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Effect of Different Levels of Planting Time and Spacing on Quality and Economics of Multiplier Onion (*Allium cepa* L. var. *aggregatum* Don.) cv. Meitei Tilhou

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ABSTRACT

Keywords

B:C ratio, Economics, Harvest index,TSS, Multiplier onion

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An investigation on the "Effect of Planting Time and Spacing on Economics and Quality of Multiplier Onion (*Allium cepa* L. var. *aggregatum* Don.) cv. Meitei Tilhou" was carried out during the *rabi* season of 2019-20 in the Horticultural research field, College of Agriculture, CAU, Imphal from November 2019 to April 2020. The layout of the experimental field was carried out in Factorial Randomized Block Design (FRBD) with three levels of spacing (S_1: 10 cm × 10cm, S_2: 10 cm × 15cm, S_3: 15 cm × 20cm) and four levels of planting time (P_1: 10th November, P_2: 25th November, P_3: 10th December, P_4: 25th December). From the present investigation, it was observed that quality parameters like TSS (21.36 ^{0}Brix) and Dry matter (17.34%) were higher at closer spacing (10 cm × 10cm).While better shape index of the bulb (1.32) and higher harvest index (79.91%) were recorded in wider spacing (15 cm × 20cm). Planting time had a significant effect on Dry matter content of the bulb and Harvest index; early planting time (10th November) recorded higher Dry matter (16.18%) and Harvest index (79.11%). The interaction of closer spacing 10cm×10cm and early planting date 10th November planting resulted in maximum gross returns (₹ 1,026,000/ha), net returns (₹ 843,591.50/ha), and higher benefit to cost ratio (B:C) of 4.62: 1.

Introduction

Multiplier onion (*Allium cepa* L. var. *aggregatum* Don.) is also known as *Aggregatum* onion, potato onion, small onion, underground onion is a biennial herbaceous plant that belongs to the family Alliaceae (Pandey, 2006). Depending on the plant's genetic character, 3-20 bulbs are observed in each plant (Brewster, 2008). It is commonly propagated by small bulbs (bulblets). Multiplier onion has good keeping quality and better tolerance for extreme climatic conditions, pests, and diseases than a common onion (Brewster, 2008). Multiplier onion is grown on a commercial scale for internal consumption and export purpose in countries like India, Indonesia, Philippines, Sri Lanka, and Thailand. It is also cultivated in the kitchen gardens of The Caucasus, Europe, Kazakhstan, North America, and Southeast Asia. In India, the estimated production of multiplier onion in 2004 was 1.2 million tonnes. (Pandey, 2006).

Multiplier onion contains carbohydrates, vitamins, and minerals. Per 100 grams of Multiplier onion provides 72 kcal of energy, carbohydrates (16.8 g), fat (0.1g), fiber (3.2 g), sugars (7.87 g), protein (2.5 g), Thiamine (0.06 mg), Riboflavin (0.02 mg), Niacin (0.2mg), Folate (34 µg) and Vitamin C (8 mg). It has comparatively higher nutrients than common onion (Saraswathi *et al.*, 2017). Volatile compound allyl propyl disulfide is responsible for characteristic flavor and pungency (Randle, 2000). Chemical composition is as follows:- moisture content (78.32 %), TSS (19.50 %), dry matter (21.68 %), reducing sugar (1.13 %), non-reducing sugar (11.00 %), pyruvic acid (10.13 µmol/g) and minerals like sulphur (154.65 mg), potassium (229.93 mg), nitrogen (356.47 mg), calcium (71.69 mg), magnesium (12.65 mg), sodium (7.26 mg), phosphorus (115.66 mg), copper (1.82 mg), iron (1.80mg) and chlorine (29.35 mg) per 100 gram of multiplier onion (Pandey, 2006).

Multiplier onion is famous for its characteristic pungency and is commonly used in curries and sambar seasoning. Leaves, immature bulbs, and mature bulbs of multiplier onion are used as vegetable and spice. It is a good appetizer and widely used in the preparation of soup and sauces. They are often eaten raw, cooked, pickled, and as a spice for fish and meat (Saraswathi *et al.*, 2017). It is important in traditional medicines and is used to cure the wound, reduce fever, reduce insect bites' inflammation, decrease blood sugar level, treat anemia, heart diseases, skin disorder, and urinary disorder. It has properties like appetizer, antidote, anti-inflammatory, carminative, antiseptic, lithontripic, diuretic, and anticoagulant (Kumar *et al.*, 2010).

Multiplier onion has good keeping quality and better tolerance for extreme climatic conditions, pests, and diseases than a common onion (Brewster, 2008). Bulbs with high TSS and dry matter content have low storage losses and are preferred for dehydration, and high dry matter content is the reason for good storability in shallots (Foskett and Peterson, 1949). For any agronomic practice to be adopted, it should positively influence the Benefit-cost relationship. Optimization of planting time and spacing for each agro-ecological region is important to get higher economic returns (Gupta *et al.*, 1994).

Materials and Methods

Data on Total Soluble Solids (^{0}Brix), Dry matter (%), Bulb shape index, Harvest index (%) 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).

Total soluble solids (^{0}Brix)

The total soluble solids of the onion bulb in each treatment were found out through a hand refractometer and expressed as degree Brix (^{0} Brix).

Dry matter (%)

The dry matter % of the bulb was calculated using the following formula.

$$\text{Dry matter \%} = \frac{\text{Dry weight of the bulb (g)}}{\text{Fresh weight of the bulb (g)}} \times 100$$

Bulb shape index

The bulb shape index at harvest was calculated by dividing the equatorial diameter by the root of the product of polar diameter and thickness of the bulb. The bulb with a shape index <1.5 is considered ‘spherical,' and >1.5 is considered 'oval' (Kaveri and Thirupathi, 2015).

$$\text{Bulb shape index} = \frac{\text{Equatorial diameter (mm)}}{(\sqrt{\text{polar diameter (mm)}} \times \sqrt{\text{thickness of bulb}})}$$

Harvest index

Harvest Index is calculated by the formula at harvest using the formula below,

$$\text{Harvest Index (\%)} = \frac{\text{Dry mass of Economic yield (g)}}{\text{Dry mass of biological yield (g)}} \times 100$$

Economics

Additional cost involved and returns obtained with seed material, different organic manures, and chemical fertilizers were worked out based on the market rate of all the applied inputs during experimentation on a per hectare basis. Based on the prevailing prices of inputs at the time of their usage and the market price of the produce at the time of their sale, the B:C ratio and net profit were worked out using the formula below.

Cost of cultivation (₹ /ha)

It was calculated on a per hectare basis for each treatment by considering the inputs, labour, and operational cost.

Gross returns (₹ /ha)

The total monetary value of the economic produce obtained from the crops was obtained based on local market prices of the product and expressed on a unit hectare

Gross income (₹ /ha) = Market value of total bulb yield

Net returns (₹ /ha): Net return was calculated by deducting the cost of cultivation from the gross return.

Net profit per hectare (₹ /ha) = Gross returns (₹ /ha) - Cost of cultivation (₹ /ha)

Benefit-Cost ratio (B:C)

Benefit: cost (B:C) ratio was computed based on the formula given below.

$$\text{Benefit-Cost ratio} = \frac{\text{Net returns (₹ /ha)}}{\text{The total cost of cultivation (₹ /ha)}}$$

Results and Discussion

Effect of planting time and spacing on the Quality parameters and Harvest index of multiplier onion cultivation

Total Soluble solids (TSS) (^{0}Brix)

Total soluble solids (TSS) of multiplier onion was significantly affected by spacing. However, planting time and interaction of planting time and spacing showed no significant effect on TSS content of bulb. Hamilton *et al.,* (1998), McCollum *et al.,* (1968) and Simon (1995) showed that genetic factor influences TSS more than environment this could be the reason for the non-significant effect of planting dates on TSS content in the current study. Closer spacing 10cm×10cm (S_1)resulted in maximum TSS of 21.33 ^{0}Brix followed by S_2 (20.01 ^{0}Brix) and S_3 (19.27 ^{0}Brix). Observation of the above statement indicates the decreasing trend of TSS content due to an increase in the size of bulbs, *i.e.*, small bulbs produced at closer spacing have comparatively higher TSS than the bigger bulbs produced at wider spacing. This result is supported by the report of Mallor *et al.,* (2011), and Rajcumar (1998) that there is a significant negative association between bulb size and soluble solid content and future elaborated that bigger sized have high water content and fewer carbohydrates and organosulfur derivatives. According to Vidya *et al.,* (2013), minimal respiration and transpiration losses in smaller bulbs due to smaller surface areas result in higher TSS. Ademe *et al.*, (2012), Kahsay *et al.*, (2013), and Shanthi and Balakrishnan (1989) also reported a similar result of higher TSS in bulbs closely spaced plants.

Dry matter (%)

The dry matter percentage of the onion bulbs harvest was significantly influenced by spacing and planting time, but their interaction did not affect dry matter percentage. Maximum dry matter was recorded from the spacing S_1 (10cm×10cm) at harvest (17.34%). Like TSS, the percentage of dry matter content in bulbs also found to decrease with an increase in bulb size; this observation is following the findings of Mallor *et al.*, (2011), Shanthi and Balakrishnan (1989), and Ushakumari *et al.*, (2001).

Table.1 Effect of planting time and spacing on Quality parameters and Harvest index of multiplier onion

Treatments		TSS (^{0}Brix)	Dry matter (%)	Bulb shape index	Harvest index (%)
10cm ×10cm	S_1	21.23	17.34	1.15	73.90
10cm×15cm	S_2	20.21	15.88	1.20	77.04
15cm×20cm	S_3	19.27	13.19	1.32	79.99
	S.Em (±)	0.44	0.31	0.03	1.12
	C.D (0.05)	0.91	0.92	0.08	3.29
10th November	P_1	19.94	16.25	1.25	79.11
25th November	P_2	20.78	15.77	1.24	78.21
10th December	P_3	20.06	15.23	1.22	76.61
25th December	P_4	19.90	14.69	1.18	73.95
	S.Em (±)	0.36	0.36	0.03	1.30
	C.D (0.05)	NS	1.06	NS	3.80
T_1	S_1P_1	21.71	17.63	1.16	75.23
T_2	S_1P_2	21.30	17.57	1.19	74.63
T_3	S_1P_3	21.30	17.32	1.15	74.29
T_4	S_1P_4	21.13	16.83	1.09	71.45
T_5	S_2P_1	19.32	16.45	1.24	78.78
T_6	S_2P_2	20.82	16.27	1.19	79.31
T_7	S_2P_3	19.60	15.79	1.20	76.12
T_8	S_2P_4	20.21	15.00	1.16	73.96
T_9	S_3P_1	19.40	14.48	1.36	83.32
T_{10}	S_3P_2	20.23	13.47	1.35	80.80
T_{11}	S_3P_3	19.19	12.57	1.31	79.07
T_{12}	S_3P_4	18.33	12.23	1.25	76.43
	S.Ed(±)	0.62	0.63	0.06	2.24
	C.D (0.05)	NS	NS	NS	NS

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

Table.2 Effect of planting time and spacing on the economics of multiplier onion cultivation

Treatment combinations	Cost of cultivation (₹ /ha)	Yield (t/ha)	Gross return (₹ /ha)	Net returns (₹ /ha)	Benefit-cost Ratio (B:C)
T_1 (S_1P_1)	182408.5	25.65	1026000	843591.5	4.62
T_2 (S_1P_2)	182408.5	21.40	856000	673591.5	3.69
T_3 (S_1P_3)	182408.5	19.55	782000	599591.5	3.29
T_4 (S_1P_4)	182408.5	18.75	750000	567591.5	3.11
T_5 (S_2P_1)	172208.5	16.45	658000	485791.5	2.82
T_6 (S_2P_2)	172208.5	16.42	656667	484458.17	2.81
T_7 (S_2P_3)	172208.5	16.18	647333	475124.83	2.76
T_8 (S_2P_4)	172208.5	15.73	629333	457124.83	2.65
T_9 (S_3P_1)	167408.5	11.57	462667	295258.17	1.76
T_{10} (S_3P_2)	167408.5	11.15	446000	278591.5	1.66
T_{11} (S_3P_3)	167408.5	10.06	402333	234924.83	1.40
T_{12} (S_3P_4)	167408.5	9.55	382000	214591.5	1.28

Note: market value of Multiplier onion (local) is ₹ 40/kg
S.Em (±): Standard error of mean; C.D (0.05): critical difference; NS: non-significant

The maximum dry matter percentage compared to other planting time was recorded in P_1-10th November (16.25%) at harvest. A higher percentage of dry matter in bulbs of P_1 may be because of higher leaf area, LAI, and maximum interception of light resulting in the production of more photosynthates (sugars) by leaves, which is translocated to the storage organ (bulb) at maturity. This result is supported by the findings of Aboukhadrah *et al.,* (2017) and Kandil *et al.,* (2013). Interaction of planting time and spacing had no significant effect on dry matter percentage of multiplier onion.

Bulb shape index

The shape index of the multiplier onion bulb was measured at harvest. Spacing significantly influenced the bulb shape, while planting time and interaction showed no significant effect. Bulb shape index was observed to be less than 1.5 irrespective of treatment combinations; this indicates that shape of onion bulbs was spherical. This observation agrees with the bulb shape index estimated by Kaveri and Thirupati (2015) in *aggregatum* onion cv. CO-4 and Priya *et al.,* (2015) in *aggregatum* onion cv. CO-3.

Spacing S_3 (15cm×20cm) recorded maximum bulb shape index (1.32) at harvest; this might be due to the higher equatorial diameter of the bulbs produced in wider spacing. Bosekeng and Coetzer (2015) also reported that plant density influenced bulb shape in onion. According to their observation, the bulb shape changed from spindle shape to oval with the decrease in plant density and concluded that the change in the bulbs' shape is because of space constraints.

The findings of researchers like Ademe *et al.,* (2012), Grant and Carter (1994), and Kanton *et al.,* (2002) further supports this result; they observed that increase in plant density had a negative effect on bulb shape index. Planting time and interaction of planting time with spacing did not affect the bulb shape index.

Harvest index (%)

Onion has a higher Harvest Index (HI) compared to other crops. Mondal *et al.,* (1986) explained that partitioning 70 to 80% of shoot dry matter towards the bulb takes place at maturity. They further elaborate that onion has low light interception capacity and average in using the intercepted light for dry matter production, but the partitioning of the dry matter produced to bulbs is maximum. Analysis of the result showed that spacing and planting had a significant influence on the harvest index. However, interaction had no significant effect on the harvest index of multiplier onion in the current study.

Spacing S_3 recorded the maximum harvest index (79.91%). The maximum harvest index in wider spacing might be because of maximum bulb weight per plant and longer growing period, which created an excellent source to sink relationship resulting in the maximum partition of assimilates from vegetative parts towards bulblets (sink). This result is in line with the findings of Misra *et al.,* (2014) and Muthal *et al.,* (2019) in onion. Planting time P_1 (10^{th} November) recorded maximum harvest index of 79.11%, this could be because of longer growth period of early planting date resulting in maximum partition of dry matter to the bulbs.

Effect of planting time and spacing on the economics of multiplier onion cultivation

The cost-return relationship of a particular crop is an essential factor that decides the crop cultivation by the farmer. For any agronomic practice to be adopted, it should positively influence the Cost-return relationship. Farmer follows the practice, which decreases the cost of cultivation and increases profit. Economics of multiplier onion cultivation is influenced by different spacing, planting time, and their interaction is calculated in terms of cost of cultivation (₹ /ha), gross returns (₹ /ha), and net returns (₹ /ha). The benefit to cost relationship was calculated to know the profitability of each treatment combination.

The cost of cultivation of multiplier onion was calculated based on fixed cost and input cost incurred on cultivation. A higher cost of cultivation was incurred on closer spacing S_1 than S_2 and S_3 due to the higher plant population, which increases the seed rate and the expense to procure seed bulb. This result is in agreement with the findings of Aboukhadrah *et al.,* (2017) and Muthal *et al.,* (2019) in onion.

Gross returns and net returns were maximum in the treatment combination T_1 (10cm×10cm and 10^{th} November planting) due to higher yield per hectare, while lower yield per hectare resulted in minimum gross returns and net returns in treatment combination T_{12} (15cm×20cm and 25^{th} December planting). Aboukhadrah *et al.,* (2017) in onion and Vidya *et al.,* (2013) in garlic also obtained a similar result.

The benefit to cost ratio (B:C) was higher in treatment combination T_1 (10cm×10cm and 10^{th} November), *i.e.,* 4.62: 1, and the lowest ratio was obtained in the treatment combination T_{12} (15cm×20cm and 25^{th} December), *i.e.,* 1.28: 1. Maximum B: C ratio in the interaction of early planting and closer spacing maybe because of higher yield, thereby increasing the monetary returns, whereas low yield per hectare might be the reason for comparatively low returns, thereby lower the ratio of benefit to cost. The result was in agreement with the findings of Devi *et al.,* (2008) and Misra *et al.,* (2015).

It can be concluded that the Total Soluble Solids (TSS) and Dry matter content of bulbs are higher at closer spacing (10cm×10cm).

Bulbs of better bulb shape index and high harvest index were obtained at wider spacing (15cm×20cm). Economically profitable yield is obtained by the interaction of closer spacing 10cm×10cm and early planting date 10th November planting.

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