EFFECT OF CROP GEOMETRY AND AGE OF SEEDLINGS ON ITS GROWTH, FLOWER YIELD AND QUALITY OF STATICE (*Limonium sinuatum* L.) UNDER PRAYAGRAJ AGRO CLIMATIC CONDITIONS

ABSTRACT

The present investigation was carried out to find out the most suitable treatments for plant growth and flower yield and quality of Limonium during Rabi season 2021-2022 at Experimental field, Department of Horticulture, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.), India. The experiment was laid out in a Factorial randomized block design (FRBD) with 8 treatments which is replicated thrice. The first factor consists of four different levels age of seedlings *i,e.* 25,30,35,40 days old seedlings, second factor with two different spacings 45×60 cm and 30×45 cm. In Growth parameters, T_7 (40 days seedlings + spacing of 45×60cm) recorded significantly highest number of leaves (80.49), leaf length (32.20cm), plant spread(45.65cm^2) Whereas, plant height was recorded significantly highest (84.80cm) in T_6 (35 days seedlings + spacing of 30×45cm). In photosynthetic characteristics, the maximum leaf area (66.09 cm^2), leaf weight (24.94gm) and chlorophyll content (97.90 SPAD UNITS) was recorded in T_7 (40 days seedlings + spacing 45×60 cm)**.** In flowering parameters, the minimum number of days for flower stalk initiation (47.28 days) and flower duration (45.72 days) was recorded significantly in T_7 (40 days seedlings + spacing of 45×60cm) whereas, the length of flower stalk was recorded significantly highest (80.07) in T_6 (35 days seedlings + spacing of 30×45cm).The maximum yield with superior quality of flower stalks/plot was obtained significantly highest (80.22) in T_6 (35 days seedlings + spacing of 30×45cm).In post-harvest parameters the vase life of statice flower placed in water recorded maximum (8.69 days) in T_6 (35 days seedlings + spacing 30x45cm), whereas vase life of statice flower placed in 2% sucrose (14.35 days) and self-life (63.33 days) of flower was recorded maximum in T_7 (40 days seedlings + spacing of 45x60cm).

Keywords**:** *Age of seedlings, plant geometry, photosynthetic characteristics, Limonium*

1. INTRODUCTION

Limonium (*Limonium sinuatum* L.) is the modern name to **'Statice'** or sometimes **'Sea Lavender'**. Limonium adds variety in terms of colour, flower size and shape to the beautiful world of flowers. The production of Limonium is of special interest because the flowers may be used either fresh or dried and are available in an assortment of colours. The plants are grown in the border, rockery and for cut flowers

in green houses. The flowers may be dried and used as everlasting ones. Some of the species are also used for medicinal purpose. Limionium belongs to the family **Plumbaginaceae** and genus 'Limonium'. They are native to Europe, Mediterranean regions, Asia, the Canary Islands and Africa. These plants once belonged to the genus Armeria and were later changed to the genus Limonium. The name 'Statice' was entirely rejected botanically but is still in common usage. Genus Limonium is classified into annual and perennial ones. **Statice** is a biennial plant, but treated as an annual, usually grown as a half hardy annual.

Statice is also suitable for flower beds, borders, small clumps, rock gardens as a pot plant. **(Frances perry 1986)**. *L. sinuatum* originated in Mediterranean region, *L.bonduelli* from Algeria while *L.suworawii* mainly used for dried flower arrangement originated in Turkastan **(Frances perry, 1972).** The ideal temperature for best flower production is 22 to 27^0 c during day time and 12 to 16^oc during night time **(Hilverda.,1994).**

Commercially, both annuals and perennials are popular but the perennials are more in demand. It is one among the top ten flowers sold at the Aalsmeer Flower Auction Centre, Holland. Around 60 percent of Netherlands auction supply is from Israel, Kenya and Zimbabwe. Total Netherlands supply of perennial statice was 58.2 million stems in 1993,73.4 million stems in 1994 and 61.5 million stems in 1995 (**Anon.,1997**).

Plant density plays an important role in case of physiological functioning of plant. The planting distance affect the availability of nutrients, water, and light to plant which affect the photosynthetic activities which have ultimate effect on plant growth and yield. Thus, plant density at which a crop is planted has an immense role in growth, yield and flowering of crop. It has been reported by many workers that a close spacing has an adverse effect on the growth and quality of flowers even though the total yield increases, while wide spacing induces vigorous vegetative growth but yields are due to limited plant population.

Time of planting is the most important factor in influencing the yield of crop. performance of genotype entirely depends upon the time of planting. Delay in planting generally results in yield reduction which cannot be compensated by any other means. Timely transplanting seedlings results in earlier harvest than early transplanting Tender aged or over aged seedlings are not suitable for better yield. Medium aged seedlings result in greater leaf area, high yield **(Hassan, 1967).**

Several investigations have been conducted to see the effect of transplant age on crop performance. Those results showed that too young or too old seedlings reduced the plant growth significantly as compared to normal middle age seedlings. The seedlings of too young age might have setback in reestablishment after transplanting perhaps because of their soft and tender roots, thus their growth is retarded in main field after transplanting. On the other hand, plants kept for longer time in nursery bed either get too leggy or become too woody due to check of growth and such old age seedlings do not make a quick start when transplanted in the main field **(Thompson and Kelly, 1983)**

2. MATERIAL AND METHODS

The experiment was carried out at the department of research field, department of Horticulture, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj(2021-22) which is situated in the agro climatic zone (sub-tropical belt) of Uttar Pradesh. Prayagraj is located in the south-east part of Uttar Pradesh India. Prayagraj falls under agro-climate zone IV which is named as “middle Gangetic plains” the site of experiment is located at 98 meters from sea level at 25.57º N latitude 81.51º E longitude has a typical subtropical climate with extremes of summer and winter. The maximum temperature of the location reaches up to 46ºc - 48ºc and seldom falls down as low as 4ºc-5ºc during winter the average rainfall in this area is around during winter season especially in the month of December and January the average rainfall in this area is around 1027 mm annually with maximum concentration during July to September with few showers and drizzles in winter also.

The expirement was laid out in Factorial randomized block design (FRBD) with eight treatments which is replicated thrice with two factors, Factor I (age of seedlings) with 25, 30, 35, 40 days old seedlings and Factor-II (spacing) with 45×60 cm ,30×45 cm which is conducted in October 2021, after 30,60,90,120 DAT the readings recorded were growth parameters, photosynthetic characteristics, flowering parameters, yield parameters, post-harvest parameters. The results and data were subjected to statistical analysis separately by using analysis of variance technique (ANOVA). The difference among treatments means was compared by using least significant difference test at 5% probability levels.

3. RESULT AND DISCUSSION

3.1 Growth Parameters

The growth parameters were measured in terms of plant height (cm), number of leaves, length of leaves(cm), plant spread (cm^2) in table 1. At 120 DAT, in different levels of age of seedlings the plant height (79.93 cm) was recorded significantly highest in T_3 (35 days old age of seedlings), followed by T_4 (40 days old age of seedlings) with (79.91cm) and lowest plant height (65.61cm) was recorded in 25 days old age of seedlings. The number of leaves (79.22), length of leaves (31.41cm), plant spread (39.00cm^2) was significantly recorded highest in 40 days old age of seedlings, followed by T_3 (35 days old age of seedlings) in number of leaves (78.37), leaf length (30.60 cm), plant spread (37.88cm^2), and lowest was recorded in T_1 (25 days old age of seedlings).

In different levels of spacings the plant height (79.51cm) was recorded significantly highest in S_2 (30×45cm) and lowest (70.34 cm) in S_1 (45x60cm). Whereas the number of leaves (78.05), length of leaves (30.53cm), plant spread (37.03cm^2) were significantly recorded highest in S_1 and minimum number of leaves (69.83), length of leaves(29.41cm), plant spread (30.23cm^2) was recorded in S_2 (30×45cm) significantly.

Among the interactions between age of seedlings and spacing, the plant height was recorded significantly highest (84.80cm) in T_6 (35 days old age of seedlings with spacing 30×45 cm) ,followed by (81.62 cm) in T_8 (40 days old age of seedlings with spacing 45×60 cm) and lowest plant height (60.03 cm) was

recorded in T_1 (25 days old age of seedlings with spacing of 45×60 cm), where highest number of leaves (80.49), leaf length (32.20cm), plant spread (45.65cm^2) were recorded in T_7 (40 days old age of seedlings with spacing 45×60 cm) followed by T_5 (35 days age of seedlings with spacing of 45×60 cm) with number of leaves(79.59), length of leaves (31.50), plants spread (44.32 cm^2) and lowest were recorded in T_2 (25 days old age of seedlings with 30×45cm) significantly .

Plant height increases gradually with the advancement of age. Maximum plant height was recorded in 35 days old age of seedlings with closer spacing ,at a closer planting distance, less space is available for the spread of the plant, and hence all the food material is utilized in erect growth of the plant, resulting in more plant height .Whereas planting distance increased, plants got more space for their spread and food material is used for the growth of spread ,vegetative buds hence there is more cell division ,cell elongation and get more sunlight for synthesis of food material which is used for leaf bud formations, resulting in more number of leaves, length of leaves ,plant spread at wider planting distance. . The same result is reported by **Chaudhary *et al*. (2007)** in zinnia, **Karuppaiah *et al*. (2005)** in marigold.

Table 1. **Growth parameters as influenced by different levels of age of seedlings, spacing and their interaction effect in statice.**

Treatments	Plant height (cm)	Number of leaves	Length of leaves (cm)	Plant spread(cm^2)
Levels of age of seedlings				
T_1 (25 days old age of seedlings)	65.61	74.69	28.43	27.93
T_2 (30 days old age of seedlings)	74.25	76.63	29.45	29.70
T_3 (35 days old age of seedlings)	79.93	78.37	30.60	37.88
T_4 (40 days old age of seedlings)	79.91	79.22	31.41	39.00
S.Em	0.41	0.170	0.138	0.432
C.D	1.27	0.520	0.423	1.323
Levels of Spacing				
S_1 (45×60 cm)	70.34	78.05	30.53	37.03
S_2 (30×45 cm)	79.51	76.41	29.41	30.23
S.Em	0.29	0.120	0.098	0.305
C.D	0.90	0.367	0.299	0.935
Interaction (T × S)				
S.Em	0.58	0.240	0.195	0.611
C.D	1.80	0.735	0.598	1.871

3.2 Photosynthetic Characteristics

The photosynthetic characteristics are measured in terms of Leaf area (cm^2), leaf weight (g), chlorophyll content (SPAD UNITS). In different levels of age of seedlings, the maximum leaf area (65.03cm^2), leaf weight (23.83 gm) and chlorophyll content (97.25 SPAD UNITS) were recorded in T_4 (40 days old age of seedlings) followed by T_3 (35 days old age of seedlings) in leaf area (64.49cm^2), leaf weight (22.61 gm) and chlorophyll content (95.95 SPAD UNITS) and minimum were recorded in T_1 (25 days old age of seedlings).

In different levels of spacing the maximum leaf area (63.67cm^2), leaf weight (22.33 gm) and chlorophyll content (88.79 SPAD UNITS) were recorded in S_1(45**×** 60cm) and minimum leaf area (62.04cm^2), leaf weight (21.37 gm) and chlorophyll content (86.43 SPAD UNITS) were recorded in S_2 (30×45cm)

Among the interactions between age of seedlings and spacing, maximum leaf area (66.09), leaf weight (24.94 gm) and chlorophyll content (97.90 SPAD UNITS) is observed in T_7 (40 days old age of seedlings with spacing of 45x60cm) and minimum leaf area (59.32 cm^2), leaf weight(19.16gm), chlorophyll content (68.13 SPAD UNITS) were recorded in T_2 (25 days old age of seedlings with spacing 30×45cm) .

More photosynthetic characteristics was obtained at wider spacing because of the reason that plants grow vigorously without much competition for nutrients and sunlight which might have favoured to synthesis of plant pigments –chlorophylls and carotenes. Similar results were also obtained by **Khobragade et al. (2012** in china aster. **Agarwal et al. (2016)** in golden rod finds similar results.

Table 2: Photosynthetic characteristics as influenced by different levels of age of seedlings, spacing and their interaction effect in statice.

Treatments	Leaf area (cm^2)	Leaf weight (g)	Chlorophyll content
Levels of age of seedlings (T)			
T_1 (25 days old age of seedlings)	59.89	19.49	69.18
T_2 (30 days old age of seedlings)	62.01	21.47	88.05
T_3 (35 days old age of seedlings)	64.49	22.61	95.95
T_4 (40 days old age of seedlings)	65.03	23.83	97.25
S.Em	0.30	0.20	4.31
C.D	0.93	0.63	13.20
Levels of spacings (S)			
S_1 (45×60 cm)	63.67	22.33	88.79
S_2 (30×45 cm)	62.04	21.37	86.43
S.Em	0.21	0.14	3.04
C.D	0.65	0.45	NS
Interaction (TXS)			
S.Em	0.43	0.29	6.09
C.D	NS	0.63	NS

3.3 Flowering Parameters

The flowering parameters are measured in terms of number of days required for flower stalk initiation, length of flower stalk, flower duration. In different levels of age of seedlings, the minimum number of days for flower stalk initiation (52.10 days) was recorded in T_3 (35 days old age of seedlings) followed by T_4 (40 days old age of seedlings) with (53.03 days) and maximum number of days (64.05 days) required for flower stalk initiation was recorded in T_1 (25 days old age of seedlings) significantly. The length of flower stalk (74.71 cm) was recorded significantly highest in T_3 (35 days old age of seedlings), followed by T_4 (40 days old age of seedlings) with (73.01cm) and lowest length of flower stalk (62.26) was recorded in T_1 (25 days old age of seedlings). And the minimum number of days for flower duration (48.39 days) was recorded in T_4 (40 days old age of seedlings), followed by T_3 (35 days old age of seedlings) with (51.58 days) and maximum number of days (61.68 days) for flower duration was recorded in T_1 (25 days old age of seedlings) significantly.

In different levels of spacings the minimum number of days (53.65 days) required for flower stalk initiation was recorded in S_2 (30×45cm) and maximum number of days (60.64 days) required for flower stalk initiation was recorded in S_1(45×60 cm). The length of flower stalk (74.89 cm) was recorded significantly highest in S_2 (30×45cm**)** and lowest length of flower stalk (65.06cm) was recorded in S_1(45×60 cm). And the minimum number of days for flower duration (52.55 days) was recorded in S_1(45×60cm) and maximum number of days for flower duration (56.18 days) was recorded in S_2 (30×45 cm)

In the interaction between age of seedlings and spacing the minimum number of days required for flower stalk initiation (47.28 days) was recorded in T_6 (35 days old age of seedlings with spacing of 30×45cm) and maximum days required for flower stalk initiation (65.77 days) was recorded in T_1 (25 days old age of seedlings with wider spacing of 45×60 cm).And length of flower stalk (80.07 cm) was recorded significantly highest in T_6 (35 days old age of seedlings with spacing of 30×45cm) and lowest length of flower stalk (60.77cm) was recorded in T_1 (25 days old age of seedlings with spacing of 45×60 cm). whereas minimum days for flower duration (45.72 days) was recorded in T_7 (40 days old age of seedlings with spacing of 45×60cm) and maximum days for flower duration (62.50 days) is recorded in T_2 (25 days old age of seedlings with spacing of 30×45 cm)

It was evident from the data that closer spacing showed early flowering than wider planting distance while flowering was late in wider planting distance. Similarly, the duration required for harvesting from the appearance of flower stalk was less in more plant spacing and a longer period was required for harvesting from the appearance of the flower stalk in closer planting distance. **Jadhav *et al.* (2014)** reported that minimum days to first flower bud initiation. **Khobragade *et al*. (2012)** observed the similar result in China aster

Table 3. Flowering parameters as influenced by different levels of age of seedlings, spacing and their interaction effect in statice

Treatments	No of days for flower stalk initiation	Length of flower stalk (cm)	Flower duration (days)
Levels of age of seedlings (T)			
T_1 (25 days old age of seedlings)	64.05	62.26	61.68
T_2 (30 days old age of seedlings)	59.41	69.92	55.81
T_3 (35 days old age of seedlings)	52.10	74.71	51.58
T_4 (40 days old age of seedlings)	53.03	73.01	48.39
S.Em	0.42	0.43	0.31
C.D	1.30	1.34	0.95
Levels of spacings (S)			
S_1 (45×60 cm)	60.64	65.06	52.55
S_2 (30×45 cm)	53.64	74.89	56.18
S.Em	0.30	0.31	0.22
C.D	0.92	0.95	0.67
Interaction (T × S)			
S.Em	0.60	0.62	0.44
C.D	1.84	1.90	1.34

3.4 Yield Parameters

The yield parameters are measured in terms of number of flower stalks/plant, number of flower spikes/ plant, number of stalks/plots. In different levels of age of seedlings the number of flower stalks/plant (10.30) and number of flower spikes/plant (23.79) were recorded significantly high in T_4 (40 days old age of seedlings) followed by T_3 (35 days old age of seedlings) in number of flower stalks/plant (10.10), number of flower spikes/plant (23.79) and number of flower stalks/plant(6.56) and number of flower spikes/plant(16.44) were recorded lowest in T_1 (25 days old age of seedlings) whereas number of stalks/plot (72.40) was recorded significantly highest in T_3 (35 days old age of seedlings) followed by (71.94) in T_4 (40 days old age of seedlings) and number of stalks/plot (59.85) recorded lowest in T_1 (25 days old age of seedlings).

In different levels of spacing the number of flower stalks/plant (9.18), number of flower spikes/plant (21.90) were recorded significantly highest in S_1 (45×60 cm**)** whereas number of flower stalks/plot (74.41) was recorded significantly highest in S_2 (30×45 cm) and number of flower stalks/plant (8.29), number of flower spikes/plant (19.51) are recorded lowest in S_2 (30×45 cm) whereas the number of flower stalks/plot (60.62) is recorded lowest in S_1(45×60 cm**).**

In the interaction between age of seedlings and spacing the number of flower stalks/plant(10.74) and number of flower spikes/plant (25.63) are recorded significantly highest in T_7 (40 days old age of seedlings with spacing of 45×60cm) followed by T_5 (35 days old age of seedlings with spacing 45×60 cm) number of flower stalks/plant(10.37) and number of flower spikes/plant(24.31) .whereas the number of flower stalks/plot (80.22) recorded significantly highest in T_6 (35 days old age of seedlings with spacing of 30×45 cm) and the number of flower stalks/plant(6.28), number of flower spikes/plant(15.62) are recorded lowest in T_2 (25 days old age of seedlings with spacing of 30×45cm). whereas the number of flower stalks/plot (55.68) recorded lowest in T_1 (25 days old age of seedlings with spacing of 45×60 cm) significantly.

This might be due to a greater number of flower stalks were recorded in more dense planting distance in case of per plot and they were significantly superior to the number of stalks produced by wider planting distance. This might be due to more plant population per unit area in close spaced planting and hence a greater number of flower stalks per plot and per ha.In closer spacing increased the photosynthetic capacity by increasing the interception of available solar radation, resulting in improved yield , Similarly, **Kaur *et al*. (2009)** reported the same results in chrysanthemum.

Table.4: Yield parameters as influenced by different levels of age of seedlings, spacing and their interaction effect in statice.

Treatments	No of flower stalks/plant	No of flower spikes/plant	No of flower stalks/plot
Levels of age of seedlings (T)			
T_1 (25 days old age of seedlings)	6.56	16.44	59.85
T_2 (30 days old age of seedlings)	7.99	19.78	65.88
T_3 (35 days old age of seedlings)	10.10	22.81	72.40
T_4 (40 days old age of seedlings)	10.30	23.79	71.94
S.Em	0.10	0.25	0.67
C.D	0.32	0.78	0.95
Levels of spacings (S)			
S_1 (45×60 cm)	9.18	21.90	60.62
S_2 (30×45 cm)	8.29	19.51	74.41
S.Em	0.07	0.18	0.47
C.D	0.22	0.55	0.67
Interaction (T × S)			
S.Em	0.14	0.36	0.95
C.D	0.45	1.10	1.34

3.5 Post harvest Parameters

The post-harvest parameters are measured in terms of vase life in water, vase life in 2%sucrose solution, and self-life

In the four different levels of age of seedlings the maximum days(8.16 days) for vase life in water was recorded in T_3 (35days old age of seedlings),followed by T_4 (40 days old age of seedlings) with vase life in water (8.07and maximum days (13.82 days) of vase life in 2% sucrose was recorded in T_4 (40 days old age of seedlings), followed by T_3 (35 days old age of seedlings) with vase life in 2% sucrose (13.71), whereas minimum days(6.55 days) of vase life in water was recorded in T_1 (25 days old age of seedlings) and minimum days(10.96 days) of vase life in 2% sucrose was recorded in T_1 (25 days old age of seedlings).The maximum days (60.16 days) of self-life was recorded in T_4 (45 days age of seedlings),followed by 56.16 days in T_3(35 days old age of seedlings) and minimum days (42 days) of self-life was recorded in T_1 (25 days old age of seedlings).

In two different levels of spacing the maximum days (8.14 days) for vase life in water was recorded in S_2 (30**×**45 cm**)** and maximum days (13.18 days) for vase life in 2% sucrose was recorded in S_1(45**×**60 cm**)** where minimum days (7.08 days) for vase life in water was recorded in S_1(45**×**60 cm**)** and minimum days (12.26 days) for vase life in 2% sucrose was recorded in S_2 (30×45 cm**),** maximum days (53.75 days) for self-life was recorded in S_1 (45**×**60cm) and minimum days (49.16 days) of self-life was recorded in S_2 (30**×**45cm)

In the interaction between age of seedlings and spacing the maximum days of vase life in water (8.69 days) was recorded in T_6 (35 days old age of seedlings with spacing of 30**×**45 cm), followed by T_8 (40 days old age of seedlings with spacing of 30**×**45 cm) with (8.60 days), Where minimum days for vase life in water(6.29 days) is recorded in T_1 (25 days old age of seedlings with spacing of 45**×**60 cm), maximum days of vase life in 2% sucrose (14.35 days) was recorded in T_7 (40 days old age of seedlings with spacing of 45**×**60 cm),followed by T_5 (35 days old age of seedlings with spacing of 45**×**60 cm) with (14.19 days). minimum days for vase life in 2% sucrose (10.36 days) is recorded in T_2 (25 days old age of seedlings with spacing of 30**×**45 cm) respectively.

The maximum days (63.33 days) for self-life is recorded in T_7 (40 days old age of seedlings with spacing of 45**×**60 cm), followed by T_5 (35 days old age of seedlings with spacing of 45**×**60 cm) with (59.66 days) and minimum days (41 days) for self-life is recorded in T_2 (25 days old age of seedlings with spacing of 30**×**45 cm) respectively.

Table.5: post-harvest parameters as influenced by different levels of age of seedlings, spacing and their interaction effect in statice.

Treatments	Vase life in water (days)	Vase life in 2% sucrose (days)	Self-life of flower (days)
Levels of age of seedlings (T)			
T_1 (25 days old age of seedlings)	6.55	10.96	42.00
T_2 (30 days old age of seedlings)	7.58	12.38	47.50
T_3 (35 days old age of seedlings)	8.16	13.71	56.16
T_4 (40 days old age of seedlings)	8.07	13.82	60.16
S.Em	0.15	0.19	0.53
C.D	0.47	0.59	1.65
Levels of spacings (S)			
S_1 (45×60 cm)	7.08	13.18	53.75
S_2 (30×45 cm)	8.14	12.26	49.16
S.Em	0.11	0.13	0.38
C.D	0.33	1.41	1.16
Interaction (T × S)			
S.Em	0.22	0.27	0.76
C.D	NS	NS	2.33

CONCLUSION:

On the basis of experimental results obtained, it is concluded that treatment **T_3** (35 days old age of seedlings**)** was found more effective in different levels of age of seedlings and **S_2** (30×45 cm) was found more effective in different levels of spacings, where as in interaction between age of seedlings and spacing treatment **T_6** (35 days old age of seedlings with spacing of 30×45cm) was found significantly most effective in terms of plant growth and spike yield and vase life in water of statice.

Whereas treatment **T_4** (40 days old age of seedlings) was found more effective in different levels of age of seedlings ,**S_1** (45×60 cm) was found more effective in different levels of spacings, and interaction between age of seedlings and spacings treatment **T_7** (40 days old age of seedlings with spacing of 45**×**60 cm) was found significantly most effective in terms of vase life in 2% sucrose and self-life of statice.

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