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~~Exploring the~~ Effects of varying doses and timing of humic acid application on growth and flowering of *Zinnia elegans*

Abstract

Humic acid contributes to plant growth by improving the uptake of phosphorus and other micronutrients.Apotexperimentwasanalyzedtoknowtheeffectofhumicbasedfertilizerin changing vegetative and flowering dimension of*Zinnia elegans*. Vegetative characters~~like~~such asplantheight, leaf area,rootlength, branching and flowering dimension like days taken toflower,blooming period, flower size, number of flowers each plant was takeninto consideration ~~in this objective~~. The experiment was carried out in ashade net area spraying 3 different concentrations of humicacidindifferent interval of days after transplanting *Zinnia elegans*. Foliar application ofhumic concentration was 2.5~~ml/lit~~,3.5~~ml/lit~~ and 5.0~~ml / lit~~mL/Lsprayed at 10and 30 days. ~~In this objective the record of whole.~~The results for theset of plants sprayedwithhumicacidwerethencomparedwithplantswithoutanyapplication. Treatments dominating the effect of humic acid applicationwhere2.5~~ml/li~~and 3.5 ~~ml/li~~mL/Linboth10 and 30days. This supportsthefactthathumicacidapplicationathigherconcentrationsduringgrowing period of plants can supplement nutrient uptake of all macroand micro nutrients thus reflecting in better vegetative and floweringdimension.Which dosage provided the best result?

INTRODUCTION

Asteraceae, the family of plants that ~~includes~~comprises*Zinnia*species, includes both annual and perennialplants. *Zinnia elegans* L. is said to be the most widely known summer annual. It is a significantsummer flowering crop planted in Egypt for its beauty and various landscaping applications. ItbloomsfromMaytoOctober withavarietyofflower

formsandalovelybloomindiverseflowervarieties. The plant performs well in a variety of settings and has a long vase life. It's great forwalk ways and borders. It is utilized for bedding, mass plantings, and cut flowers in gardens aswellasincontainers andas groundcoverings(Kessler,2008).← Please insert this article in the **References** item.

The most well-known species and a representative of hot and humid climates is the zinnia.

Forcutflowers,tallerzinniacultivarsaretypicallyutilizedinbedsandborders,whiledwarfvarieties are used in window pots and other containers (Jana and Pal, 1991). Zinnias are grown fromseeds, which are first seeded directly in pots before being transplanted into the ground. Zinnianeeded a temperature of 23–27 ^{o}C to germinate in five to seven days. when seedlings aretransplanted ontoafieldorbedswhentheyare3–6weeksold (Schoellhorn*et al.*, 2004).

According to Nardi*et al.*, (2004), humic acid is a bio-stimulant that has a systematic bindingeffectonplant growthanddevelopment and increasesyield.Theorganic,chemical,andphysicalproperties of soil are improved by humic acid (Varanimi*et al.*, 1995; Keeling *et al.*, 2003;Mikkelson,2005).← Please insert these articles in the **References** item.Humic acid is an organic compound derived from plant and animal residues and microbial cells with long-term physical, chemical, and biological processes, and it is also a natural material that improves the efficiency of phosphate fertilizers (Memon et al., 2014b; Mukhtar et al., 2016; Jing et al., 2020)

Materialsandmethods

An experiment was conducted at the Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, Punjab in 2022 to study the effect of Humic acid and time of application on the growth and yield of ~~Zinnia~~*Zinnia elegans*. The experiment was designed as a complete randomized design ~~(CRD)~~ with three replications and a total of nine treatments. The treatments consisted of three different concentrations of humic acid (2.5 ~~ml/l~~, 3.5 ~~ml/l~~, and 5.0ml/L of water) applied at different times: a single spray at an early stage (10 days after transplanting), a single spray at 30 days after transplanting, and a double spray after 10 and 30 days after transplanting. The control treatment involved spraying water.←Please describe this process further. Describe the methodology according to Table 1 and 2.

The experiment began by sowing *Zinnia elegans* seeds in modulated trays placed in a regulated high take greenhouse to facilitate germination. Germination greenhouse or vegetation house with a temperature of ~25 ± 2 ^{0}C, and controlled day/night lighting (?). The sowing media consisted of a mixture of Cocopeat, sand, and soil(X:Y:Z % m/m), which was chosen to enhance germination. Once the seedlings reached the 6 to 7 leaf stage, they were transplanted into plastic pots filled with a mix of Cocopeat, vermiculite, perlite, and soil(X:Y:Z % m/m). At the predetermined time points of 10 and 30 days after transplanting, the respective concentrations of humic acid (2.5 ml, 3.5 ml, and 5 ml) were dissolved in 1 liter of water and applied as a foliar spray to the plants according to the planned treatment.How much of this solution was sprayed on each plant? All other cultural and agronomical practices were maintained uniformly across all applications throughout the process.This method was performed as suggested byAuthor et al (Year).

The **Methodology** item should only contain the detailed description of the processes used. Comments on the results obtained and comparisons with previously published data should be included in **Results and discussion**. Please follow the Guidelines for Authors. Use the suggested template.

Results and discussion

Effectofhumicacidonplantheight

The foliar application of humic acid of different concentration significantly increased plant height. clearlythrough the experiment plants sprayed with 3.5ml/li in 10 and 30 days (T9) Showedhighest increase in theHeight , the highest value of 44.77 cm.The minimum effect showed in the plant height was 2.5ml/li (T2), value of 36.90cm Which is statistically similar tonoapplication of humicacid on plants(T1)*i.e.,* 36.87 cm .The increase in the plant height could be as during the initialgrowingstageandbuddingstagethat is10daysand30daysrespectivelywhenrequirementofnutrition is high , humic acid made the plants absorb soil food more effectively increasing the ongoingmetabolism in zinnia plants. There is a gradual increase in the water holding capacity making the soilmore productive and fertile. Sani (2014) and Abourayya*et al.* (2020). Also, according to Conenose *et*

al.(1990) the presence of IAA,indole-3-acetic acid (IAA)a highly efficient growth regulator in humic acid may have resulted in high plantheight. Calcium is one of leading element to influence plant height. At higher concentration of available humicacidthereoccurshugeuptakeofcalciumfromsoiladdingpositiveimpactonmitoticactivitya tgrowingapicalmeristem,whichconsequentlyproducehigher plantheight(Ahmadian*et al.*, 2011)

Effectofhumicacid onleafarea

~~As shown in Table 1~~ the highest leaf area among all the treatment was resulted from spraying plants with 3.5 MLper liter in 10 and 30 days that is T9 treatment, value shown is 33.67cm^2(Table 1). There was a noticeable increase in the plant height and leave areaintreatmentT9 *i.e.*,3.5ml/liin10and30days. Notsosignificantchangewasseenintheplanswithzerotreatment (lowest of all value shown in T1 application *i.e.*, 20.90cm^2).Thereobservedstatisticallysimilarityinleafareaofthetreatment T6 (3.5ml/lit30days)T5 (2.5ml/lit 30days). The increment in the leaf area in T9 treatment was seen as humic acid is a decent wellspring of carbon, hydrogen,nitrogen,andoxygenwhichcanbegottenfromdecayednaturalmaterial.

Thisindirectlyresults inhealthyrootgrowth.Highrootlengthmakesnutrientsabsorptionmoreefficientthusplants Having ~~excellent~~efficientphotosynthetic activity, cell proliferation, and efficient nutrition absorption all resulted in the increment of leafarea. The increase in leaf area may attributes to presence of humic acid on soil for a longer period of time directly adding to thephoto synthetic activity of the plants. The maximum leaf area was caused by the presence of photosynthetic pigmentswith increased humic acid concentration, as well as the initiation of the production of carotenoids, which protectchlorophyll from oxidative damage, leading to an increase in the number of cells in leaves, the number ofchloroplasts per cell, and gradually the leaf area. The current findings are in agreement with (Yildirim, 2007), whoreportedthattheleafareaincreasedwithincreasinghumicacidconcentration.

Effectofhumicacidonrootlength

Dataconcerningtherootlengthofall thetreatment appliedclearlyshowsthatthetreatmentT9thatis 3.5 ml per liter in 10 and 30 days is highest(16.00cm). On a close look T8 that is 2.5 ml per literml/Lin10and30days (value of 14.57cm)and T9 (16 cm)that is3.5ml per literml/Lin10and 30daysaresimilarstatistically.

So, concentration of 2.5 ~~ml per liter~~ and 3.5 ~~ml per liter~~ml per literml/Lin 10 and 30 days seems to be significantlyeffective in order to obtain high Root length. This can be due to as during the initial days aftertransplanting *Zinnia elegans*~~plant~~ and its height growing period There is also high need to increase in the rootlength to support the plant. Improvement of soil properties by giving humic acid changes the design andelement of plant root development there is an expansion in root size stretching or potentially more roothairs thickness with a bigger surface region. Despite of absence of any rooting hormone in humic acid itfunctions to stop rootinghormones already present in the soil to oxidize and break down. Thus, keepingIAA active for prolong period of time(Ichwan et. al 2017). This improves the plant ability to absorb more water andnutrients.

Effectofhumicacid onbranchingof plants:

Asshownintable1branching of~~zinniaplant~~*Zinnia elegans*ishighestwhensprayedwith3.5ml/litofhumicacidin10and30days(T9) *i.e.*,11.91.Treatmentof3.5MLperliterthatisT9 andtreatment of2.5ML perliterthat isT8(10.77)in10and30daysforboththeconcentrationshowedsimilarbranchingstatistically. Plantwithzerotreatment(minimum value of 4.34)thatistheonehasminimumbranchingcomparedtoall theplantssprayedwithhumicacid. More ~~brunching~~ramification or branches observedat both 10 and 30 growing days can be due to you make acid boost plant uptakeutilization and transport of phosphorus and potassium while reducing damaging aluminum ionsin thesoil reducing soil acidity promoting the release of alkali hydrolysable nitrogen exchangeable calcium anexchangeable magnesium(Memon et.al 2014) As the plants get boost up with all macro and micro nutrients thus adding toits growth. One of significant role of humic acid is buffering. It buffers soil pH 5.5 to 7.5 level,maintaining perfect pH on soil makes the roots to observe nutrient more efficiently leaving a huge long-termpositive impactimplantedinsoil(shahmaleki et.al 2010).

DaystakentofloweronapplyingHumicacid

The data fromTable 2~~clearly~~ signifies plants sprayed with 3.5 mlper liter of humic acid in 10 and 30days (39.71unity?)takes 1/4 of the day to bloom completely as compared with the plants sprayed with 2.5 ml /lit ofhumic acidin 10 days (52.56unity?).after transplanting. Days to bloom for plants sprayed with 2.5 ml/litofhumicacid in 10 daysshowed to be comparatively same withplants sprayed with no treatment(T1-53.50unity?) As discussedearlier Humate based application have significant role in increasing the vegetative growth inplants. Humate basedapplication can also be a great substrate to be used for flowering, regulatingflower periodand adding high value to the ornamental quality of zinnia (Memon *et al.,* 2014). Asapplication of humic acid increases the root length of the plant with structural increase in physical andchemical properties of soil thus making roots to absorb macro elements and trace elements to apicalmeristem and other shoot parts of zinnia more profusely. This can be the reason behind early bloomingofffloweronapplicationofhighconcentrationsofhumicacidingrowingperiod(Yildirim 2007).

NumberofflowersperplantonapplyingHumicacid

Data regarding number of flowers per plant is shown in table 2 which indicates that the highest numberof flowers per plant bloomed in those plants which has been sprayed with 3.5 ML per liter and 2.5 mlperliterinboth10 and30 daysaftertransplanting (*i.e.*,14.23 and 13.59unity?, respectively).Verya smallernumberofflowersbloomedonplantswithno treatment(T1-7.77unity?) which means the spraying of higher concentration of humic acid in both 10 and 30 daysafter transplanting resulted in a greater number of flowers. It is because the high photosynthetic ability ofzinnia plants with increase in leaf area, the increase in rootabsorption efficiency of soil nutrient andbypassing the element to wholeshoot parts has a huge positive impact on blooming number of zinnias.The result is justified by (Tina et al 2015) that applying humic acid in higher concentration increasesfloweringsixtimesperplantincomparetotheplantswithoutanyhumicapplication.

Effectofhumicacidonflowersize:

Foliagesprayofhumicacidinfluencesflowerssizeasshownintable 2.Plants sprayed with higher concentration of humic acid *i.e.,* 3.5 ml/li and 2.5 ml /li for 10 and 30 days (T9-

11.62and T8 -10.42unity?,respectively) showed high rise in *Zinnia elegans* flower size in compare to the plants without any humicacid applications (T1-5.15unity?)This can be due to presence of higher amount of different carbohydrates formin plants like soluble sugar, soluble protein gets increase because of humic acid applications. The fact issupported by Gulzar et.al 2005, due to the presence of High carbohydrate products like soluble sugarand soluble proteins makes the flower size bigger adding to its ornamental values .As humic acidapplication leads to higher amount of soluble sugar and protein on leaves, increases the process ofphotosynthesisonleaves,whichgraduallyinfluencethesizeofzinniaflower(Hong-mei fanet.al2015)

BloomingperiodonapplyingHumicacid

Bloomingperiod of *Zinnia elegans*~~eachplant~~isshowninTable 2. T h e data~~clearly~~significesbloomingperiodof*Zinnia elegans*ishighestinplantssprayedwith3.5mlperliterand2.5MLperliterofhumicacid (36.40 and 37.13unity?,respectively)in10and30daysaftertransplanting.ThelowestnumberofBloomingdayswasnotedinthoseplants withnosprayingofhumicacid(*i.e.,* 28.47unity?)Ethylene which is also known as 'Ripening hormone gets reduced when plants are sprayed with Humatebased fertilizer which may be the cause of high blooming period in zinnia (Imran *et al.,* 2016). This result reported resemble with those reported by (Yazdani *et al.,* 2014), who noted effect of ethylene inplantisinverselyproportionaltotheeffectofhumicacid. Asonapplyinghumicacidthereisreductioninethyleneeffect,thusincreasingthebloomingperiod ofzinnia.

Conclusion

The phenotypical effect of present examination demonstrates that humate based foliar application toflowering ~~plants~~*Zinnia elegans*of high concentration (2.5~~ml/lit~~and 3.5 ml/lit) during growing days (*i.e.,* 10 & 30days) highly influence different vegetative and flowering parameters in plants. The humicacid applicationalso~~shows~~caused along-termpositive impacton soilincomparison to other syntheticbased fertilizer.←In this work was a comparison made with another fertilizer? It seems that a comparison was made with *Zinnia elegans* not treated with humic acid. AmongstalltheapplicationstreatmentT8(2.5

ml/li in10and30days)andT9(3.5 ml/li in10and30days)provento be superior. Hence, concluding that presence of humic acid can enhance the process of nutrientabsorption from soil, tracing the elements to shoot parts specifically to apical meristem, influenceprocess of photosynthesis due to increase in chlorophyll and prompting the ornamental values of *Zinnia elegans*fromallaspect.

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Table 1: Effect of humic acid ~~and time of application~~ in vegetative parameters in *Zinnia elegans*

Treatment	Vegetative parameters			
	Plantheight (cm)	**Leaf area (cm^2)**	**Rootlength (cm)**	**Branching**
T_1	36.9^{f}	20.9^{d}	10.97^{d}	4.34^{e}
T_2	36.87^{f}	21.87^{cd}	11.9^{cd}	5.36^{de}
T_3	37.83^{ef}	23^{cd}	11.9^{cd}	5.36^{de}
T_4	38.83^{def}	23.5^{c}	12.83^{bcd}	6.48^{d}
T_5	39.77^{cde}	28.03^{b}	13.87^{abc}	8.56^{c}
T_6	41.7^{bc}	28.73^{b}	13.67^{bc}	9.63^{bc}
T_7	38.97^{def}	23.73^{c}	12.93^{bcd}	6.46^{d}
T_8	42.53^{b}	29.03^{b}	14.57^{ab}	10.77^{ab}
T_9	44.77^{a}	33.67^{a}	16^{a}	11.91^{a}

T_{10}	40.83^{bcd}	28.47^{b}	13.9^{abc}	9^{bc}
Sem+	0.68	0.66	0.67	0.59
CD at 5%	2.02	1.94	1.98	1.76

In a column means followed by same letters are not significantly different at P=0.05.CD = ?

Table 2: Effect of humic acid and time of application in flowering parameters in *Zinnia elegans*

Treatment	Flowering parameters			
	Days taken to flower	**Number of flowers**	**Flower size**	**Blooming period**
T1	53.5^{a}	7.74^{e}	5.15^{f}	28.44^{e}
T2	52.56^{a}	7.99^{e}	5.14^{f}	29.43^{e}
T3	50.87^{b}	10.96^{d}	6.24^{ef}	29.37^{e}
T4	49.91^{bc}	12.3^{bc}	6.21^{ef}	31.34^{d}
T5	46.44^{d}	11.81^{cd}	8.29^{cd}	34.55^{c}
T6	39.37^{f}	12.81^{abc}	9.35^{bc}	34.88^{bc}
T7	48.53^{c}	10.8^{d}	7.29^{de}	31.37^{d}
T8	39.96^{f}	13.31^{ab}	10.42^{ab}	37.05^{a}
T9	39.17^{f}	13.82^{a}	11.62^{a}	36.29^{ab}
T10	42.02^{e}	12.8^{abc}	8.57^{c}	34.55^{c}
Sem+	0.48	0.38	0.40	0.52
CD at 5%	1.43	1.12	1.20	1.54

In a column means followed by same letters are not significantly different at P=0.05

Flower size = centimeters around the broadest circumference of the bulb.?

Blooming period = days?