutrients × $Al_2(SO_4)_3$ interaction exhibited no significant difference. The highest stem girth was produced by N_1×A_3 (3.68cm) whereas N_2×A_3 produced the lowest stem girth (3.08cm). Type of media × nutrients × $Al_2(SO_4)_3$ interaction was found to be non-significant .However, the highest stem girth was recorded for M_2×N_1×A_3 (3.67cm) and the lowest stem girth was produced by M_2×N_2×A_2 (2.73cm).

4.16. Number of days taken for first flower head appearance after first application of fertilizer

Observations on the number of days taken for appearance of first flower head DAF was recorded and the data so obtained were statistically analysed and presented in Table-18.

From perusal of data presented in Table-18 it was observed that the types of media differ significantly for the number of days taken for first flower head appearance .The F test was significant both at 5% and 1% level .The type of media M_1 produced flower heads at the earliest 97.00 DAF followed by M_2 which produced first flower head at 131.89 DAF .Highly significant difference was also exhibited for the levels of nutrients with respect to days taken for first flower head appearance. N_1 produced flower heads at the earliest 99.67 DAF followed by N_2 at 132.53 DAF. No significant difference was found in the time taken for flower head appearance by levels of $Al_2(SO_4)_3$. However, A_3 produced flower heads at earliest 115.50 DAF followed by A_2 at 115.50 DAR and A_1 117.67 DAF.

Significant difference was exhibited by types of media × nutrients interaction for the days taken to flower head appearance.

Table-18 Effect of media, nutrients and aluminium sulphate on days taken for first flower head appearance after first application of fertilizer

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1 (0gm)	A_2(4gm)	A_3 (6gm)		
M_1 (1:1:1)	N_1 (1:1:1)	95.67	96.67	98.67	**97.00**	
	N_2 (2:1:1)	102.50	104.83	103.50	**103.61**	
	Mean	**99.08**	**100.75**	**101.08**		**100.31**
M_2 (2:1:1)	N_1 (1:1:1)	101.50	102.17	103.33	**102.33**	
	N_2(2:1:1)	171.00	158.33	155.00	**161.44**	
	Mean	**136.25**	**130.25**	**129.17**		**131.89**
N_1 (1:1:1)		98.58	99.42	101.00		**99.67**
N_2 (2:1:1)		136.75	131.58	129.25		**132.53**
Grand mean		**117.67**	**115.50**	**115.13**		

Effects	**F test**	**SE(m)±**	**CD at 5%**
Types of Media	**	2.91	8.4
Nutrients	**	2.91	8.4
Aluminium sulphate	NS	3.56	_
Interactions			
Media × Nutrients	**	4.11	11.9
Media × $Al_2(So4)_3$	NS	5.04	_
Nutrients × $Al_2(So4)_3$	NS	5.04	_
Media × Nutrients × $Al_2(So4)_3$	NS	7.12	_

* = Significant at 5% level. ** = Significant level at 1% level.

M_1× N_1 produced flower heads at the earliest 97.00 DAF followed by M_2×N_1 at 102.33 DAF and M_1× N_2 at 103.61 DAF which were at par with each other.M_2×N_2 took the longest time for appearance of flower heads (161.44 DAF) .No-significant difference was observed for types of media × $Al_2(SO_4)_3$ interaction. However, the earliest flower head were produced by M_2 × A_1 (99.08DAF) followed by M_1 × A_2 (100.75DAF). M_2× A_1 took the longest time for flower head appearance (136.25 DAF). The interaction levels of nutrients × $Al_2(SO_4)_3$ exhibited no significant difference. However, N_1×A_1 produced flower heads at the earliest (98.58 DAF) followed by N_1×A_2 (99.42 DAF). N_2×A_1 took the longest time to produce flower heads (136.75 DAF). Media × nutrients × $Al_2(SO_4)_3$ interaction was also found to be non-significant . However, the treatment M_2×N_1×A_1 produced flower heads at the earliest (95.67 DAF) followed by M_1×N_1×A_2(96.67 DAF).The treatment M_2×N_2×A_1 took the longest time for production of flower heads(171.00 DAF).

4.17. Days taken for first floret opening from appearance of first flower head

Observations on the days taken for first floret opening from the appearance of first flower head were recorded and data so obtained was statistically analysed and presented in Table-19.

From the perusal of data presented in Table-19 it was observed the treatments under types of media differ significantly for days to first floret opening in first flower head The earliest floret opening was observed in M_2 at (8.28 days) followed by M_1 at (9.89 days). The levels of nutrients exhibited significant difference with respect to days taken to first floret opening. Earliest floret opening was observed in N_2 at(8.39 days) followed by N_1 at (9.78 days).The F- test was significant both in 5 % and 1% level for different doses of $Al_2(SO_4)_3$.

Table-19 Effect of media, nutrients and aluminium sulphate on days taken to first floret opening in first flower head

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1 (0gm)	A_2 (4gm)	A_3 (6gm)		
M_1 (1:1:1)	N_1 (1:1:1)	8.67	8.67	9.33	**8.89**	
	N_2 (2:1:1)	12.67	13.00	7.00	**10.89**	
	Mean	**10.67**	**10.83**	**8.17**		**9.89**
M_2 (2:1:1)	N_1 (1:1:1)	11.00	10.33	10.67	**10.67**	
	N_2 (2:1:1)	7.00	7.33	3.33	**5.89**	
	Mean	**9.00**	**8.83**	**7.00**		**8.28**
N_1 (1:1:1)		9.83	9.50	10.00		**9.78**
N_2 (2:1:1)		9.83	10.17	5.17		**8.39**
Grand mean		**9.83**	**9.83**	**7.58**		

Effects	**F test**	**SE(m)±**	**CD at 5%**
Types of Media	*	0.42	1.2
Nutrients	*	0.42	1.2
Aluminium sulphate	**	0.51	1.4
Interactions			
Media × Nutrients	**	0.59	1.72
Media × $Al_2(SO_4)_3$	NS	0.72	_
Nutrients × $Al_2(SO_4)_3$	**	0.72	2.10
Media×Nutrients ×$Al_2(SO_4)_3$	NS	1.02	_

* = Significant at 5% level. ** = Significant level at 1% level.

The earliest floret opening was recorded in A_3 at (7.58 days) followed by A_1 and A_2 at (9.83 days) which were at par with each other.

Types of media × nutrient interaction exhibited highly significant difference among the treatments .The earliest floret opening was recorded for the treatment $M_2 \times N_2$ (5.89 days) followed by $M_1 \times N_1$ at (8.89 days). The longest time for first floret opening was observed in $M_1 \times N_2$ at (10.89 days) which was at par with $M_2 \times N_1$ (10.67 days).No-significant difference was exhibited by types of media × $Al_2(SO_4)_3$ interaction .However, $M_2 \times A_3$ took the shortest time for first floret opening at (7.00 days) followed by $M_1 \times A_3$ at (8.17 days).The longest time was observed in $M_1 \times A_2$ for first floret opening at (10.83 days).The F-test was significant both at 5% and 1% level for nutrients×$Al_2(SO_4)_3$ interaction .The earliest floret opening was observed in $N_2 \times A_3$ at (5.17 days) followed by $N_1 \times A_2$ (9.50 days) and $N_2 \times A_1$ at (9.83 days) which were at par with each other. However, the longest time for first floret opening was recorded in $N_2 \times A_2$ at (10.17 days) followed by $N_1 \times A_3$ at (10.00 days) which were at par with each other. No-significant difference for first floret opening was exhibited by types of media × nutrients× $Al_2(SO_4)_3$ interaction .However, the earliest floret opening was recorded for $M_2 \times N_2 \times A_3$ at (3.33 days) followed by $M_2 \times N_2 \times A_1$ at (7.00 days).The longest time taken for first floret opening was recorded in $M_1 \times N_2 \times A_2$ at (13.00 days) followed by $M_2 \times N_2 \times A_1$ at (12.69 days).

4.18. Number of days taken for full bloom of first flower head from first floret opening

Observations on number of days taken to full bloom from days after first floret opening were recorded and data so, obtain were statistically analysed and presented in Table-20.

From the perusal of data presented in Table-20 it was observed that the types of media exhibited significant difference both at 5% and 1% level. The minimum days taken to full bloom of flower head was recorded in M_1 at 12.50 days followed by M_2 at 13.94 days. Highly significant difference in days taken to full bloom of flower head after first floret opening was observed for level of nutrients. The minimum number of days for full bloom was taken by N_1 at 12.17 days whereas the maximum time was taken by N_2 for full bloom at 14.28 days .There was no significant difference for the days taken to full bloom for doses of $Al_2(SO_4)_3$. However, flower heads in A_1 reached full bloom earlier at 12.83 days followed by A_3 at 13.33 days and A_2 at13.50 days.

Table-20 Effect of media, nutrients and aluminium sulphate on days taken for full bloom of first flower head

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1(0gm)	A_2 (4gm)	A_3 (6gm)		
M_1 (1:1:1)	N_1(1:1:1)	11.00	11.67	11.33	**11.33**	
	N_2(2:1:1)	13.33	13.67	14.00	**13.67**	
	Mean	**12.17**	**12.67**	**12.67**		**12.50**
M_2 (2:1:1)	N_1 (1:1:1)	12.33	13.00	13.67	**13.00**	
	N_2 (2:1:1)	14.67	15.67	14.33	**14.89**	
	Mean	**13.50**	**14.33**	**14.00**		**13.94**
N_1 (1:1:1)		11.67	12.33	12.50		**12.17**
N_2 (2:1:1)		14.00	14.67	14.17		**14.28**
Grand mean		**12.83**	**13.50**	**13.33**		

Effects	**F test**	**SE(m)±**	**CD at 5%**
Types of Media	**	0.30	0.88
Nutrients	**	0.30	0.88
Aluminium sulphate	NS	0.37	_
Interactions			
Media × Nutrients	NS	0.43	_
Media × Al $_2(SO_4)_3$	NS	0.53	_
Nutrients × Al $_2(SO_4)_3$	NS	0.53	_
Media × Nutrients × Al $_2(SO_4)_3$	NS	0.75	_

* = Significant at 5% level. ** = Significant level at 1% level.

Types of media × nutrients interaction was found to be non-significant for the character days taken to full bloom after first floret opening. However, minimum number of days was taken by $M_1 \times N_1$ at 11.33 days whereas maximum number of days was taken by $M_2 \times N_2$ for full bloom at 14.89 days. No significant difference was exhibited by types of media × $Al_2(SO_4)_3$ interaction. However, $M_1 \times A_1$ took the minimum time for full bloom at 12.17 days followed by $M_1 \times A_2$ and $M_1 \times A_3$ at 12.67 days. $M_2 \times A_2$ took the maximum time for full bloom at 14.33 days. Levels of nutrients × $Al_2(SO_4)_3$ interaction also exhibited non-significant difference. However, $N_1 \times A_1$ took minimum time for full bloom at 11.67 days followed by $N_1 \times A_2$ at 12.33 days. The longest time taken for full bloom was recorded for $N_2 \times A_2$ at 14.67 days. Types of media × nutrients× $Al_2(SO_4)_3$ interaction exhibited non-significant difference .However, the minimum days taken for full bloom was recorded in $M_1 \times N_1 \times A_1$ at

11.00 days followed by $M_1 \times N_1 \times A_3$ at 11.33 days. $M_2 \times N_2 \times A_2$ took maximum days for full bloom at 15.67 days.

4.19. Diameter of first flower head (cm)

Observations on diameter of first flower head (cm) were recorded and data so obtained was statistically analysed and presented in Table-21.

From the perusal of data presented in Table-21 it was observed that the F-test was significant at both 5% and 1% level for types of media. The diameter of flower head was highly significant for M_1 (15.17cm) as compared to flower heads produced in M_2 (9.05cm)..Highly significant difference was exhibited by levels of nutrients.N_1 produced the longest flower head diameter of (14.33cm) whereas N_2 produced flowers with minimum diameter (9.89cm) .There was no significant difference in flower head diameter for doses of $Al_2(SO_4)_3$. However, the highest diameter of flower heads was produced by A_3 (12.99cm) followed by A_1 (12.00cm) and A_2 (11.34cm).

Table 21 - Effect of media, nutrients and aluminium sulphate on diameter of first flower head (cm)

Media	Nutrients	$Al_2(SO_4)_3$			Mean	Grand mean
		A_1 (0gm)	A_2 (4gm)	A_3 (6gm)		
M_1 (1:1:1)	N_1 (1:1:1)	16.73	16.50	17.90	**17.04**	
	N_2 (2:1:1)	13.00	11.67	15.23	**13.30**	
	Mean	**14.87**	**14.08**	**16.57**		**15.17**
M_2 (2:1:1)	N_1 (1:1:1)	11.20	10.80	12.87	**11.62**	
	N_2(2:1:1)	7.07	6.40	5.97	**6.48**	
	Mean	**9.13**	**8.60**	**9.42**		**9.05**
N_1 (1:1:1)		13.97	13.65	15.38		**14.33**
N_2 (2:1:1)		10.03	9.03	10.60		**9.89**
Grand mean		**12.00**	**11.34**	**12.99**		

Effects	**F test**	**SE(m)±**	**CD at 5%**
Types of Media	**	0.78	2.2
Nutrients	**	0.78	2.2
Aluminium sulphate	NS	0.95	_
Interactions			
Media × Nutrients	NS	1.10	_
Media × $Al_2(SO_4)_3$	NS	1.35	_
Nutrients × $Al_2(SO_4)_3$	NS	1.35	_
Media × Nutrients × $Al_2(SO_4)_3$	NS	1.91	_

* = Significant at 5% level. ** = Significant level at 1% level.

Types of media × nutrients interaction exhibited non-significant difference .However, the largest flower head diameter was recorded in $M_1 \times N_1$ (17.04) cm followed by $M_1 \times N_2$ (13.30cm) and $M_2 \times N_1$ (11.62cm).The smallest diameter of flower head was produced by $M_2 \times N_2$ (6.48cm). Non-significant difference was exhibited by types of media × $Al_2(SO_4)_3$ interaction. $M_1 \times A_3$ produced the largest diameter of flower heads (16.57cm) followed by $M_1 \times A_1$ (14.87 cm) and $M_1 \times A_2$ (14.08 cm) .The smallest diameter of flower head was produced by $M_2 \times A_2$ (8.60 cm). Level of nutrients × $Al_2(SO_4)_3$ interaction also exhibited non-significant difference .However, $N_1 \times A_3$ produced the largest diameter of flower heads 15.38cm followed by $N_1 \times A_1$ (13.97cm) and $N_1 \times A_2$ (13.65cm).The smallest diameter of flower heads was recorded in $N_2 \times A_2$ (9.03cm).No significant difference was exhibited by types of media × nutrients× $Al_2(SO_4)_3$ interaction. However, the largest diameter of flower heads was recorded for $M_1 \times N_1 \times A_3$ (17.90cm) followed by $M_1 \times N_1 \times A_1$ (16.73cm) and $M_1 \times N_1 \times A_2$ (16.50cm). $M_2 \times N_2 \times A_3$ produced the smallest diameter of flower heads (5.97cm).

4.20. Number of florets per head in first flower head

Observations on number of florets per head in first flower head were recorded and data so obtained were statistically analysed and presented in Table-22.

From the perusal of data presented in Table-22 it was observed that the F-test was significant at both 5% and 1% level and highly significant difference was exhibited by types of media on number of florets per flower head. M_1 produced the highest number of florets per flower head (43.41).The lowest number of florets were produced by M_2 (19.33).Highly significant difference was also exhibited by the levels of nutrients. N_1 produced the highest number of florets per flower head (40.96) were as N_2 produced the lowest number of florets per flower head (21.78).No significant difference was exhibited by the levels of $Al_2(SO_4)_{3..}$ However, highest number of florets were produced A_3 (34.25) followed by A_1 (32.17) were as the lowest number of florets per flower head (27.69) was recorded for$A_{2.}$

Types of media×nutrients interaction exhibited non-significant difference. However, $M_1 \times N_1$ produced the highest number of florets (53.48) followed by $M_1 \times N_2$ (33.33) number of florets per head.$M_2 \times N_1$ produce the lowest number of florets (28.44) followed by $M_2 \times N_2$ (10.22).No-significant difference was exhibited by media × $Al_2(SO_4)_3$ interaction. However, $M_1 \times A_1$ produced the highest number of florets

(46.33) followed by $M_1\times A_3$ (44.83) and $M_1\times A_2$ (39.05). The lowest number of florets was produced by $M_2\times A_3$ (23.67) followed by $M_2\times A_1$ (18.00) and $M_2\times A_2$(16.33) number of florets per flower head. Level of nutrients × $Al_2(SO_4)_3$ interaction was also non-significant. However, the highest number of florets per flower heads was produced by $N_1\times A_3$ (47.50) followed $N_1\times A_1$ (40.83) and $N_1\times A_2$ (34.55). The lowest number of florets produced by $N_2\times A_1$(23.50) followed by $N_2\times A_3$ (21.00) and $N_2\times A_2$ (20.83).No significant difference was observed for types of media × nutrients× $Al_2(SO_4)_3$ interaction The highest number of florets was produced by $M_1\times N_1\times A_3$ (57.33) were as, the lowest number of florets was recorded with $M_2\times N_2\times A_3$ (9.67)

Table 22-Effect of media, nutrients and aluminium sulphate on number of florets in first flower head

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1 (0gm)	A_2 (4gm)	A_3(6gm)		
M_1 (1:1:1)	N_1 (1:1:1)	56.67	46.43	57.33	**53.48**	
	N_2 (2:1:1)	36.00	31.67	32.33	**33.33**	
	Mean	**46.33**	**39.05**	**44.83**		**43.41**
M_2 (2:1:1)	N_1(1:1:1)	25.00	22.67	37.67	**28.44**	
	N_2 (2:1:1)	11.00	10.00	9.67	**10.22**	
	Mean	**18.00**	**16.33**	**23.67**		**19.33**
N_1 (1:1:1)		40.83	34.55	47.50		**40.96**
N_2 (2:1:1)		23.50	20.83	21.00		**21.78**
Grand mean		**32.17**	**27.69**	**34.25**		

Effects	**F test**	**SE(m)±**	**CD at 5%**
Types of Media	**	2.49	7.25
Nutrients	**	2.49	7.25
Aluminium sulphate	NS	3.05	_
Interactions			
Media × Nutrients	NS	3.52	_
Media × $Al_2(SO_4)_3$	NS	4.32	_
Nutrients × $Al_2(SO_4)_3$	NS	4.32	_
Media × Nutrients × $Al_2(SO_4)_3$	NS	6.10	_

* = Significant at 5% level. ** = Significant level at 1% level.

4.21. Leaf area (sq.cm) of 3rd leaf at flowering

Observations on leaf area (sq.cm) of 3rd leaf at flowering were recorded and data so obtained were statistically analysed and presented inTable-23.

From the table-23 it was observed that the types of media differ significantly at 5% and 1% level for producing leaf area of 3rd leaf at flowering. M_2 produced the highest leaf area (34.98sq.cm) whereas M_1 produced the lowest leaf area (30.09sq.cm). Highly significant difference was exhibited by the level of nutrients. N_2 produced the highest leaf area (36.31sq.cm) whereas the lowest was recorded for N_1 (28.77 sq.cm). There was no significant difference among the treatments for levels of $Al_2(SO_4)_3$. However, A_1 produced the highest leaf area (32.75 sq.cm) followed by A_2 (32.48sq.cm) and A_3 (32.38 sq.cm). Types of media × nutrients interaction exhibited significant difference. The highest leaf area was recorded under $M_2 \times N_2$ (39.56 sq.cm) followed by $M_1 \times N_2$ (33.07 sq.cm) and $M_2 \times N_1$ (30.41 sq.cm). $M_1 \times N_1$ produced the lowest leaf area (27.12 sq.cm).

Table -23 Effect of media, nutrients and aluminium sulphate on 3rd leaf area at flowering

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1 (0gm)	A_2(4gm)	A_3(6gm)		
M_1 (1:1:1)	N_1 (1:1:1)	27.47	26.80	27.10	**27.12**	
	N_2(2:1:1)	33.17	32.63	33.40	**33.07**	
	Mean	**30.32**	**29.72**	**30.25**		**30.09**
M_2 (2:1:1)	N_1 (1:1:1)	30.87	30.07	30.30	**30.41**	
	N (2:1:1)	39.50	40.43	38.73	**39.56**	
	Mean	**35.18**	**35.25**	**34.52**		**34.98**
N_1 (1:1:1)		29.17	28.43	28.70		**28.77**
N_2 (2:1:1)		36.33	36.53	36.07		**36.31**
Grand mean		**32.75**	**32.48**	**32.38**		

Effects	**F test**	**SE(M)±**	**CD at 5%**
Types of Media	**	0.52	1.52
Nutrients	**	0.52	1.52
Aluminium sulphate	NS	0.64	_
Interactions			
Media × Nutrients	*	0.74	2.1
Media × $Al_2(SO_4)_3$	NS	0.91	_
Nutrients × $Al_2(SO_4)_3$	NS	0.91	_
Media × Nutrients × $Al_2(SO_4)_3$	NS	1.28	_

* = Significant at 5% level. ** = Significant level at 1% level.

Types of media × $Al_2(SO_4)_3$ interaction exhibited no-significant difference. However, the highest leaf area was recorded in M_2× A_2 (35.25 sq.cm) and the lowest leaf area (29.72 sq.cm) was produced byM_1× A_2. Levels of nutrients × $Al_2(SO_4)_3$ also exhibited non-significant difference. The highest leaf area was produced by N_2×A_2 (36.53 sq.cm) whereas the lowest leaf area was recorded for N_1×A_2 (28.43 sq.cm). Types of media × nutrients× $Al_2(SO_4)_3$ interaction revealed no-significant difference. However, the highest leaf area (40.43 sq.cm) was produced by M_2×N_2×A_2 followed by M_2×N_2×A_1 (39.50 sq.cm). The lowest leaf area (26.80 sq.cm) was produced by M_1×N_1×A_2.

4.22. Chlorophyll content of 3rd leaf at flowering (SPAD value)

Observations on chlorophyll content of 3rd leaf (SPAD value) at flowering were recorded and data so obtained were statistically analysed and presented in Table-24.

From the perusal of data presented in Table-24 it was revealed that the types of media differ significantly at 5% and 1% level for chlorophyll content of 3rd leaf at flowering. The chlorophyll content of 3rd leaf was highest (12.24) in M_1 whereas the lowest chlorophyll content (9.23) was recorded for M_2.

The levels of nutrients also exhibited highly significant difference at 1% level. N_1 recorded the highest chlorophyll content (11.63) whereas the lowest chlorophyll content (9.84) was recorded for N_2 .No significant difference was revealed for the level of $Al_2(SO_4)_3$ which had almost similar chlorophyll content in 3rd leaf .The highest chlorophyll content (10.77) was observed in A_2 and the lowest chlorophyll content was recorded for A_1(10.70).

Types of media × nutrients interaction were found to be non-significant. However, M_2×N_1 produced the highest chlorophyll content (13.36) whereas the lowest chlorophyll content (8.54) was recorded in M_2×N_2. Types of media × $Al_2(SO_4)_3$ interaction was also found to be non-significant .The highest chlorophyll content (12.45) was recorded in M_1× A_1 whereas lowest chlorophyll content was recorded for M_2× A_1(8.17). No-significant difference was observed for level of nutrients × $Al_2(SO_4)_3$ interaction .The highest chlorophyll content (11.75) was recorded in N_1×A_1 and N_1×A_3 whereas N_2×A_1 recorded the lowest chlorophyll content (9.65). Types of media × nutrients× $Al_2(SO_4)_3$ interaction was also found to be non-significant.

However, the highest chlorophyll content was produced by $M_1 \times N_1 \times A_1$ (13.77) whereas the lowest chlorophyll content 8.17 was recorded for $M_2 \times N_2 \times A_1$

Table -24 Effect of media, nutrients and aluminium sulphate on chlorophyll content of 3rd leaf (SPAD value) at flowering

Media	Nutrients	$Al_2(SO_4)_3$			**Mean**	**Grand mean**
		A_1 (0gm)	A_2 (4gm)	A_3 (6gm)		
M_1 (1:1:1)	N_1(1:1:1)	13.77	13.13	13.17	**13.36**	
	N_2 (2:1:1)	11.13	11.13	11.13	**11.13**	
	Mean	**12.45**	**12.13**	**12.15**		**12.24**
M_2 (2:1:1)	N_1 (1:1:1)	9.73	9.67	10.33	**9.91**	
	N_2(2:1:1)	8.17	9.13	8.33	**8.54**	
	Mean	**8.95**	**9.40**	**9.33**		**9.23**
N_1 (1:1:1)		11.75	11.40	11.75		**11.63**
N_2 (2:1:1)		9.65	10.13	9.73		**9.84**
Grand mean		**10.70**	**10.77**	**10.74**		

Effects	**F test**	**SE(m)±**	**CD at 5%**
Types of Media	**	0.30	0.93
Nutrients	**	0.30	0.93
Aluminium sulphate	NS	0.37	_
Interactions			
Media × Nutrients	NS	0.42	_
Media × $Al_2(SO_4)_3$	NS	0.52	_
Nutrients × $Al_2(SO_4)_3$	NS	0.52	_
Media × Nutrients × $Al_2(SO_4)_3$	NS	0.73	_

* = Significant at 5% level. ** = Significant level at 1% level.

Fig.1 General view of Treatment blocks at flowering



Fig-2 General view of the plants in M_1 potting media with N,P,K @ 1:1:1 at flowering period



Fig-3 General view of the plants in M_1potting media with N,P,K @ 2:1:1



Fig-4 General view of the plants in M_2 potting media with N,P,K@ 1:1:1



Fig-5 General view of the plants in M_2 potting media with N,P,K @ 2:1:1



Fig.6 Developmental stages of flower head in Hydrangea



Initiation of bud



Full development of bud



Full bloom of flower head



Onset of senescence in bloom

CHAPTER 5

DISCUSSION

DISCUSSION

The results presented in the preceding chapter pertaining to the study "Effect of media and nutrients on the growth and flowering of Hydrangea (*Hydrangea macrophylla* Thunb. Ser)" revealed some interesting results. The relevant of these results are discussed in this chapter.

Broadly, *Hydrangea macrophylla* is a plant of cooler region and grows well at higher altitudes. When it is grown at lower elevations with adverse climatic conditions it encounters several effects physiologically which influences growth and flowering. The plant may suffer from high rate of transpiration, poor vegetative growth and change in flowering time as well as duration of flowering. Therefore, the trial was designed with a view to maintain high water holding capacity in the growing medium and management of nutrients especially nitrogen and aluminium sulphate to hasten the flowering process and to induce change in colour of flower heads if any.

5.1. Effect of types of media, nutrients and aluminium sulphate on growth parameters *viz*. plant height, number of branches, number of leaves, number of sprouts and stem girth

At 30 DAF as regards to the extension in plant height, increase in number of branches per plant, number of leaves per plant and stem girth; no significant difference was revealed for the types of media, levels of aluminium sulphate and all the interactions. However, application of different levels of nutrients was found to be highly significant for growth parameters like height of the plant, number of branches per plant and number of leaves per plant as well as production of new sprouts at 30 DAF. The maximum plant height was recorded in N_2 (N,P,K@ 2:1:1) *ie.* 49.37 cm where as N_1 (N,P,K@ 1:1:1) recorded the lowest plant height 48.41 cm. Similarly, N_2 produced higher number of branches per plant (8.67) followed by N_1 (7.22). N_2 also produced more number of leaves per plant (49.72) as compared to N_1 (45.33). A similar trend was also observed for production of new sprouts at 30 DAF, where N_2 recorded higher number of sprouts (10.97) followed by N_1 (9.19). On the other hand, no significant result was revealed for increasing the stem girth due to effect of types of media, nutrients and aluminium sulphate and their interactions at 30DAF.

Normally it was observed that media takes a longer time to express their effect on the growth parameters. So, at 30 DAF the growth parameters did not exhibit any enhancement with respect to growth parameters. It was observed that nutrient application was quick to increase the growth parameters within a short period of time. The results corroborate with the finding of Waters (1967) who observed that application of nitrogen to the potted plants of *Rosa hybrida* cv. Celebration increased the relative growth rate over all other treatments. Increased stem length was also reported by Young Iley and Hayslip (1966) in rose cvs."Happiness" and "Christian Dior" and also in other crops as reported by Mc George (1923).

Application of varying doses of aluminium sulphate did not exhibit any effect on growth parameters as they were applied at very low doses aimed at changing of the colour of flower heads.

At 60 DAF, the plant height was significantly influenced by the types of media and level of nutrients as 5% and 1% level. M_2 (soil: FYM: coco peat @ 2:1:1v/v) produced the maximum plant height (52.75 cm) whereas M_1 (soil: FYM: cocopeat @ 1:1:1v/v) recorded the lowest plant height (51.47 cm). The plant height was significantly increased due to application of N_2 (N,P,K @ 2:1:1) *i.e.*53.21 cm as against 51.28 cm under N_1 (N,P,K@ 1:1:1). The types of media × nutrients interaction were found to be highly significant. The highest plant height was recorded with $M_2 \times N_2$ (54.19 cm) as over $M1\times N_2$ (52.23 cm), $M_2 \times N_1$ (51.31 cm) and $M_1\times N_1$ (51.26 cm). The results suggested that N_2 had significant effect irrespective of the type of media (M_1 and M_2) w.r.t the character plant height. At 60 DAR nutrient levels had highly significant effect on the increase in number of branches per plant. N_2 produced 13.11 branches per plant as against 9.78 under N_1. Thus, it can be concluded that nutrient applications especially nitrogen play an important role in increasing the branch number/ plant as corroborated by the findings of Sharma (2002) in Gaillardia, Aruna *et al.* (2007) in Crossandra, Ahmad *et al.*(2007) in *Zinnia elegans,* Mohit *et al.* (2008) in China aster and Pal and Ghosh (2010) in African Marigold.

Application of nutrients significantly increased the number of leaves per plant at 60 DAF. The highest number of leaves per plant was recorded for N_2 (54.35) as against N_1 (51.22).Media × nutrient interaction exhibited significant result at 5% level.The highest number of leaves was produced by $M_1\times N_2$ (55.67) as against

$M_1 \times N_2$ (53.03)followed by $M_2 \times N_1$ (51.70) and $M_1 \times N_1$ (50.73). All other interactions were non-significant.

From the result it appears that $M_2 \times N_2$ interaction increased the plant height and so also the number of branches and number of leaves per plant. No significant results for increase in stem girth were noticed either for the types of media, level of nutrients and their interactions. Normally, in active growth phase of plant especially a shrub the increase in plant height, number of branches and number of leaves dominates by arresting the increase in plant girth which is accomplished at the later phases of growth. This sequence of growth is generally observed in ornamental shrubs. As regards to the production of new sprouts at 60 DAF it was found to be highly significant due to the levels of nutrients. It was observed that N_2 produce 15.34 sprouts as against 11.53 by N_1 .It has been reported that higher amount of nutrition not only increases the plant height but also the number of branch per plant, number of leaves per plant and bud break as reported by Shanks *et al.*(1950) in Hydrangea, Qasim *et al.*(2003) in *Jasminum sambac*, Ahmad *et al.* (2007) in *Zinnia elegans* and Aruna *et al.* (2007) in Crossandra. The nutrients especially nitrogen plays a significant role on the increase in plant height with increasing levels of doses. This has been corroborated by Gowda *et al.* (1991) in tuberose. It can be concluded that hydrangea shrubs in general have a high demand for nutrients especially nitrogen and the vegetative growth parameters respond favourably to an increase in levels of nitrogen applied keeping the phosphorus and potassium levels constant. This result corroborates with the findings of Link and Shanks (1952) reported in Hydrangea. Levels of aluminium sulphate had no significant effect on the vegetative growth parameters at 60 DAF as it was supplied with a view to influence floral growth parameters especially change in colour of flower head at later stages of growth.

At 90 DAF the increase in plant height was found to be highly significant due to the effect of type of media, level of nutrients and media × nutrient interaction. It was observed that M_2 produced the highest plant height (54.04cm) as against M_1 (52.74cm). Among the levels of nutrients, N_2 recorded 54.45cm of plant height as compared to 52.33cm in N_1.Among the interactions, except types of media × level of nutrients the other interactions were non-significant. Within the interaction between media × nutrients, the interactions $M_2 \times N_2$ recorded the highest plant height 55.74cm which is significantly the highest plant height as against $M_1 \times N_2$ (53.16cm), $M_2 \times N_1$

(52.33cm) and $M_1 \times N_1$ (52.32cm).The growth parameter number of branches per plant was significantly influenced by the type of media at 5%level and levels of nutrients at1% level where as no significant difference was observed for the interactions. Among the types of media, M_2 produced 14.17 branches per plant which was higher as against M_1 which produced only 13.17 branches per plant .On the other hand among the levels of nutrients, N_2 produced significantly higher number of branches per plant i.e. 15.50 as compared to 11.83 branches per plant under N_1.

At 90 DAF production of leaves was significantly influenced by the nutrient levels, where it produced 57.11 number of leaves per plant in N_2 as against 54.78 leaves per plant in N_1 and the significant difference was only observed at 5% level. When the age of plants advances and proceeds towards flowering gradually the increase in plant height ,number of branches, number of leaves and production of new sprouts generally slows down as the photosynthates are diverted for flower bud differentiation after receiving an optimum level of nutrients as reported by Qasim *et al.* (2005)in *Rosa chinensis,* Natarajan *et al*.(1981)in *Jasminum sambac* and Bhattacharjee (1981)in gladiolus. The increase in plant height along with number of branches per plant was influenced by types of media and level of nutrients. The level of nutrients had a direct and quick effect on augmenting the plant growth parameters were as types of media has an indirect effect on the growth parameters. The effect of media on enhancing the above growth parameters was due to its good water holding capacity and nutritional value especially due to addition of coco peat as reported by Rexilius (1990) and Noguera *et al.* (2000).

At 90 DAF production of leaves was significantly influenced by nutrient levels N_2 Produced maximum number of leaves (57.11) as against N_1 (54.87) leaves and the significant difference was only observed at 5% level. It has been observed that when the age of the plants advances and proceeds towards flowering the production of leaves generally slows down as reported by Qasim *et al.* (2005)in gladiolus and Khalaj *et al.*(2012) in tuberose.

At 90 DAF highly significant difference for levels of nutrients at 5% and 1% level was observed for production of sprouts. Among the nutrient levels N_2 produced 17.44 sprouts per plant as against N_1 (13.47 sprouts). At 90 DAF the increase in plant girth was noticed only with type of media at 5% level where as nutrients, aluminium

sulphate and interaction had no significant effect. The highest plant girth was recorded in M_1 (3.53m) as compared to M_2 (3.07m).When the plants proceed towards flowering some portion of photosynthates are diverted resulting in enhancement of girth.

5.2. Effect of media, nutrients and aluminium sulphate on floral characters viz. days to first flower head appearance ,diameter of flower head ,number of florets per flower head ,days to opening of first floret in the flower head and days to full bloom

In a pot experiment especially for a shrub, potting media plays an important role in the proper growth and development of plants. Deficiency or excess of any nutrient can lead to improper growth. Also when plants are grown in substrates, proper maintenance of nutrient level in media is an important pre-requisite. Texture, structure, porosity, water holding capacity and element composition of media are major factor which determine whether nutrients are available to plant or not.

From the results of the present investigation is was found that the days taken to the first flower head appearance was significantly influenced by the types of media, nutrients and media × nutrients interaction at 5% level as well as1% level. Earliest flower bud appearance was recorded in M_1 (soil: FYM: coco peat 1:1:1, v/v) which was at 100.31 DAF, whereas flower buds appeared at a later period (131.89 DAF) in M_2 (Soil: FYM: coco peat 2:1:1, v/v)

Nutrients though exhibited a significant effect with respect to earliness in flower head appearance in plant, it was observed that the plants receiving N_1 (NPK@ 1:1:1) came to flowering earlier (99.67 DAF) as compared to application of higher level of nitrogen in N_2 (NPK @ 2:1:1) which was at 132.53 DAF. There was no effect of levels of $Al_2 (SO_4)_3$ on the days taken for first flower head appearance. Among the interactions, only media × nutrients interactions was found to be highly significant. Whereas other interactions were statistically non-significant. It was found that earliest flower bud appearance was in $M_1 \times N_1$ (97.00 DAF) followed by $M_2 \times N_1$ (102.33 DAF), $M_1 \times N_2$ (103.61 DAF) whereas plants in $M_2 \times N_2$ took the longest time for flower head appearance (161.44 DAF). The days taken for first floret opening in first flower head from the date of first flower head appearance revealed some interesting findings. It was observed that types of media and nutrients had significant effect on

the above floral character whereas $Al_2 (SO_4)_3$ was found to significantly influence the days taken to first floret opening at 5% and 1%level .Among the types of media earliest first floret opening was observed in M_2 (8.28 days) followed by M_1 (9.89 days) .Among the nutrient levels, first floret opening was recorded for N_2 at 8.39 days followed by N_1at 9.78 days after appearance of flower head.A_3(6gm) resulted in earliest first floret opening at 7.85 days as compared to A_2 (4gm) and A_1 (0gm) where first floret opening was later at 9.83 days. Among the interactions, media × nutrients and nutrients× $Al_2 (SO_4)_3$ interactions effected the time of first floret opening significantly at 5% and 1% level. The other interactions namely media×$Al_2 (SO_4)_3$ and media × nutrients× $Al_2 (SO_4)_3$ were found to be statistically non-significant .

Among the media× nutrients interactions the earliest first floret opening was observed in M_2× N_2 (5.89 days) followed by M_1× N_1(8.89 days). M_1× N_2 and M_2× N_1 responded almost similarly to the days taken for first floret opening which was 10.89days and 10.67days respectively.

Days taken to full bloom of first flower head was significantly influenced by types of media and nutrients at 5% and 1% level, whereas the effect of $Al_2 (SO_4)_3$ was found to be non-significant. Among the media, the shortest days taken to full bloom was 12.50 days in M_1 while it was 13.94 days in M_2. It was found that N_1 recorded the lowest number of days to full bloom of first flower head (12.17 days) whereas it was significantly higher (14.28 days) in N_2 .However, all the interactions exhibited non-significant difference with respect to the parameter i.e. days to full bloom.

From the results it was observed that the diameter of first flower head was significantly influenced by types of media and level of nutrients at 5% and1% level whereas effect of $Al_2 (SO_4)_3$ was found to be non-significant. Among the media M_1 produced flower heads with largest diameter (15.17cm) whereas M_2 produced flower heads of least diameter (9.05cm). On the other hand, the nutrient level N_1 produced flower heads of large diameter (14.33cm) whereas N_2 recorded the lowest flower head diameter (9.89cm).All the interactions were found to be non-significant with respect to the parameter diameter of the first flower head.

As regards the parameter number of florets in first flower head, significant difference was observed due to the effects of types of media and levels of nutrients

both at 5% and 1%level.The application of varying doses of $Al_2 (SO_4)_3$ did not having any significant effect on the number of florets in first flower head. Among the media, M_1 produced maximum number of florets (43.41) in the first flower head whereas M_2 produced only 19.33 florets in first flower head. The highest number of florets in first flower head (40.96) was produced by N_1 whereas least number of florets (21.78) was produced by N_2 .The interactions were found to be statistically non-significant in their effect.

The success in growing a broad leaf shrub like hydrangea aims at getting early flower heads during cooler times of the year so that their longevity is extended for a longer period .On the other hand, delayed flower head appearance during warmer period will have an effect on longevity of flower heads.

In the present investigation, medium (M_1) with soil: FYM: coco peat (1:1:1,v/v) force the flower heads to appear at 100.31days as compared to medium (M_2) consisting of soil: FYM: coco peat (2:1:1,v/v) i.e. 131.89 days. Normally pot plants are grown with soil and FYM mixture. But addition of coco peat with equal proportion of soil and FYM perhaps maintains proper C:N balance as per Krauss and Kraybill (1918) as observed in tomato. Proper C:N ratio helps in attaining earlier reproductive phase in plants. The effect of well decomposed coco peat on plant growth has been reported by Suharban (2004). Similar findings have been reported in Alstroemeria by Wazir *et.al.*(2009), Sekar and Sujata (2001) in Gerbera and in Geranium by Singh (2010).However, the average moisture percentage in the medium (M_2) is lower than M_1 which might have caused a stress condition in the plants resulting in delayed flowering. Application of excess of nitrogen has been observed to delay the flower head appearance by almost 32 days. As already mentioned the C:N ratio with excess nitrogen delayed the expression of reproductive phase.

The interaction of nutrients and media also exhibited a similar result. Flower head appearance was earlier in $M_1 \times N_1$ (97 days). A critical analysis of data revealed that excess of nitrogen in M_2 medium highly influenced and delayed the appearance of flower head by almost two months. This may be attributed to a lesser moisture content and excess of nitrogen in $M_2 \times N_2$ which delayed flower head appearance which is very prominent and needs a careful and critical analysis as we are growing the plants in pots. The present finding is very useful for pot culture of hydrangeas by growers

where it is essential to use a good medium with coco peat and nitrogen at lower level. This corroborate with the findings of Singh (2002) in *Lillium*, Gupta *et al.* (2004) in Gerbera, Grewal *et al.* (2004) in Chrysanthemum cv.Flirt. and Ahmed *et al.*(2007) in *Zinnia elegans*.

The first floret opening in M_2 was earliest as compared to M_1 which may be due to low moisture content in the medium. On the other hand, earliest floret opening in N_2 may be due to a congenial condition for production of flower heads. Normally in small flower heads the opening of florets is earlier .The floret opening took the minimum days in $M_2 \times N_2$ (5.89 days)which may be attributed to smaller flower heads, moisture stress and excess of nitrogen .It was interestingly noted that the opening of the first floret was earliest under $N_2 \times A_3$ (5.17 days). Thus the effect of Aluminium sulphate on earlier floret opening may not be ruled out.

Full bloom of the flower head was earlier in M_1 as compared to M_2 which can be attributed to the good growing condition in M_1 in comparison to M_2 where higher proportion of soil might have created moisture stress. The time taken for full bloom was earliest in M_1 (12.17 days) than M_2 (14.28 days) i.e. 2.11 days earlier .This trend is due to lower level of nitrogen in the medium. Effect of excess nitrogen universally retards the floret opening as reported by Ahmad *et al.* (2007) in *Zinnia elegans*.

The diameter of flower head was found to be 6.12cm higher in M_1 (15.17cm) than in M_2 (9.05cm).This may be due to balanced growth condition of plants under M_1 as compared to M_2. In N_1 the flower head diameter was higher by 4.44cm than N_2 which can be attributed to excess vegetative growth antagonizing expression of reproductive phase. The results corroborate with a findings of Shanks *et.al* (1950) in hydrangea.

The number of florets in a flower head in hydrangea is very crucial from aesthetic point of view. The number of florets per flower head was higher in M_1 (43.41) than in M_2 (19.33) i.e.by 24 more florets this can be attributed to the balanced proportion of soil:FYM:cocopeat in M_1 which passively retain higher amount of moisture as compared to medium M_2 where higher amount of soil created a poor growing condition probably due to poor water holding capacity of the medium. In culture of hydrangea continuous and uninterrupted uniform water supply is a prime factor for good blooms. The numbers of florets are higher by 19.18 in N_1 as compared

to N_2. This can be attributed to excess of nitrogen in the growing media. It has been observed that in general higher levels of nitrogen produce lesser number of flowers in other plants as reported by Aruna *et al.* (2007) in Crossandra.

5.3. Effect of media, nutrients and aluminium sulphate on leaf area (sq.cm) and chlorophyll content (SPAD value) of 3rd leaf at flowering

The leaf area of the 3rd leaf was recorded at flowering in the plants. From the results it was observed that the type of media had significant effect on the third leaf area. The highest leaf area (34.98 sq.cm) was recorded M_2 whereas M_1 recorded the lowest leaf area (30.90 sq.cm). The leaf area was also significantly influenced by the level of nutrients and the highest leaf area (36.31 sq.cm) was recorded for N_2 followed by N_1 (28.77 sq.cm). From the media x nutrient interaction, it was found that highest leaf area was produced by $M_2 \times N_2$ (39.56 sq.cm) and the lowest leaf area in $M_1 \times N_1$ (27.12 sq.cm).

It is a well-known fact that when the media has good nutrient retention capacity, water holding capacity along with sufficient aeration the growth of the plant is enhanced. Thus, it can be presumed that higher leaf area was recorded in media M_2 (34.98 sq.cm) as all the conditions were congenial compared to medium M_1 where the leaf area was lowest (30.09sq.cm). Link & Shanks (1952) reported that growing plants of hydrangea have a high demand for nutrients, especially nitrogen .This finding corroborates with the results of investigation where N_2 produce more leaf area (36.31sq.cm) as compared to N_1 (28.77 sq.cm).This trend is attributed to application of higher levels of nitrogen to the plants. The same trend was also observed in media ×nutrient interaction were, $M_2 \times N_2$ recorded the highest leaf area(39.56 sq.cm) and $M_1 \times N_1$ the lowest leaf area (27.12sq.cm).The results corroborate with a findings of Thakur (2005) in rose, Bhaseer and Thekkayam (2012)in anthurium and Qasim *et al.*(2005) in rose.

From the perusal of data on the chlorophyll content (SPAD value) of 3rd leaf at flowering, it was found that types of media and level of nutrients influence the chlorophyll content of leaves significantly. The highest chlorophyll content was recorded in M_1 (12.24 SPAD) and lowest in M_2 (9.23 SPAD). Among the effect of nutrients the leaves had least chlorophyll (9.84 SPAD) in N_2 whereas the highest was recorded in N_1 (11.63 SPAD). It is observed that when plants transit from vegetative

stage to reproductive stage more of the photosynthates are diverted towards reproductive growth. The chlorophyll content in the leaf is associated with the stage of growth of plants. During flowering the chlorophyll content of the leaves decreases in comparison to when in vegetative stage. This corroborates with the previous results were it was found that plants in M_1 come to flowering earlier as compared to M_2.Thus,the chlorophyll content of the 3rd leaf of plants in M_2 was found to be lower than M_1 due to delayed flowering. The same trend was also observed with a level of nutrients where lower chlorophyll content (9.84 SPAD) was recorded in N_2 were plants flowered much later than those receiving N_1. The result corroborates with the findings of Saifuddin *et al.* (2010) in Bougainvillea.

CHAPTER 6

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The present investigation entitled "Effect of media and nutrients on the growth and flowering of Hydrangea (*Hydrangea macrophylla* Thunb. Ser.)" was carried out in the Department of Floriculture and Landscaping, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar during the year 2017-2018 with the following objectives:

1. To study the effect of nutrients and growing media on growth parameters of Hydrangea.
2. To study the flowering in Hydrangea as influenced by the growing media and nutrients.
3. To study the change in colour of flower heads in Hydrangea as influenced by nutrients specifically by the application of aluminium sulphate.

The experiment was conducted by taking one year old Hydrangea plants from November 2017 to May 2018 which were planted in two types of media viz. M_1- soil+ FYM+ coco peat @ 1:1:1(v/v) and M_2- soil+ FYM+ coco peat @ 2:1:1(v/v) and two levels of nutrients i.e. N_1- NPK@ 1:1:1 and N_2 - NPK@2:1:1 with three levels of aluminium sulphate viz. A_1(0gm),A_2(4gm) and A_3(6gm) .The research program was conducted by following factorial CRD. There were 12 treatments with 3 replications each and all together 72 plants were observed .The salient findings are presented below:

6.1. Effect of media, nutrients and aluminium sulphate on vegetative growth parameters of Hydrangea

1. Plant height was not significantly influenced by types of media at 30 DAF. However, it was significantly influenced due to the types of media at 60 DAF and 90 DAF. The highest plant height was recorded by M_2 (soil+ FYM+ cocopeat@ 2:1:1 v/v) at 90 DAF (54.04cm) as against M_1 (52.74cm). At all stages the plant height was effected significantly by the application of levels of nutrients. The highest plant height was recorded at all stages with N_2 (NPK@ 2:1:1) as compared to N_1 (NPK@ 1:1:1) at 90 DAF. The highest plant height was recorded for N_2 (54.45cm) followed by N_1 (52.33cm).However, the

interaction of media × nutrients exhibited significant effect on plant height at 60 DAF and 90 DAF. The highest plant height was recorded by $M_2 \times N_2$ (55.74cm) at 90 DAF and the lowest by $M_1 \times N_1$ (52.32cm).The other interactions did not exhibit any significant effect on plant height. Application of aluminium sulphate had no significant effect on plant height during the course of investigation.

2. Branch number per plant was only significantly effected at 90 DAF by media at 5% level. The maximum number of branches per plant was recorded by M_2(14.17)at 90DAF.However, the level of nutrients had a significant effect of number of branches per plant at all stages of growth and the highest number of branches per plant was observed with N_2 (15.50) at 90 DAF. The interactions did not exhibit significant effect on number of branches. No effect of aluminium sulphate was observed on number of branches per plant during investigation.
3. At all the stages the type of media exhibited no significant effect on production of number of leaves per plant. On the other hand level of nutrients significantly promoted leaf production at all stages and at 90 DAF the highest number of leaves (57.11) was recorded under N_2. Doses of aluminium sulphate and the interactions had no significant effect on number of leaves produced per plant.
4. Bud sprouts produced per plant were not significantly influenced by media at all stages of growth .However, level of nutrients had significant effect on bud sprout at all stages. The highest number of bud sprouts was observed in N_2 (17.44) at 90 DAF. Aluminium sulphate and interactions had no significant effect on number of sprouts at all stages of growth.
5. Nutrient, media, aluminium sulphate and their interactions had no significant effect on stem girth at all stages of growth except type of media at 90 DAF. M_1 increased the plant girth significantly (3.53cm) as compared to M_2 (3.07cm).

6.2. Effect of media, nutrients and aluminium sulphate on floral characters of Hydrangea

1. The flower head appearance was significantly earliest with M_1 (100.31 DAF) as compared to M_2 (131.89 DAF).Flower head appearance was delayed by 31.58 days in M_2. The level of nutrients also significantly influenced the days taken for flower head appearance .Earlier flower head appearance was with N_1 (99.67 DAF) as compared to N_2 (132.53 DAF).Thus, flowering was delayed by 32.86 days in N_2 . Aluminium sulphate had no effect on days taken for flower head appearance. All the interactions had non-significant effect on days taken for flower head appearance excepting media × nutrients interaction. $M_1 \times N_1$ was significantly earliest (97.00 DAF) to produce flower heads.

2. The first floret opening was significantly earliest with M_2 (8.28days) as compared to M_1 (9.89 days).Similarly, first floret opening was significantly earliest in M_2 (8.39days) as compared to N_1 (9.78 days). $Al_2(SO_4)_3$ had highly significant effect on first floret opening and it was the earliest in A_3 (7.58 days) The first floret opening was significantly influenced by media ×nutrients interaction and was earliest with $M_2 \times N_2$ (5.89days). Nutrient × $Al_2(SO_4)_3$ interaction also exhibited highly significant effect and the earliest first floret opening was recorded for $N_2 \times A_3$ (5.17 days).

3. Days taken to full bloom of flower head was significantly influenced by media and nutrients but not by $Al_2(SO_4)_3$ and their interactions. The flower heads were significantly earliest to open in M_1 (12.50days) as compared to M_2 (13.94days).Also the flower heads bloomed fully earlier under N_1 (12.17 days) than N_2 (14.28days).

4. Media and nutrients had highly significant effect on number of florets in flower heads but it was not influenced by $Al_2(SO_4)_3$ and the interactions. In M_1 the numbers of florets per flower head were 43.41 as compared to 90.33 under M_2 .Also the number of florets per flower head was 40.96 in N_1 as compared to 21.78 in N_2.

5. The diameter of the flower head was highly significantly influenced by media and nutrients but not by $Al_2(SO_4)_3$ and their interactions. The diameter of flower head was highest under M_1 (15.17cm) as compared to M_2 (9.05cm).N_1 recorded the largest diameter of flower head (14.33cm) as compared to N_2 (9.89cm).

6.3. Effect of media, nutrients and aluminium sulphate on leaf area (sq.cm) and chlorophyll content (SPAD) of 3rd leaf

1. The leaf area of 3rd leaf was significantly influenced by media and nutrients but not by $Al_2(SO_4)_3$. Among the interactions, media ×nutrients only had significant effect on leaf area. The leaf area was highest in M_2 (34.98 sq.cm) as compared to M_1 (30.09 sq.cm) N_2 recorded the highest leaf area (36.31sq.cm)as compared to N_1 (28.12 sq.cm).In media × nutrients interactions the leaf area was highest with $M_2 \times N_2$ (39.56sq.cm) as compared to $M_1 \times N_1$ (27.12 sq.cm)

2. The chlorophyll content of the 3rd leaf was significantly influenced by media ×nutrients. But not by $Al_2(SO_4)_3$ and the interactions. The chlorophyll content was higher in M_1 (12.24 SPAD) as compared to N_2 (9.23 SPAD).Similarly the chlorophyll content of 3rd leaf was found to be highest in N_1 (11.63 SPAD) in comparison to N_2 (9.84 SPAD).

6.4. Effect of media, nutrients and aluminium sulphate on colour change of flower heads.

1. It was found that media, nutrients and aluminium sulphate had no influence with regard to the change in colour of the flower heads. The flower heads were pink in colour in all the treatments and blue colouration of flower heads was not observed.

CONCLUSION

Growing hydrangea in pots with M_1 i.e. soil +FYM+ coco peat @ 1:1:1 (v/v) has been found to be best for over all plant growth, development and specifically for earliness of flower head appearance (97.00 DAF) as well as production of larger flower heads (15.17 cm) than M_2 i.e.soil+FYM+coco peat @ 2:1:1 (v/v) .The overall performance of plants receiving N_1 i.e. NPK@ 1:1:1 is better than N_2 i.e. NPK @ 2:1:1. The different doses of aluminium sulphate had no specific effect on colour change of flower heads which needs to be investigated in future studies. The presence of excess soil and nitrogen in the growing medium may be avoided in pot culture of Hydrangeas.

REFERENCES

REFERENCES

Abou Dahab TAM and Habib AM A. 2005. Production of *Barleria cristata* L. as a dwarf flowering pot plant. *Annals of Agricultural Science, Moshtohor*. **43**(2): 727-746

Adkins JA and Dirr MA. 2003 Remontaul flowering potential of ten Hydrangea macrophylla(Thunb)Ser. Cultivars Department of Horticulture ,The university of Georgia,Athens,GA30602-7273,USA

Ahmad I, Ahmad T, Zafar M S and Nadeem A. 2007. Response of an elite cultivar of zinnia(*Zinnia elegans* cv. 'Giant Dahlia Flowered') to varying levels of nitrogenous fertilizer. *Sarhad Journal of Agriculture*. **23**(2): 309-312

Aladakatti YR, Palled YB, Chetti MB, Halikatti SI, Alagundagi SC, Patil P L, Patil VC and Janawade AD. 2012. Effect of nitrogen, phosphorus and potassium levels on growth and yield of stevia (*stevia rebaudiana*bertoni), *Karnataka Journal of Agricultual Science.,**25** (1) : 25-29*

Aruna P, Rajangam J, Geetha Rani P and Manivannan M I. 2007. Nutrient studies in crossandra (*Crossandra infundibuliformis* L. Nees). *The Asian Journal of Horticulture*. **2**(2): 169-177

Asen A, Stuart , NW, and Cox, EL .1963.Proceedings. *American Society for Horticultural Science*.**82**;504-7-10

Asen S, Stuart NW and Siegelman HW. 1958. Effect of various concentration of nitrogen, phosphorus and potassium on sepal colour of *Hydrangea macrophylla*. *American Society for Horticultural Science*. **73**: 495-501

Bailey DA.1992. Hydrangeas..In;R..A.Larson(ed.)Introduction to floriculture,second edition Academic press. San diego, California. p:365-383

Bailey DA.1992. Commercial Hydrangea forcing .Department of Horticulture science University of Georgia .published by North carlonia cooperative extension service.Pg.No.323-326

Bankar G J. 1988. Nutritional studies in tuberose (*Polianthes tuberosa)* cv. 'Double'. *Prog. Hort.*, **20** (1-2): 49-52.

Basheer S.N and Thekkayam SG. 2012. Effect of growing media and organic nutrition on vegetative growth in Anthurium plants (*Anthurium ndreanum*

Bhattacharjee SK. 1981. Influence of Nitrogen, Phosphorus and Potash fertilization on flowering and corm production in gladiolus. *Singapore Jr. of primary industries* **9***(1):23-27*

Bi G and Scagel C F. 2008. Nitrogen uptake and mobilization by hydrangea leaves from foliar-sprayed urea in fall depend on plant nitrogen status. *Horticultural Science.* **43**(7): 2151-2154

Bi G, Scagel C F and Harkess R. 2008. Rate of nitrogen fertigation during vegetative growth and spray application of urea in the fall alter growth and flowering of florist's hydrangeas. *HortScience.* **43**(2): 472-477

Bloom TJ and Piott BD.1992 Florists' Hydrangea blueing with aluminium sulphate applications during forcing .*HortScience* 27:1084-1087

Chattopadhyaya, TK, Biswas MR and Jana, S.C.1995 Nutritional studies in Gladiolus cv. Tropica Sea .National seminar on Ornamental Horticulture and Environment Abstract.**72:**432-440

Chavan M D, Jadhav P B and Rugge V C. 2010. Performance of China aster varieties and their response to different levels of nitrogen . *Journal of Ornamental Horticulture.***6**(4):310-315

Dhanajaya MV and Sulladmath VV. 2003.Assessment of media among tissue culture derived plants of *Anthurium andreanum* cv.Singapore hybrid *Journal of Ornamental Horticulture*. 6(**4)**: 310-315.

Dien, L.Q. (2003) Standardization of growing media under protected environment in Gerbera. M.sc. thesis abstracts .Department of floriculture and Land scaping , Dr. Y. S. parmer University of Horticulture and Forestry , Nauni, Sola

Dilta B S, Latpate M K B, Gupta Y C, Sharma B P , Negi N and Kaushal S. 2015. Influence of growing media and daminozide on growth, flowering and pot presentability of *Hydrangea macrophylla (*Thunb.). *International Journal of Farm Sciences* **5**(3): 111-118

Dilta B S, Latpate M K B, Gupta Y C, Sharma B P , Negi N and Kaushal S. 2016. Effect of growing media and paclobutrazol on growth, flowering and pot presentability of geranium .Pelargonium x hortorum LH Bailey *International journal of farm science* **6(2):**128-136.

Dirr M.A., 2004 Hydrangeas for American gardens Timber press. Portland, America author, University of Georgia **vol(3)** :321-325

Gauarav SB, Katwate SM, Singh BR, Sabale RN, Kakade DS and Dhane AV. 2004.Effect of various nutritional levels on growth and yield of gerbera. *Journal of Ornamental Horticulture*. 7(3): 226-29.

Gowda JVN, Jacob S. and Huddar A.G.(1991) Effect of N,P and K on growth and flowering of Tuberose (*Polianthes tuberosa* Linn) cv. 'Double'. *Indian Perfumer* ,35(2) :100-101

Grewal H S, Kumar R and Singh H. 2004. Effect of nitrogen, planting time and pinching on flower production in chrysanthemum (*Dendranthema grandiflora* Ramat.) cv. 'Flirt'.*Journal of Ornamental Horticulture*. **7**(2): 189-192

Guerin V and Morel P. 1998. 'Blue colouring of Hortensia and aluminium:case study *PHM Revue Horticole* **398**:48-51.

Gupta J and Dilta B S. 2013. Efect of growing substrates and pot sizes on growth and flowering of *Primula malaccoides* Franch, MSc.thesis, Dr.Y.S.Parmar University of Horticulture and Forestry, Nauni,Solan,H.P.

Gupta J and B.S.Dilta. 2015. Effect of growing substrates and pot sizes on growth, flowering and pot presentability of *Primula malacoides* French.*International journal of current research and Acadamic review* ISSN:2347-3215 **3(7):**174-183

Gupta YC, Dein LQ, Dhiman SR and Jain R. 2004.Standardization of growing Media under protected environment for gerbera in mid hill of Himachal Pradesh . *Journal of Ornamental Horticulture*. **7(1):** 99-102.

Jawaharlal M, Prem Joshua J, Arumugam S, Subramanian S. and Vijayakumar M. 2001. Standardization of nutrients and growth regulators to reduce pre-blooming period and to promote growth and flowering in *Anthurium andreanum* under protected shade net house. *South Indian Horticulture* **49**:342-344

Jessica A. 2008 Why are my Hydrangeas not flowering ? bay landscaping news. Perennials plant care, published on September 15.

Jones KD and Reed SM. 2006. production and verification of Hydrangea arborescence "Dardom" × H. involucrata hybrids, *Publication of the American society for horticulture science*. June.**41**(3):564-566.

Kameswari PL, Pratap M, Anuradha G and Hameedunnisa B. 2014. Genetic divergence studies in Chrysanthemum (*Dendranthema grandiflora* tzvelev), *Indian Journal of Science Research and Technology*. **2**(3):4-10

Khalaj M A and Edrisi B. 2012. Effect of plant spacing and nitrogen levels quantity and quality characteristics of Tuberose (*Polianthes tuberosa* L.) under field experiment. *International Journal of Agriculture Sciences*. **2**(3): 244-255

Khalaj M A, Edrisi B and Amiri M. 2012. Effect of nitrogen and plant spacing on nutrients uptake, yield and growth of Tuberose (*Polianthes tuberosa* L.). *Journal of Ornamental and Horticultural Plants*. **2**(1): 45-54

Kraus EJ and Kraybill HR.1918. Vegetative growth and reproduction with special reference to the Tomato, Oregon Agric. coll. Experimental station Bulletin,149.

Link C B and Shanks J B. 1952. Experiments on fertilizer level for greenhouse hydrangeas.*Proceedings of the American Society for Horticultural Science*. **60**. 449-458

Mc George WT.1923.The assimilation of nitrogen by sugarcane nitrate vs ammonium salts ,Planters Rec.**27**:347-52

Merhaut D. and Newman j. 2005. Effect of substrate type on plant growth and nitrate leaching in cut flower production of Oriental lilies, *Horticultural Science*. **40**(3-4):269-273

Mohit M, Umrao V K, Tyagi A K and Meena P M. 2008. Effect of nitrogen and phosphorus levels on growth, flowering and yield of China aster. *Agricultural Science Digest*. **28**: 97-100

Mojahed A.M., Mankareos T.,and Abo Rayaa M.A., 1969, Assortment of vascular plants,773-774

Natarajan S, Nambisan K M P, Krishnan B M and Shanmugavelu K G. 1981. Effect of application of N,P and K on flower yield of *Jasminum sambac* Ait cv. Gundumalli *Indian Perfumer* **35**: 89-92.

Naumann A and Horst WJ. 2003. Effect of aluminum supply on aluminum uptake, translocation and blueing of *Hydrangea macrophylla* (Thunb.) Ser. cultivars in a peat-clay substrate. *Journal of Horticultural Science Biotechnology*. **76**:463–469.

Noguera P, Abad M and Nogura V.2000. Coconut coir waste a new and variable ecologically friendly peat substitute, Acta Hort.**517**:279-283

Pal P and Ghosh P. 2010. Effect of different sources and levels of potassium on growth,flowering and yield of African marigold (*Tagetes erecta* Linn.) cv. 'Siracole'. *Indian Journal of Natural Products and Resources*. **1**(3): 371-375

Qasim M, Ahmad I, Khan M A and Ziaf K. 2005. Efficacy of varying nitrogen levels on growth, flower yield and leaf N contents of *Rosa chinensis* cv. 'Gruss-an-Teplitz'. *Pakistan Journal of Agricultural Sciences*. **42**(3-4): 16-19

Reshma 2002.Effects of growing media on growth and flowering of chrysanthemum M.Sc. (Ag) Thesis abstracts, Department of Floriculture and Land scaping ,Dr.Y.S Parmar University of Horticulture and Forestry, Nauni, Solan,(HP)

Rexilius R .1990. Coconut fibres as crop substrates. *Deutscher Gartenban*, **44(13):**856

Saifuddin M, Hossain AMBS and Normaniza O. 2010. Impacts of shadding on flower formation and longevity, Leaf chlorophyll and growth of Bougainvillea glabra.Asian journal of plantsciences volume **9**(1):20-27,2010

Schreiber HD, Jones AH, Lariviere CM, Mayhew KM and Cain JB, 2011 Role of Aluminium in Red to Blue colour change in *Hydrangea macrophylla* sepals. *Bio metals* .2011 Dec;**24(6):**1005-1015.

Sekar K and Sujata A. 2001. Effect of growing media and GA_3 on growth and flowering of Gerbera (*Gerbera jamsonii* H.Bolus) under naturally ventilated green house. South indian Hort. **49**:338-339

Shah A, Lal SD and Seth JN.1984.Effect of different levels of nitrogen and phosphorus on growth, flowering , and corm yield of gladiolus cv. Vink's Glory. *Progressive Horticulture* .**16**(3-4):305-307

Shanks J B, Haun J R and Link C B. 1950. A preliminary study on the mineral nutrition of ,Hydrangeas.*American Society for Horticultural Science*.**58**:457-465

Sharma MK. 2002. Effect of nitrogen levels and planting dates on growth, yield and quality of gaillardia (*Gaillardia pulchella* Fouger) cv. 'Yellow Double'. M.Sc. (Ag.) Thesis.Gujarat Agricultural University, Sardarkrushinagar, Gujarat (India).

Singatkar SS, Sawant RB, Ranpise SA and Wavhal KN. 1995. Effects of different levels of N, P and K on growth and flower production of gaillardia. *Journal of Maharashtra Agricultural Uniersity*. **20**(3): 392-394

Singh A, Godara N and Kumar A .1996. Effect of NPK on flowering and flower quality of tuberose (*Polianthes tuberosa* L.)cv. Single. *Haryana Agril. Univ .J. of. Research,***26**(1):43-49

Singh J .2010. Studies on the Effect of growing media and paclobutrazol on growth and Flowering of geranium (*Pelargonium* × *hortorum* L.H.Baily). Msc.Thesis,Dr.Y.S.Parmar University of Horticulture and Forestry Nauni,Solan,H.P.

Singh P, Dhaduk B K , Chawla S L, Singh A , Aklade S. A, Desai J. R. and Yadav M. K. 2009. Standardization of growing media for anthurium (*Anthurium andreanum* L.) cv. Flame under protected conditions. *Journal of Ornmental. Horticulture,* **12**(2): 101-105.

Singh,A.2002. Thesis on effect of scale position, plant growth regulators an growing media on bulblet production of *Lilium* hybrids. Department of floriculture and landscaping ,Dr.Y.S. Parmar University of Horticulture and Forestry ,Nauni- Solan(H.P)

Suharban M.2004.Coir pith composting and its utilization organic farming for sustainable agriculture Winter school report. ICAR

Thakur R. 2005. Thesis title- Effect of growing media and fertilizers on growth and Flowering of Rose cv. " Frist red " under protected conditons. Dept. of floriculture and landscaping ,Dr. Y. S. Parmer University of Horticulture and Forestry ,Nauni, Solan (HP)

Thaneshwari .2014. Effect of nitrogen and potassium on growth and flowering of hydrangea (*Hydrangea macrophylla*Thunb.), MSc,Thesis abstracts. Dr. Y.S. Parmar University of Horticulture and Forestry Nauni, Solan (H.P.) 173 230 Department of Floriculture and Landscaping.

Theo J, Blom I and Brian DP. 1992. Florists' Hydrangea Blueing with Aluminum Sulfate Applications during Forcing, *Proceedings of the American Society for Horticultural Science* **27**(10):1084-1087**.**

Tilt K. 2008.Extension specialist and professor, Horticulture, Department, Auburn- University www.what grows there .com/grow/2010/08/15 pruning-big- leaf-hydrangea.

.

Waber A.A and Evens,M.R. 1996. Growth and development *Lilium longi florum.*'Nellie white' in sphagnum peat moss and coir dust based substrates Department of Horticulture, IOWA State University ,Ames. IA, 50011.

Wang Y T. 2007. Potassium nutrition effects on Phalaenopsis growth and flowering. *HortScience*. **42**(7):1563–1567

Waters WE .1967. Influence of nutrition on yield. Quality and chemical composition of Tropicana roses on *Rosa fortuniana* root stocks. Proc St.Hort.Soc.. .**80**:396-400

Wazir JS, Sharma YO and Dhiman SR. 2009. Performance of potted Alstromeria *(Alstroemeria hybrida*) in different growing media under wet temperate conditions, *Journal of Ornamental horticulture* **12**(3):167-174

Young TW, Iley JR and Hayslip NC.1967. Response of roses grown with and without plastic mulch at 3 nitrogen levels. *proc.st.hort.soc*.1966, **79**:438- 443

Zubair M, Ayub G, Khan W F, Khan M and Mahmood Z. 2006. Effect of potassium on preflowering growth of gladiolus cultivars. *Journal of Agricultural and Biological Science*. **1**(3): 36-46

APPENDIX-1

Monthly metrological weather data during the crop growth season (2017-18)

Year	Month	Temperature ^{0}C		Actual (mm)	Relative humidity (%)		Wind Velocity	BSH	Evaporation
		Min	Max		FN	AN	km/hr	hrs	(mm d^{-1})
2017	Sep	33.6	25.7	245.2	92	70	2.4	4.7	3.4
2017	Oct	32.2	24.3	204.5	93	69	2.5	6.0	3.3
2017	Nov	29.6	18.7	55.2	89	56	3.0	7.1	3.3
2017	Dec	28.2	14.4	36.3	92	48	1.9	7.0	3.4
2018	Jan	28.0	12.0	0.0	92	35	1.8	7.3	3.7
2018	Feb	33.7	15.9	0.0	91	29	2.5	8.4	4.2
2018	Mar	36.9	22.2	0.0	92	33	3.8	6.6	5.4
2018	Apr	37.3	24.7	43.9	87	47	7.1	8.4	7.2

FN-Forenoon

AN-Afternoon