Influence of different levels of planting time and spacing on growth and yield of multiplier onion (Allium cepa L. var. aggregatum Don.) Cv. Meitei Tilhou under Manipur condition

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Abstract
Study on the “Effect of Planting Time and Spacing on Growth and Yield of Multiplier Onion (Allium cepa L. var. aggregatum Don.) cv. Meitei Tilhou under Manipur Condition” in the rabi season of 2019-20 in the research field of Department of Horticulture, COA, CAU, Imphal from November 2019 to April 2020. The layout of the experimental field was carried out in Factorial Randomized Block Design (FRBD) constituting three levels of spacing (S1: 10 cm × 10cm, S2: 10 cm × 15cm, S3: 15 cm × 20) and four levels of planting time (P1: 10th November, P2: 25th November, P3: 10th December, P4: 25th December). From the current study, it was observed at wider spacing 15cm×20cm (S3), growth parameters like number of leaves (49.52), number of bulblets per clump (14.38), and neck girth (6.36 mm) were maximum, yield contributing characters fresh weight of compound bulb (41.7 g), polar diameter (22.92 mm) and equatorial diameter (16.59 mm) and maximum average bulb weight (2.54 g) were also higher. However, maximum plant height (45.47 cm) and yield per hectare (21.34 t/ha) was obtained at closer spacing 10cm×10cm (S1). Early planting date of 10th November (P1) resulted in superior growth, maximum bulb yield and yield contributing characters, and it was closely followed by 25th November (P4). Interaction of planting time and spacing significantly influenced plant height, number of leaves, fresh weight of compound bulb, and yield.

Keywords: Planting time, spacing, growth, yield, multiplier onion

Introduction
Onion (Allium cepa L.) is a major bulb crop used as both vegetable and spice in India and across the globe for many centuries. Cultivated onion is broadly classified into Common onion (Allium cepa L.) and Multiplier onion (Allium cepa L. var. aggregatum Don.) (Hanelt, 1990) [18]. Multiplier onion (Allium cepa L. var. aggregatum Don.) is a biennial herbaceous plant that belongs to the family Alliaceae under the order Asparagales. It is also known as Aggregatum onion, potato onion, small onion. It is also known as underground onion as it produces a closely packed cluster of bulbs underground, unlike shallot (Pandey, 2006) [39]. Each plant produces 3 to 20 bulbs covered with the dry outer skin; the number of bulbs produced depends on the plant's genetic characteristics (Brewster, 2008) [10]. It is propagated vegetatively through bulbs. Multiplier onion has good keeping quality and better tolerance for extreme climatic conditions, pests, and diseases than a common onion (Brewster, 2008) [10]. Despite being hardy in nature with a high nutritive and medicinal value, the area under multiplier onion production is limited, and the yield and productivity are not up to the level. This is due to a lack of standard cultural practices and improved technologies, which are still not in high use to increase the crop yield potential of Multiplier onion. Determining an optimum spacing for each agro-ecological region helps to increase the production and productivity of the onion (Gupta et al., 1994) [17]. Bulbing in onion has great influenced by photoperiod and environmental factors like the intensity of light, temperature, fertility, and irrigation (Brewster, 2008) [10]. Among the different agronomic practices followed in onion cultivation, planting time significantly influences growth and yield. It affects the size of the bulb and the yield; late planting reduces
the bulb size and yield (Mondal and Brewster, 1986) [33]. Photoperiod has a significant influence on bulb initiation and development; it also decides the cultivar’s suitability to that particular agro-ecological zone (Jones and Mann, 1963) [22]. Spacing regulates the plant density, photosynthetic area, interception of light in the canopy, and competition between plants for soil nutrients, space, and water thereby affecting the growth of the plant, size of the bulb, yield, and quality parameters (Devulkar et al., 2015) [15]. Optimum spacing also results in higher economic returns (Rashid and Rashid, 1976) [41].

Materials and methods

The investigation was carried out during the rabi season 2019-20 at the experimental field, College of Agriculture, Central Agricultural University, located at a Latitude of 24° 81' N and longitude of 93° 89' E and at an altitude of 784 m above mean sea level. The experimental layout was laid out in Factorial Randomized Block Design (FRBD) design constituting three levels of spacing (S1: 10 cm × 10 cm, S2: 10 cm × 15 cm, S3: 15 cm × 20) and four levels of planting time (P1: 10th November, P2: 25th November, P3: 10th December, P4: 25th December). The field layout and randomization of treatments to the plots were carried out as per the statistical methods given by Panse and Sukhatme (1985) [40]. Data on plant height (cm), number of leaves per plant, number of bulblets per clump, neck girth (mm), fresh weight of compound bulb (g), polar diameter (mm), equatorial diameter (mm), bulb yield (t/ha) and an average weight of bulblet (g) were recorded and subjected to statistical analysis, the test of significance (F-test) and critical difference (C. D.) at 0.05 probability (Sundararaj et al. 1972) [43].

Results and discussion

Plant height (cm)

During the course of observation, maximum plant height was recorded in the spacing S1-10cm×10cm (45.47 cm) and planting time P1- 10th November (44.96 cm). Treatment combination T1 (10cm×10cm and 10th November) recorded maximum plant height (49.07 cm), and minimum plant height (38.41 cm) was recorded in T2 (15cmx20cm and 25th December). Maximum plant height in closer spacing (10cm ×10cm) than in wider spacing could be because of competition for sunlight in high-density planting due to a nearby canopy’s shading effect, causing the plants to increase the height and leaf length to get maximum sunlight. The findings were similar to that of Anal (2005) [4], Ansari et al. (2007) [5], Bosekeng and Coetzter (2015) [9], Dawar et al. (2007) [13], and Shanti and Balakrishna (1989) [42]. Early planting dates recorded higher plant height, which decreased with the later planting dates. The possible reason for the maximum plant height in 10th November planting could be because of a comparatively longer photoperiod during the early growth stage of multiplier onion. As per the observation of Khokhar (2017) [25], an increase in the plant height of the onion is faster under the longer photoperiodic condition.

Number of leaves per plant

The maximum number of leaves was observed in the spacing S1-15cm×20cm (49.52) and planting time P1- 10th November (45.98). The highest number of leaves (53.88) per plant were produced in the treatment combination T6 (15cmx20cm and 10th November, and the lowest number of leaves (36.68) were recorded in T4 (10cm×10cm and 25th December). Plants at wider spacing have less competition for light, nutrients, and water, resulting in the diversion of photosynthates to produce more leaves than to increase the plant height (Jawadagi et al., 2012) [20]. The number of leaves increased with the decrease in plant population. Dawar et al. (2007) [13], Jawadagi et al. (2012) [20], Kumar et al. (2015) [27], and Walle et al. (2018) [47] reported similar findings in common onion, Muthuramalingam et al. (2001) [38] in multiplier onion, and by Mehta and Mangat Ram (2006) [29] in garlic. Planting on 10th November (P1) recorded a significantly higher number of leaves at all growth stages than other dates of planting; this might be because of comparatively lower temperatures during the vegetative growth stage, facilitating the plants to grow vigorously. The observation is parallel to the findings of Ali et al. (2016) [3], Devulkar et al. (2015) [15], Mohanty (2001) [32], and UD-Deen (2008) [45].

Number of bulblets per clump

The number of bulbs per clump at harvest was highest in spacing S1-15cm×20cm (14.38) and planting time P1- 10th November (13.96). Interaction of planting time and spacing resulted in the highest number of bulblets (15.00) in the treatment combination T6 (15cmx20cm and 10th November, while the lowest number of bulblets (11.40) were recorded in T1 (10cm×10cm and 25th December). The number of bulblets produced per plant was significantly influenced by spacing and planting time, but interaction had no influence. More bulblets per clump were observed in wider spacing S1 (15cm×20cm) than in closer spacing might be because of less competition, and more availability of nutrients and moisture per plant promoted the plant's vigorous growth and rapid division of bulbs and formation of laterals in multiplier onion. While in the lesser spacing, the formation of laterals is restricted due to limited spacing, present observation is supported by the findings of Nasrin (2008) [37] in onion and Ahmed et al. (2017) [2], Asgharipour and Arshadi (2012) [6], and Fakhar et al. (2019) [16] in garlic. Planting time 10th November produced more number of bulblets per clump than other planting dates; the result was similar to the findings of Okubo et al. (1999) [38] in shallot and Mamkagh and Mahadeen (2008) [28] in garlic. This might be because of the comparatively lower temperature during the vegetative phase, i.e., in December and January facilitated the vigorous plant growth and rapid division resulting in more number of lateral bulbs per plant.

Neck girth (mm)

Neck girth of onion at harvest was highest in spacing S1-15cm×20cm (6.36 mm) and planting time P1-10th November (6.14 mm). The neck girth of the bulblet was highest (6.61 mm) in the treatment combination T6 (15cmx20cm and 10th November), while the lowest neck girth (5.35 mm) was recorded in T4 (10cm×10cm and 25th December). The neck girth of the multiplier onion bulblet was significantly affected by spacing. The highest neck girth was observed in wider spacing (15cmx20cm). This could be because of less competition and more number of leaves per bulblets. The result is in agreement with the findings of Kahsay et al. (2013) [23] and Jilani et al. (2009) [21], who also observed maximum neck girth at wider spacing. Planting time also significantly affected the girth of the neck at all stages; planting on 10th November (P1) produced significantly maximum neck girth than other planting dates. This could be because of the vigorous growth of the plant in P1 (10th November) compared to other planting dates. The result is in

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conformity with the findings of Bosekeng and Coetzer (2015) [9].

**Fresh weight of compound bulb (g)**

The fresh weight of the compound bulb directly corresponds to the yield in multiplier onion, and it showed a significant response to different treatments of spacing, planting time, and their interaction. The fresh weight of the bulb decreased with an increase in plant population. The fresh weight of compound bulbs was highest (45.67 g) in the treatment combination T₀ (15 cm × 20 cm) and 10th November, while the lowest fresh weight of compound bulbs (25.00 g) was observed in T₄ (10 cm × 10 cm and 25th December). Higher fresh weight of bulbs in wider spacing maybe because of less competition for light, space, moisture, and nutrients, leading to good vegetative growth and bigger-sized bulbs. The result was at par with the findings of Kanton et al. (2002) [24], Jawadagi et al. (2012) [20], Kumar et al. (2001) [26] in common onion, and Tendaj (2005) [44] in shallot. The comparatively lower temperature during the vegetative phase and longer growth period, which provided sufficient time for bulb enlargement and translocation of carbohydrates from leaves to bulbs, might be the reason for the higher fresh weight of bulbs in early planting dates. Bosekeng and Coetzer (2015) [9] also reported similar findings.

| Treatments | Plant height (cm) | Number of leaves | Number of bulblets per clump | Neck girth (mm) |
|------------|------------------|------------------|-------------------------------|-----------------|
| 10 cm × 10 cm | S₁ | 45.47 | 37.57 | 11.96 | 5.64 |
| 10 cm × 15 cm | S₂ | 41.98 | 44.43 | 13.33 | 5.91 |
| 15 cm × 20 cm | S₃ | 40.51 | 49.52 | 14.38 | 6.36 |
| 10 cm × 10 cm | C.D (0.05) | 2.57 | 2.03 | 1.02 | 0.25 |
| 10th November | P₁ | 44.96 | 45.98 | 13.96 | 6.14 |
| 25th November | P₂ | 43.44 | 45.19 | 13.69 | 6.08 |
| 10th December | P₃ | 43.08 | 42.60 | 13.08 | 6.01 |
| 25th December | P₄ | 39.14 | 41.60 | 12.16 | 5.65 |
| C.D (0.05) | 1.43 | 1.13 | 0.57 | 0.14 |
| T₃ | S₁P₁ | 49.07 | 38.80 | 12.61 | 5.92 |
| T₂ | S₁P₂ | 47.12 | 37.79 | 12.23 | 5.75 |
| T₁ | S₁P₃ | 46.09 | 37.01 | 11.58 | 5.55 |
| T₄ | S₁P₄ | 40.61 | 36.68 | 11.40 | 5.35 |
| T₃ | S₂P₁ | 44.17 | 45.27 | 14.27 | 5.90 |
| T₅ | S₂P₂ | 42.14 | 45.00 | 14.00 | 5.98 |
| T₆ | S₂P₃ | 42.20 | 43.43 | 13.47 | 6.08 |
| T₇ | S₂P₄ | 39.41 | 44.02 | 11.58 | 5.69 |
| T₈ | S₃P₁ | 41.65 | 53.88 | 15.00 | 6.61 |
| T₉ | S₃P₂ | 41.05 | 52.77 | 14.83 | 6.52 |
| T₁₀ | S₃P₃ | 40.93 | 47.35 | 14.20 | 6.41 |
| T₁₁ | S₃P₄ | 38.41 | 44.10 | 13.49 | 5.91 |
| T₁₂ | S₄P₁ | 2.48 | 1.96 | 0.98 | 0.24 |
| C.D (0.05) | NS | 4.07 | NS | NS |

S.Ed (±): standard error of mean difference; C.D (0.05): critical difference; NS: non-significant

**Equatorial diameter (mm) and Polar diameter (mm) of the bulblet**

Spacing had a significant effect on the equatorial diameter and polar diameter of multiplier onion at all growth stages. The maximum equatorial diameter (16.69 mm) and a polar diameter (22.92 mm) of the bulblet at harvest were recorded in spacing S₅ (15 cm × 20 cm). It was also observed that equatorial and polar diameters of bulblets decreased as the plant population increased; this could be because of limited space for bulb enlargement in closer spacing, and higher competition for nutrients and moisture might have reduced the size of the bulblet. Bosekeng and Coetzer (2015) [9], Khashay et al. (2013) [23], Mekonnen et al. (2017) [100], and Misra et al. (2014) [112] also made a similar report of maximum equatorial and polar diameter of bulb at wider spacing.

Planting time also had a significant influence on equatorial and polar diameters at all stages. The maximum equatorial diameter (16.04 mm) and polar diameter (21.82 mm) of the onion bulblet were recorded at harvest in planting time P₁ (10th November). Good vegetative growth (maximum number of leaves) in early planting dates might have resulted in thicker leaf scales, thereby increasing the diameter of the bulblet. This result is supported by the findings of Bosekeng and Coetzer (2015) [9], Caruso et al. (2014) [111], and Ikeda et al. (2019) [119] in onion.

Although there was an individual effect of spacing and planting time on the equatorial and polar diameter of the bulblet, their interaction showed no significant difference between treatment combinations. The maximum equatorial diameter (17.69 mm) and polar diameter (24.09 mm) was recorded in T₀ (15 cm × 20 cm and 10th November). The result is parallel to the findings of Devulkar et al. (2015) [115].

**Bulb yield (t/ha)**

The maximum bulb yield was obtained in the spacing S₁ (21.34 t/ha), and the lowest yield was recorded from the spacing S₃ (10.58 t/ha). Higher plant population in closer spacing results in the production of more number of bulbs per unit area and thereby increasing the total yield per hectare. Ademe et al. (2012) [11], Devi et al. (2008) [114], Kanton et al. (2002) [24], and Tendaj (2005) [44] also made a similar observation.

Planting time had a significant influence on the bulb yield of multiplier onion. According to Corgan and Kedar (1990) [12],
there should be a progressive increase in photoperiod after planting to ensure sufficient leaf growth before bulb initiation to produce large-sized bulbs. Also, Brewster (2008) stated that higher temperatures limit the leaf growth and shift to bulb initiation in onion, thereby low LAI and a light interception, which results in lower yield. This might be the reason for maximum yield (17.89 t/ha) in 10\textsuperscript{th} November planting followed by 25\textsuperscript{th} November planting as comparatively lower temperature and shorter day length was observed during the initial growth period promoting good vegetative growth in terms of leaf length, the number of leaves resulting in higher photosynthesis and accumulation of photosynthates in leaves. The gradual increase in temperature and day length after bulb initiation hastens the translocation of photosynthates from leaves (source) to bulblets (sink), thereby increasing the size of bulblets. In comparison, the lower yield (14.68 t/ha) on the 25\textsuperscript{th} December planting date may be due to a rise in temperature in the following months after planting. This result is in line with the findings of and Mamkagh and Mahadeen (2008) [28], Murmu et al. (2019) [34], and Vidy et al. (2013) [46] in garlic.

Interaction of planting time and spacing was found significant for bulb yield. The highest yield was recorded from the interaction S\textsubscript{1}P\textsubscript{1} (T\textsubscript{1}), i.e., planting at 10cm×10cm spacing on 10\textsuperscript{th} November (25.65 t/ha), and the lowest yield was recorded from S\textsubscript{3}P\textsubscript{3} (T\textsubscript{3}) i.e., planting at 15cm×20cm spacing on 25\textsuperscript{th} December (10.06 t/ha). Higher yield in early planting and closer spacing is because of more plants per hectare and vigorous growth of plants in early planting dates, and it was noticed that yield decreased as the spacing between plants increased and delayed in planting. The observation is in agreement with the findings of Badaruddin and Haque (1977) [7], Brewster (2008) [10], Devulkar et al. (2015) [13], Kamas et al. (2013) [23], and Naik and Hosamani (2003) [30] in onion and Mamkagh and Mahadeen (2008) [28] and Vidy et al. (2013) [46] in garlic.

The average weight of bulblet (g)

Planting time and spacing had a significant influence on the average weight of bulblet. Spacing S\textsubscript{1} (15cm×20cm) produced bigger bulblets of 2.55 g, and smaller bulblets were produced at spacing S\textsubscript{3} (1.95g). The higher average weight of bulblets in wider spacing could be because of lesser competition for spacing, nutrients, and more leaves resulted in better photosynthesis and accumulation of photosynthates, thereby producing bigger bulblets. The result was similar to the observation of Ademe et al. (2012) [1] and Mekonnen et al. (2017) [30] in onion. The average weight bulblet was found to be higher (2.30 g) in early planting time P\textsubscript{1} (10\textsuperscript{th} November). This could be because of a good source to sink the relationship in these plants. The above result is supported by the findings of Badaruddin and Haque (1977) [7], and Bharathi and Mohan (2018) [18] in onion, and Mamkagh and Mahadeen (2008) [28] in garlic. In the present study, the interaction of planting time and spacing had no significant effect on the average weight of bulb. However, the maximum average weight of the bulb (2.69 g) was recorded in T\textsubscript{3} (15cm×20cm and 10\textsuperscript{th} November). The result is parallel to the findings of Devulkar et al. (2015) [15] and Jilani et al. (2009) [21].

### Table 2: Effect of planting time and spacing on yield and yield contributing characters of multiplier onion at harvest.

| Treatments | Fresh weight of compound bulb (g) | Equatorial dia. (mm) | Polar dia. (mm) | Bulb yield (t/ha) | Avg. weight Of bulblet (g) |
|------------|---------------------------------|---------------------|----------------|------------------|---------------------------|
| 10cm×10cm  | S\textsubscript{1}              | 28.12               | 14.25          | 19.49            | 21.34                     | 1.95                      |
| 10cm×15cm  | S\textsubscript{2}              | 32.39               | 14.93          | 20.37            | 16.20                     | 2.15                      |
| 15cm×20cm  | S\textsubscript{3}              | 41.80               | 16.59          | 22.92            | 10.58                     | 2.55                      |
|            | S.Ed (±)                        | 0.88                | 0.38           | 0.49             | 0.54                      | 0.06                      |
|            | C.D (0.05)                      | 1.82                | 0.80           | 1.02             | 1.13                      | 0.13                      |
| 10\textsuperscript{th} November | P\textsubscript{1}           | 37.14               | 16.04          | 21.82            | 17.89                     | 2.30                      |
| 25\textsuperscript{th} November | P\textsubscript{2}           | 35.32               | 15.62          | 21.59            | 16.32                     | 2.27                      |
| 10\textsuperscript{th} December | P\textsubscript{3}           | 32.89               | 15.07          | 20.64            | 15.26                     | 2.18                      |
| 25\textsuperscript{th} December | P\textsubscript{4}           | 31.06               | 14.29          | 19.67            | 14.68                     | 2.10                      |
|            | S.Ed (±)                        | 1.02                | 0.44           | 0.57             | 0.63                      | 0.07                      |
|            | C.D (0.05)                      | 2.11                | 0.92           | 1.18             | 1.30                      | 0.15                      |
| T\textsubscript{1} | S\textsubscript{1}P\textsubscript{1} | 32.87               | 14.87          | 20.41            | 25.65                     | 2.01                      |
| T\textsubscript{2} | S\textsubscript{1}P\textsubscript{2} | 28.53               | 14.51          | 21.20            | 21.40                     | 2.00                      |
| T\textsubscript{3} | S\textsubscript{1}P\textsubscript{3} | 26.07               | 14.08          | 18.08            | 19.55                     | 1.92                      |
| T\textsubscript{4} | S\textsubscript{1}P\textsubscript{4} | 25.00               | 13.54          | 18.27            | 18.75                     | 1.87                      |
| T\textsubscript{5} | S\textsubscript{2}P\textsubscript{1} | 32.90               | 15.58          | 20.97            | 16.45                     | 2.22                      |
| T\textsubscript{6} | S\textsubscript{2}P\textsubscript{2} | 32.83               | 15.17          | 21.26            | 16.42                     | 2.16                      |
| T\textsubscript{7} | S\textsubscript{2}P\textsubscript{3} | 32.37               | 14.65          | 20.06            | 16.18                     | 2.15                      |
| T\textsubscript{8} | S\textsubscript{2}P\textsubscript{4} | 31.47               | 14.32          | 19.20            | 15.73                     | 2.07                      |
| T\textsubscript{9} | S\textsubscript{3}P\textsubscript{1} | 45.67               | 17.69          | 24.09            | 11.57                     | 2.69                      |
| T\textsubscript{10} | S\textsubscript{3}P\textsubscript{2} | 44.60               | 17.18          | 22.30            | 11.15                     | 2.65                      |
| T\textsubscript{11} | S\textsubscript{3}P\textsubscript{3} | 40.23               | 16.47          | 23.77            | 10.06                     | 2.48                      |
| T\textsubscript{12} | S\textsubscript{3}P\textsubscript{4} | 36.70               | 15.02          | 21.53            | 9.55                      | 2.37                      |
|            | S.Ed (±)                        | 1.76                | 0.77           | 0.99             | 1.09                      | 0.12                      |
|            | C.D (0.05)                      | 3.65                | NS             | NS               | 2.25                      | NS                       |

S.Ed(±): standard error of mean difference; C.D (0.05): critical difference; NS: non-significant

### Conclusion

From the current study, it can be inferred that at wider spacing 15cm×20cm (S\textsubscript{3}), the maximum number of leaves, number of bulblets per clump, neck girth (mm), fresh weight of the compound bulb (g), polar and equatorial diameter of the bulb (mm), and higher average weight of each bulblet (g) was observed. But, at closer spacing 10cm×10cm (S\textsubscript{1}), parameters like plant height (cm) and yield per hectare (t/ha) were maximum. Early planting date 10\textsuperscript{th} November (P\textsubscript{1}) resulted in better growth and maximum bulb yield, and it was closely followed by 25\textsuperscript{th} November (P\textsubscript{2}). A combination of closer spacing 10cm×10cm and early planting date 10\textsuperscript{th} November results in good growth and
maximum yield of multiplier onion cv. Meitei Tilhou under Manipur condition.

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