Effect of seaweed extracts on growth and yield of China aster cv. Arka Archana under Prayagraj agro climatic conditions

ABSTRACT

The objective of this study was to assess the effect of seaweed extracts on the growth and yield of China aster (cv. Arka Archana). Thirteen different treatments,along with control were employed in order to investigate their effects. The treatments consisted of two concentrations (2ML/L and 4ML/L) of *Ascophyllum nodosum* seaweed extract, two concentrations (2ML/L and 4ML/L) of *Durvillaea potatorum* seaweed extract, and application intervals of 5, 10, and 15 days.To ensure accuracy and reliability, each treatment in the study was replicated three times using a randomized block design (RBD).Various growth parameters, including plant height (cm), number of leaves, number of branches, plant spread (cm), were examined to assess the plant's growth progress. The yield parameter was assessed by examining flower yield per plant, flower yield per plot, and flower yield per hectare.Among the different treatments, treatment T9 (2ML/L *Ascophyllum nodosum* applied at 15 days interval) demonstrated the highest values for various parameters, including plant height (53.41 cm), number of leaves (172.78), number of branches (25.40), plant spread (53.33 cm), flower yield per plant (367.15 g), flower yield per plot (2202.92 g), and flower yield per hectare (23.13 t). Conversely, the control group (water spray) exhibited the lowest values across all parameters. These findings led to the conclusion that foliar applications of 2ML/L A*scophyllum nodosum* at 15 days interval have the potential to significantly enhance flower yield, making it a promising option for improving overall productivity.

Keywords*: *Ascophyllum nodosum, Durvillaea potatorum, China aster, Seaweed extracts,RBD.

Introduction

China aster, scientifically known as *Callistephus chinensis* and belonging to the Asteraceae family, is a highly sought-after winter annual flower that ranks third in popularity, just after Chrysanthemum and Marigold (Sheela, 2008**).** The name of the genus, '*Callistephus*,' originates from the Greek words 'Kalistos,' which means 'most beautiful,' and 'Stephos,' which means 'a crown.' The term 'China aster' signifies a star, symbolizing the flower's stunning beauty and vibrancy. Native to China, it expanded its presence to Europe and other tropical countries around 1731 AD (Desai, 1967). Linnaeus originally named the flower Aster chinensis, but it was later reclassified by Nees as *Callistephus chinensis*, marking a change in its scientific nomenclature (Janakiram, 2001). The present-day asters have been developed from a single form of wild species, *Callistephus chinensis.*

China aster, scientifically known as *Callistephus chinensis*, is a half-hardy annual plant characterized by erect branches covered in hispid hair. The leaves are arranged alternately on the branches, broadly ovate or triangular-ovate in shape, deeply and irregularly toothed. The flowers of China aster are solitary in nature. The evolution of China aster has been a fascinating journey marked by notable variations. The original plant featured single flowers with two or four rows of blue, violet, or white ray florets. It had a medium-tall stature, ranging from 18 to 24 inches in height. The first notable change in the flower type involved the extension or development of central florets, resulting in the production of high-quality flowers. China aster blooms consist of two types of florets: ray florets and disc florets. The disc florets are short, while the ray florets are typically long. The type of bloom largely depends on the relative number and shape of these two types of florets.

The utilization of liquid seaweed extract has been suggested to promote plant growth (Metting *et al.*, 1990). It has been used in agriculture for many years (Crouch, 1990). In the North Atlantic Ocean, *Ascophyllum nodosum* is a well-known species of brown algae (Phaeochyceae) (Verkleij, 1992). The application of seaweed extracts as soil conditioners and foliar sprays has been employed to enhance the growth, yield, and overall productivity of various crops (Norrie and Keathley, 2006). According to a report from FAO (2006), a substantial quantity of seaweeds (approximately 15 million metric tonnes per year) is utilized as nutrient supplements and biostimulants in the cultivation of agricultural and horticultural crops.

The utilization of biostimulants is known to enhance nutrient uptake and improve nutrient use efficiency, leading to reduced reliance on synthetic fertilizers and promoting soil health. Plant biostimulants, including protein hydrolysates and seaweed extracts, have garnered significant attention from scientists and vegetable growers due to their potential to enhance crop yield and nutritional quality. Although the concept of biostimulants has been studied since 1933 (Yakhin et al., 2017), their importance has gained prominence in recent years as a possible solution to mitigate the adverse effects of climate change on agriculture. Seaweed extracts are among the inputs classified as biostimulants, which are substances that stimulate plant growth when applied in small quantities and are also known as metabolic enhancers. Furthermore, they not only promote plant growth but also improve yield and quality. The use of biostimulants, capable of positively modifying plant growth, has experienced significant growth in the past decade (Vinutha et al., 2017).

The use of seaweed and seaweed-derived products as amendments in crop production systems is prevalent due to the presence of various compounds that stimulate plant growth. Seaweeds, unlike terrestrial organisms, produce specific stress-related compounds that are crucial for their survival in marine environments (Shukla et al., 2016). Consequently, selected seaweed resources serve as valuable sources of plant biostimulants and are extensively utilized to enhance agricultural productivity (Khan et al., 2009; Sharma et al., 2014; Van Oosten et al., 2017). Moreover, the efficacy of algae in promoting the growth and flowering of ornamental plants has been scientifically substantiated.

However, the research related to use of seaweed extracts in China aster is meagre. Hence, in view of the above facts the present study was formulated to study the effect of seaweed extracts on growth and yield of China aster cv. Arka Archana.

Materials and Methods

The research was conducted at the Department of Horticulture, Naini Agricultural Institute, SHUATS, Prayagraj (U.P)during 2022-2023.Under open field condition, the soil was prepared to a fine tilth and raised beds of 3.0 m x 1.0 m were prepared. Healthy seedlings of China aster cv. Arka Archana (White) 45 days old were planted at 30 cm x 30 cm spacing. The experiment used a Randomized Block Design (RBD), with thirteen treatments and three replications. Treatments consisted of T0-Control,T1 -2ML/L *Durvillaea potatorum* @ 5 days interval, T2 -2ML/L *Durvillaea potatorum* @ 10 days interval, T3 -2ML/L *Durvillaea potatorum* @ 15 days interval, T4 -4ML/L *Durvillaea potatorum* @ 5 days interval, T5 -4ML/L *Durvillaea potatorum* @ 10 days interval T6 -4ML/L *Durvillaea potatorum* @ 15 days interval T7 -2ML/L *Ascophyllum nodosum* @ 5 days interval, T8 - 2ML/L *Ascophyllum nodosum* @ 10 days interval T9 - 2ML/L *Ascophyllum nodosum* @ 15 days interval, T10 - 4ML/L *Ascophyllum nodosum* @ 5 days interval ,T11 -4ML/L *Ascophyllum nodosum* @ 10 days interval ,T12 - 4ML/L *Ascophyllum nodosum* @ 15 days interval.The observations that were recorded are plant height (cm),number of leaves, number of branches, plant spread (cm),flower yield per plant(g),flower yield per plot(g),flower yield per hectare(t) at 90 DAT and the data was subjected to statistical analysis using the Fisher's analysis of variance (ANOVA) technique, following the guidelines provided by Gomez and Gomez (1984).

The formulas used for calculating yield parameters were as follows:

- Flower yield per plant = Total number of flowers x Weight of single flower

- Flower yield per plot = Total number of plants in the plot x Flower yield per plant

- Flower yield per hectare = Flower yield per plant x Total number of plants per hectare

These formulas enable the estimation of flower yields at different levels, from individual plants to entire plots and hectares, allowing for comprehensive analysis and assessment of production potential.

Results and discussion

The effect of seaweed extract on growth and yield of China aster cv. Arka Archana are presented in Table 1 and 2 respectively.

Growth parameters

Plant height (cm) –At 90 days after transplanting (DAT), the treatment T9, which involved spraying 2ML/L *Ascophyllum nodosum* at 15 days interval, exhibited the highest plant height (53.41 cm) which was significantly superior to all the treatments. Following closely was treatment T12, which employed 4ML/L *Ascophyllum nodosum* at 15 days interval with plant height (52.39 cm). In contrast, the control treatment (T0) consisting of water spray recorded the lowest plant height (39.73 cm).

The remarkable increase in plant height observed in the treatments using *Ascophyllum nodosum* can be attributed to its influence on cell enlargement, cell division, and inter nodal elongation. This seaweed extract contains growth regulators like auxins and cytokinins, which promote these cellular processes. Additionally, *Ascophyllum nodosum* is rich in macro and micronutrients that enhance the utilization of chemical fertilizers by stimulating cell division and expansion. Consequently, plants experience heightened growth and accelerated vegetative development.

Similar findings have been reported in previous studies. Hegde et al. (2018) observed comparable results in chrysanthemum, Tartil et al. (2016) in pot marigold, Kahkashan et al. (2017) in tuberose, and Praveen et al. (2020) in rose, further supporting the beneficial effects of *Ascophyllum nodosum* on plant growth.

Number of leaves per plant-At 90 days after transplanting (DAT), the treatment T9, which involved spraying 2ML/L *Ascophyllum nodosum* at 15 days interval, exhibited the highest number of leaves (172.78) which was significantly superior to all the treatments. Following closely was the treatment T12, which employed 4ML/L *Ascophyllum nodosum* at 15 days interval, with a number of leaves (159.55). In contrast, the control treatment (T0) consisting of water spray recorded the lowest number of leaves, with a count of (90.00).

The significant increase in the number of leaves observed in the treatments using *Ascophyllum nodosum* can be attributed to the presence of cytokinins and auxin precursors, as well as macro and micronutrients in the seaweed extract. These components promote cell division and expansion, facilitating rapid vegetative development. Furthermore, auxin and cytokinins directly influence plant architecture by guiding the establishment, maintenance, and growth of shoot apical and axillary meristems.

These findings align with previous research conducted in marigold by Machado et al. (2014) and Rajarajan et al. (2014), which also demonstrated the positive effects of *Ascophyllum nodosum* on leaf production and overall plant development.

Number of branches- At 90 days after transplanting (DAT), the treatment T9, which involved spraying 2ML/L *Ascophyllum nodosum* at 15 days intervals, exhibited the highest number of branches (25.40) which was significantly superior to all the treatments.. Following closely was the treatment T12, which employed 4ML/L *Ascophyllum nodosum* at 15 days interval, with a number of branches measuring (24.07). In contrast, the control treatment (T0) consisting of water spray recorded the lowest number of branches, with a count of (18.41).

The remarkable increase in the number of branches observed in the treatments using *Ascophyllum nodosum* can be attributed to the presence of auxins, particularly indole-3-acetic acid (IAA), which promotes the development of adventitious roots and facilitates robust growth. Additionally, the cytokinins present in the *Ascophyllum nodosum* seaweed extract stimulate lateral growth by triggering the sprouting of axillary buds (Selvakumari and Venkatesan, 2017).

Similar findings have been reported in previous studies conducted on various plant species. Bhargavi et al. (2018) observed similar effects in chrysanthemum, Hegde et al. (2018) in chrysanthemum, Praveen et al. (2020) in rose, and Tartil et al. (2016) in pot marigold.

Plant spread (cm) - At 90 days after transplanting (DAT), the treatment T9, which involved spraying 2ML/L *Ascophyllum nodosum* at 15 days intervals, exhibited the maximum plant spread, measuring (53.33 cm) which was significantly superior to all the treatments.Following closely was the treatment T12, which employed 4ML/L *Ascophyllum nodosum* at 15 days interval, with a plant spread of (52.00 cm).In contrast, the control treatment (T0) involving water spray recorded the minimum plant spread, measuring (44.00 cm).

The significant improvement in plant spread observed in the treatments utilizing *Ascophyllum nodosum* can be attributed to the presence of plant growth regulators and nutrients within the seaweed extract. These substances may have influenced cellular metabolism in the treated plants, leading to enhanced vigor and growth.

Similar effects have been reported in a study conducted on rose by Praveen et al. (2020).

Flower yield parameters

Number of flower yield /plant (g)– Among all the treatments, the treatment T9, which involved spraying 2ML/L *Ascophyllum nodosum* at 15 days intervals, recorded the highest flower yield per plant, measuring (367.15g) which was significantly superior to all the treatments.Following closely was the treatment T12, which employed 4ML/L *Ascophyllum nodosum* at 15 days interval, with a flower yield per plant of (290.92g). In contrast, the control treatment (T0) involving water spray recorded the minimum flower yield per plant, measuring (159.99g).

The increase in flower yield per plant observed in the treatments utilizing *Ascophyllum nodosum* can be attributed to the enhanced vegetative development induced by the seaweed extract. This increased vegetative growth likely resulted in higher production and accumulation of photosynthates, which were directed towards increased flower output. The greater number of leaves per plant in these treatments may have contributed to the higher flower yield, as more leaves can produce and store more photosynthates in the plant, leading to increased cell formation and ultimately more flowers.

Similar findings have been reported in previous studies conducted on various plant species, including marigold by Russo et al. (1994), chrysanthemum by Hegde et al. (2016) and Bhargavi et al. (2018), pot marigold by Tartil et al. (2016), rose by Praveen et al. (2020), and Chinese carnation and Gazania splender by Majeed Khadim Al-Hamzawi (2019).

Number of flower yield/plot (g) – Among all the treatments, the treatment T9, which involved the application of 2ML/L *Ascophyllum nodosum* at 15 days intervals recorded the highest flower yield per plot (2202.92g) which was significantly superior to all the treatments.. Following closely was T12 which employed 4ML/L *Ascophyllum nodosum* at 15 days interval with a flower yield per plot of 1745.54g. In contrast, the control treatment (T0) with water spray recorded the lowest flower yield per plant (959.92g).

The notable increase in flower yield can be attributed to the enhanced vegetative growth stimulated by the treatment. This increased growth led to the production of a larger amount of photosynthates, which were likely redirected towards promoting flower production. The higher number of flowers can be attributed to the presence of more leaves in the treated plants. The increased leaf area allowed for greater photosynthate accumulation in the plant's sink, which facilitated the formation of new cells and ultimately resulted in a higher flower yield.

Similar findings have been reported by Russo et al. (1994) in marigold, Pruthvi et al. (2016) in chrysanthemum, Tartil et al. (2016) in pot marigold, Bhargavi et al. (2018) in chrysanthemum, Praveen et al. (2020) in rose, and Majeed Khadim Al-Hamzawi (2019) in Chinese carnation and Gazania splender. Their studies also demonstrated the positive effects of treatments on flower yield, emphasizing the importance of vegetative growth and photosynthate utilization in maximizing flower production.

Number of flower yield /hectare (t) - Among all the treatments, T9, which involved the application of 2ML/L *Ascophyllum nodosum* at 15 days intervals, recorded the highest flower yield per hectare (23.13 t) which was significantly superior to all the treatments. Following closely was T12 which employed 4ML/L *Ascophyllum nodosum* at 15 days interval with a flower yield per hectare of 18.32 t. In contrast, the control treatment (T0) with water spray recorded the lowest flower yield per hectare (10.08 t).

The significant increase in flower yield can be attributed to the enhanced uptake of nutrients such as nitrogen and phosphorus, as well as the synthesis of carbohydrates and proteins stimulated by the treatment. These factors contributed to the overall improvement in plant growth, including plant height, plant spread, and number of branches. The positive correlation between these growth parameters and flower yield is well-supported by the findings of Pruthvi et al. (2016) in chrysanthemum, Bhargavi et al. (2018) in chrysanthemum, and Haider et al. (2012) in potato.

The results highlight the importance of proper nutrient uptake and utilization in maximizing flower production, leading to higher yields per hectare.

CONCLUSION

Based on the findings of the current study, it can be concluded that treatment T9 (2 ML/L *Ascophyllum nodosum* @ 15 days interval) was effective in enhancing China aster growth and yield. The usage of seaweed as a method to increase crop yield is an environmentally beneficial practice, according to the current study. In order to get the maximum flower yield, it may be advised to spray the China aster plants with (2 ML/L *Ascophyllum nodosum* @ 15 days interval).

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Table 1. Growth parameters of effect of seaweed extracts on China aster cv. Arka Archana

Notation	Treatment combination	Plant height (cm)	Number of leaves per plant	Number of branches	Plant spread (cm)
T_0	Control	**39.73**	**90.00**	**18.41**	**44.00**
T_1	2 ML/L *Durvillaea potatorum* @ 5 days interval	**48.92**	**100.11**	**19.10**	**51.44**
T_2	2 ML/L *Durvillaea potatorum* @ 10 days interval	**47.86**	**99.44**	**19.75**	**44.44**
T_3	2 ML/L *Durvillaea potatorum* @ 15 days interval	**44.24**	**104.55**	**21.09**	**51.00**
T_4	4 ML/L *Durvillaea potatorum* @ 5 days interval	**49.00**	**102.00**	**20.87**	**44.33**
T_5	4 ML/L *Durvillaea potatorum* @ 10 days interval	**46.94**	**119.33**	**23.30**	**49.77**
T_6	4 ML/L *Durvillaea potatorum* @ 15 days interval	**48.70**	**129.00**	**20.30**	**47.77**
T_7	2 ML/L *Ascophyllum nodosum* @ 5 days interval	**47.84**	**91.67**	**20.17**	**48.44**
T_8	2 ML/L *Ascophyllum nodosum* @ 10 days interval	**50.13**	**133.77**	**22.63**	**50.00**
T_9	2 ML/L *Ascophyllum nodosum* @ 15 days interval	**53.41**	**172.78**	**25.40**	**53.33**
T_{10}	4 ML/L *Ascophyllum nodosum* @ 5 days interval	**46.64**	**139.44**	**21.53**	**44.66**
T_{11}	4 ML/L *Ascophyllum nodosum* @ 10 days interval	**48.92**	**141.00**	**22.07**	**51.22**
T_{12}	4 ML/L *Ascophyllum nodosum* @ 15 days interval	**52.39**	**159.55**	**24.07**	**52.00**
	Sem (±)	**2.05**	**1.98**	**0.42**	**2.06**
	CD (5%)	**6.01**	**5.80**	**1.22**	**6.02**

Table 2.Yield parameters of effect of seaweed extracts on China aster cv. Arka Archana

Notation	**Treatment combination**	**Flower yield/plant (g)**	**Flower yield/plot (g)**	**Flower yield/hectare (t)**
T_0	Control	**159.99**	**959.92**	**10.08**
T_1	2 ML/L *Durvillaea potatorum* @ 5 days interval	**218.90**	**1313.38**	**13.79**
T_2	2 ML/L *Durvillaea potatorum* @ 10 days interval	**206.86**	**1241.14**	**13.03**
T_3	2 ML/L *Durvillaea potatorum* @ 15 days interval	**201.55**	**1209.28**	**12.69**
T_4	4 ML/L *Durvillaea potatorum* @ 5 days interval	**206.52**	**1239.14**	**13.01**
T_5	4 ML/L *Durvillaea potatorum* @ 10 days interval	**256.73**	**1540.40**	**16.17**
T_6	4 ML/L *Durvillaea potatorum* @ 15 days interval	**265.59**	**1593.53**	**16.73**
T_7	2 ML/L *Ascophyllum nodosum* @ 5 days interval	**206.72**	**1240.30**	**13.07**
T_8	2 ML/L *Ascophyllum nodosum* @ 10 days interval	**228.08**	**1368.50**	**14.37**
T_9	2 ML/L *Ascophyllum nodosum* @ 15 days interval	**367.15**	**2202.92**	**23.13**
T_{10}	4 ML/L *Ascophyllum nodosum* @ 5 days interval	**186.61**	**1119.66**	**11.75**
T_{11}	4 ML/L *Ascophyllum nodosum* @ 10 days interval	**221.96**	**1331.76**	**13.98**
T_{12}	4 ML/L *Ascophyllum nodosum* @ 15 days interval	**290.92**	**1745.54**	**18.32**
	Sem (±)	**13.23**	**79.43**	**0.83**
	CD (5%)	**38.64**	**231.85**	**2.43**