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Poovamma BC
Department of Horticulture, College of Agriculture, Central Agricultural University, Imphal West, Manipur, India

Dr. AK Bijaya Devi
Professor, Head of the Department, Department of Horticulture, College of Agriculture, Central Agricultural University, Imphal West, Manipur, India

Dr. U Chaoba Singh
Professor, Department of Horticulture, College of Agriculture, Central Agricultural University, Imphal West, Manipur, India

Dr. A Herojit Singh
Professor, Head of the Department, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Central Agricultural University, Imphal West, Manipur, India

Dr. N Okendro Singh
Professor, Head of the Department, Department of Agricultural Statistics, College of Agriculture, Central Agricultural University, Imphal West, Manipur, India

Corresponding Author:
Poovamma BC
Department of Horticulture, College of Agriculture, Central Agricultural University, Imphal West, Manipur, India

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

Poovamma BC, Dr. AK Bijaya Devi, Dr. U Chaoba Singh, Dr. A Herojit Singh and Dr. N Okendro Singh

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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 (S_1: 10 cm × 10cm, S_2: 10 cm × 15cm, S_3: 15 cm × 20) and four levels of planting time (P_1: 10th November, P_2: 25th November, P_3: 10th December, P_4: 25th December). From the current study, it was observed at wider spacing 15cm×20cm (S_3), 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 (S_1), Early planting date of 10th November (P_1) resulted in superior growth, maximum bulb yield and yield contributing characters, and it was closely followed by 25th November (P_2). 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 (S_1: 10 cm × 10cm, S_2: 10 cm × 15cm, S_3: 15 cm × 20) and four levels of planting time (P_1: 10th November, P_2: 25th November, P_3: 10th December, P_4: 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 S_1-10cm×10cm (45.47 cm) and planting time P_1- 10th November (44.96 cm). Treatment combination T_1 (10cm×10cm and 10th November) recorded maximum plant height (49.07 cm), and minimum plant height (38.41 cm) was recorded in T_{12} (15cm×20cm 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 Coetzer (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 S_3-15cm×20cm (49.52) and planting time P_1- 10th November (45.98). The highest number of leaves (53.88) per plant were produced in the treatment combination T_9 (15cm×20cm and 10th November, and the lowest number of leaves (36.68) were recorded in T_4 (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) [35] in multiplier onion, and by Mehla and Mangat Ram (2006) [29] in garlic. Planting on 10th November (P_1) 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 S_3-15cm×20cm (14.38) and planting time P_1- 10th November (13.96). Interaction of planting time and spacing resulted in the highest number of bulblets (15.00) in the treatment combination T_9 (15cm×20cm and 10th November, while the lowest number of bulblets (11.40) were recorded in T_4 (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 S_3 (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 S_3-15cm×20cm (6.36 mm) and planting time P_1-10th November (6.14 mm). The neck girth of the bulblet was highest (6.61 mm) in the treatment combination T_9 (15cm×20cm and 10th November), while the lowest neck girth (5.35 mm) was recorded in T_4 (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 (15cm×20cm). 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 (P_1) produced significantly maximum neck girth than other planting dates. This could be because of the vigorous growth of the plant in P_1 (10th November) compared to other planting dates. The result is in 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 in spacing S_3-15cm×20cm (41.80 g) and planting time P_1-10th November (37.14 g). The fresh weight of compound bulbs was highest (45.67 g) in the treatment combination T_9 (15cm×20cm and 10th November, while the lowest fresh weight of compound bulbs (25.00 g) was observed in T_4 (10cm×10cm 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.

Table 1: Effect of planting time and spacing on growth and yield contributing characters of multiplier onion.

Treatments		Plant height (cm)	Number of leaves	Number of bubletsper clump	Neck girth (mm)
10cm ×10cm	S_1	45.47	37.57	11.96	5.64
10cm×15cm	S_2	41.98	44.43	13.33	5.91
15cm×20cm	S_3	40.51	49.52	14.38	6.36
	S.Ed (±)	1.24	0.98	0.49	0.12
	C.D (0.05)	2.57	2.03	1.02	0.25
10th November	P_1	44.96	45.98	13.96	6.14
25th November	P_2	43.44	45.19	13.69	6.08
10th December	P_3	43.08	42.60	13.08	6.01
25th December	P_4	39.14	41.60	12.16	5.65
	S.Ed (±)	1.43	1.13	0.57	0.14
	C.D (0.05)	2.97	2.35	1.18	0.29
T_1	S_1P_1	49.07	38.80	12.61	5.92
T_2	S_1P_2	47.12	37.79	12.23	5.75
T_3	S_1P_3	46.09	37.01	11.58	5.55
T_4	S_1P_4	40.61	36.68	11.40	5.35
T_5	S_2P_1	44.17	45.27	14.27	5.90
T_6	S_2P_2	42.14	45.00	14.00	5.98
T_7	S_2P_3	42.20	43.43	13.47	6.08
T_8	S_2P_4	39.41	44.02	11.58	5.69
T_9	S_3P_1	41.65	53.88	15.00	6.61
T_{10}	S_3P_2	41.05	52.77	14.83	6.52
T_{11}	S_3P_3	40.93	47.35	14.20	6.41
T_{12}	S_3P_4	38.41	44.10	13.49	5.91
	S.Ed(±)	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 S_3 (15 cm×20cm). 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], Kahsay *et al*. (2013) [23], Mekonnen *et al.* (2017) [30], and Misra *et al*. (2014) [31] 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 P_1 (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) [11], and Ikeda *et al*. (2019) [19] 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 T_9 (15cm×20cm and 10th November). The result is parallel to the findings of Devulkar *et al*. (2015) [15].

Bulb yield (t/ha)

The maximum bulb yield was obtained in the spacing S_1 (21.34 t/ha), and the lowest yield was recorded from the spacing S_3 (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) [1], Devi *et al*. (2008) [14], 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) [10] 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 10th November planting followed by 25th 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 25th 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 Vidya *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_1P_1 (T_1), *i.e.*, planting at 10cm×10cm spacing on 10th November (25.65 t/ha), and the lowest yield was recorded from S_3P_4 (T_{12}), *i.e.*, planting at 15cm×20cm spacing on 25th 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) [15], Kahsay *et al*. (2013) [23], and Naik and Hosamani (2003) [36] in onion and Mamkagh and Mahadeen (2008) [28] and Vidya *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_3 (15cm×20cm) produced bigger bulblets of 2.55 g, and smaller bulblets were produced at spacing S_1 (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_1 (10th 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) [8] 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 bulblet. However, the maximum average weight of the bulb (2.69 g) was recorded in T_9 (15cm×20cm and 10th 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_1	28.12	14.25	19.49	21.34	1.95
10cm×15cm	S_2	32.39	14.93	20.37	16.20	2.15
15cm×20cm	S_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
10th November	P_1	37.14	16.04	21.82	17.89	2.30
25th November	P_2	35.32	15.62	21.59	16.32	2.27
10th December	P_3	32.89	15.07	20.64	15.26	2.18
25th December	P_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_1	S_1P_1	32.87	14.87	20.41	25.65	2.01
T_2	S_1P_2	28.53	14.51	21.20	21.40	2.00
T_3	S_1P_3	26.07	14.08	18.08	19.55	1.92
T_4	S_1P_4	25.00	13.54	18.27	18.75	1.87
T_5	S_2P_1	32.90	15.58	20.97	16.45	2.22
T_6	S_2P_2	32.83	15.17	21.26	16.42	2.16
T_7	S_2P_3	32.37	14.65	20.06	16.18	2.15
T_8	S_2P_4	31.47	14.32	19.20	15.73	2.07
T_9	S_3P_1	45.67	17.69	24.09	11.57	2.69
T_{10}	S_3P_2	44.60	17.18	22.30	11.15	2.65
T_{11}	S_3P_3	40.23	16.47	23.77	10.06	2.48
T_{12}	S_3P_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_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 bulblet (mm), and higher average weight of each bulblet (g) was observed. But, at closer spacing 10cm×10cm (S_1), parameters like plant height (cm) and yield per hectare (t/ha) were maximum. Early planting date 10th November (P_1) resulted in better growth and maximum bulb yield, and it was closely followed by 25th November (P_2).

A combination of closer spacing 10cm×10cm and early planting date 10th November results in good growth and maximum yield of multiplier onion cv. Meitei Tilhou under Manipur condition.

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