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Maturity and bolting behavior of late *kharif* onion (*Allium cepa* L.) under Jorhat conditions of Assam

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Abstract
An experiment was conducted at Horticulture Experimental Farm, Department of Horticulture, College of Agriculture, Assam Agricultural University, Jorhat, Assam during the year 2020-21 and 2021-22 to find out the optimum sowing dates and varieties of onion suitable for late *kharif* season in this region. The treatments consisted of three dates of sowing [25th August (D_1), 5th September (D_2) and 15th September (D_3)] and five varieties [Arka Kalyan (V_1), Bhima Dark Red (V_2), Agrifound Dark Red (V_3), Bhima Super (V_4) and Bhima Red (V_5)]. The experiment was laid out in factorial randomized block design with three replications. The results revealed from pooled analysis that relationship of different growth characters with various sowing dates and varieties that the minimum days to bulb development (48.52) and minimum days for bulb maturity (109.36) were recorded in D_3V_2 (Bhima Dark Red sowing on 15th September) but Minimum bolting (2.08) and minimum number of bulb doubles (0.35) were found in D_1V_4 (Bhima Super sowing on 5th August).

Keywords: Indian mustard, path coefficient analysis

Introduction
The growth and yield of cultivated crops are influenced by genotype, growing environment and agronomic practices. Good production often associated with good growth and development of any crop. In India, the main season or *rabi* crop of onion is harvested during summer, stored and slowly made available for domestic supply as well as export (Mohanta *et al.*, 2017). There is critical gap in supply of onion in the country from November to February and as a result the prices shoot up. Importance of late *kharif* cultivation of onion to stabilize the prices is well accepted. Assam has to depend on the other states which produce *kharif* and late *kharif* onion for supply of bulb during lean period (November to March). Onion is not cultivated commercially in Assam region due to unfavourable climatic conditions. Being a biennial vegetable, time of sowing plays an important role in its growth, development and successful cultivation of onion because it is very much sensitive to the photoperiod and temperature. Bulb formation is influenced by high temperature and long photoperiod. Hence time of sowing and transplanting is of prime importance for successful cultivation of onion in a particular agro-climatic situation. These environmental factors (temperature and photoperiod) and their interactions with genotype determine the performance of an onion cultivar (Brewster, 1994; Khan *et al.*, 2001; Jilani and Ghaffoor, 2003) [3, 11 8], and this interaction defines the selection of variety for the specific area (Bosekeng and Coetzer, 2015) [2]. Thus, it is imperative to assess the stability in performance of recommended varieties of onion for a specific location, especially for late *kharif* onion (Haldar *et al.*, 2009) [6]. At present, very little information is available on different aspects of *kharif* onion cultivation in Assam. The present research work was therefore designated to study the growth performance and bolting behavior of some *kharif* onion varieties in different dates of sowing under Jorhat region of Assam to make onion bulb available during lean period (November to March).

Materials and Methods
The present study was conducted at Horticulture Experimental Farm, Department of Horticulture, College of Agriculture, Assam Agricultural University, Jorhat, Assam during the year 2020-21 and 2021-22 to find out the optimum sowing dates and varieties of onion suitable for late *kharif* season in this region. The seeds were sown on raised bed and seedlings were prepared. The plot was 4.8 sqm (2.4 m x 2.0 m) in area and the total experimental area was 304 sq. m. The space between replications was 60 cm and between plots was 50 cm. The plant population in each plot was 220.

Five varieties of onion were evaluated in randomized block design with three replications. Recommended cultural practices were followed to ensure good crop. Observations were recorded on total number of days required from sowing to onset of bulbing was recorded for bulb development and total number of days required from transplanting to maturity was recorded when leaves turned yellow and tops started falling. Doubling of bulbs was recorded from each plot at the time of harvesting and after computing the mean and it was expressed in percentage. The experimental data recorded were subjected to statistical analysis using analysis of variance technique suggested by Panse and Sukhatme (1978) [16]. The per cent bolting was calculated out as number bolted flowering plants at early stage of crop from each plot divided by total number of plants, multiplied by 100.

$$\text{Premature bolting (\%)} = \frac{\text{Number of bolted plants/plot}}{\text{Total number of plants/plot}} \times 100$$

Results and Discussion

Days to bulb development: Non-significant effect of Date of sowing did not influence bulb development statistically was recorded in both the years but pooled data showed significant results (Table 1 and 2). Late sowing D_3 (15th Sep) recorded minimum days (52.58) for bulb development while the maximum days (54.10) was recorded for early sowing (D_1) on pooled analysis, Bulb initiation was earliest (50.35 days) in V_2 (Bhima Dark Red) which was followed by V_3 (AFDR) and then V_1 (Arka Kalyan). The maximum days (56.67) was taken by V_5 (Bhima Red). This can be attributed to genetic makeup of the varieties. Significant interaction effect of these revealed that minimum days (48.52) were taken by D_3V_2 (Bhima Dark Red sowing on 15th September), followed by D_3V_3 (AFDR sowing on 15th September) and then D_1V_2 (Bhima Dark Red sowing on 25th August). The maximum days (57.91) were recorded in D_1V_5 (Bhima Red sowing on 25th August). This might be attributed to interaction of environmental factors and genotype. The results were conformity with the findings of Singh *et al.* (2011) [19], Sharma *et al.* (2014) [17], Meena *et al.* (2019) [12] and Khan *et al.* (2020) [10].

Days to bulb maturity: Non-significant effect of date of sowing on days to bulb maturity was recorded in both years but in pooled data significant effect was recorded (Table 1 and 2). Last date of sowing, D_3 (15th Sep) needed minimum days (118.17) to attain bulb maturity while first date of sowing D_1 (25th Aug) took maximum days (120.99) to attain bulb maturity in pooled analysis. Bulbs were reached to maturity in minimum days (111.57, 115.05 and 113.31) in V_2 (Bhima Dark Red) which was followed by V_3 (AFDR) and then V_1 (Arka Kalyan) and maximum number of days (124.50, 127.76 and 126.13) was recorded in V_5 (Bhima Red) in 2021, 2022 and pooled data, respectively. Significant interaction effect was revealed that minimum (109.36) days to attain bulb maturity in D_3V_2 followed by D_2V_2 and D_1V_2 on pooled analysis and maximum days (128.39) were recorded in D_1V_5.

Above results clearly show that delay in sowing date resulted in early maturity of onion bulbs while due to early sowing (25th August) maturity got delayed. The time from commencement of bulb formation to bulb maturity is related to environmental conditions and the necks thicker that also a reason of delayed maturity (Khan *et al.*, 2020) [10]. Minimum days to maturity recorded in variety Bhima Dark Red and maximum days were taken by variety Bhima Red. This could be attributed to their varietal response, since varieties differ in the length of time they remain vegetative before bulbs are formed and become matured. The findings were in agreement with the results of several workers like Hirave *et al.* (2015) [7], Basha *et al.* (2018) [1], Gosai *et al.* (2018) [4], Kasera *et al.* (2019) [9], Gupta *et al.* (2020) [5], Shinde *et al.* (2020) [18] and Mishra and Napit (2021) [13], reported the influence of onion varieties on days required for maturity. Bhima Dark Red with sowing on 5th September took minimum days to reach maturity. This might be attributed to interaction of environment and genotypes. Secondly, early bulb development leads to early bulb maturity.

Premature bolting incidence (%)

Differences in sowing dates, varieties and their interaction had significant effect on premature bolting incidence in onion (Table 3 and 4). Lowest bolting (3.37, 2.93 and 3.15%) percent was observed in D_1 (25th August) and in variety Bhima Super (4.81, 4.24 and 4.53%) followed by V_5 and V_2 during 2021, 2022 and in pooled data, respectively. Lowest bolting percent (2.29, 1.87 and 2.08) was observed in D_1V_4, followed by D_1V_5 and then D_1V_2 during 2020, 2021 and pooled data, respectively and highest percent (9.17%) exhibited by D_3V_1 (Fig. 1). In onion quality of bulb was affected by production of bolters. The bolter production is affected by various factors like time of planting, cultural practices and variety grown. Lower number of bolters had been observed in early sowing. The bolting was very low in general in this experiment. It may be due suitable temperature prevalence throughout the crop period and varietal character.

The cultivar Bhima Super recorded minimum (4.53%) bolting of bulb whereas, maximum (6.44%) was recorded in the cultivar Arka Kalyan. These types of differences among different varieties may be due to genetic makeup of different varieties and adoptability under different climatic conditions as observed by Hirave *et al.*(2015) [7], Tripathy *et al.* (2016) [22], Vibhute and Singh (2016) [21], Gupta *et al.* (2020) [5], Mishra and Napit (2021) [13] and Nayak *et al.* (2022) [15]. Bhima Super with sowing on 25th August recorded the minimum premature bolting incidence. This might be attributed to interaction of environment and genotypes.

Bulb Doubles (%)

Significant effect of date of sowing, varieties and their interaction was noticed for bulb doubles in the years and pooled analysis (Table 3 and 4). Minimum incidence (0.64, 0.50 and 0.57%) of double bulbs were found in D_1 (25th Aug) and in variety Bhima Super (1.39, 1.11 and 1.25%), followed by V_5 and V_2 in2021, 2022 and pooled data, respectively. The interaction effect was also significant for bulb doubles in both the years and pooled data. In 2021, minimum 0.42 percent of double bulbs were recorded in D_1V_4, followed by D_1V_5 and D_1V_2. In 2022, minimum 0.28 percent of double bulbs were recorded in D_1V_4 followed by D_1V_5, D_1V_3 and D_1V_2. Minimum 0.35 percent of double bulbs were recorded in D_1V_4, followed by D_1V_5 and then D_1V_2 in pooled data. Maximum (3.19%) incidence was recorded in D_3V_3 during both the years and in pooled data.

In onion quality of bulb is negatively affected by production of twins/split/double bulbs. Production of doubles is brought

in by various factors viz. time of planting, cultural practices and the variety grown. Data in respect of bulb doubles indicated that lower number was found in early sowing (25th Aug) and the variety Bhima Super produced minimum double bulbs. These types of differences among different varieties may be due to genetic makeup of different varieties and adoptability under different climatic conditions. These results were in conformity with the findings of Supe *et al.* (2008), Tripathy *et al.* (2016) [22], Basha *et al.* (2018) [1], Kasera *et al.* (2019) [9] and Nayak *et al.* (2022) [15]. Bhima Super with sowing 25th August recorded minimum double bulbs. This might be attributed to interaction of environments with genotypes.

Table 1: Effect of sowing dates and varieties on days to bulb development and days to bulb maturity

Treatment	Days to bulb development			Days to bulb maturity		
Sowing date	**2020-21**	**2021-22**	**Pooled**	**2020-21**	**2021-22**	**Pooled**
D_1 (25th Aug)	52.63	55.56	54.10	119.17	122.81	120.99
D_2 (5th Sep)	52.17	55.16	53.67	118.26	121.90	120.08
D_3 (15th Sep)	51.28	53.87	52.58	116.41	119.93	118.17
SEd (±)	0.84	0.77	0.51	1.62	1.67	1.04
CD (0.05)	NS	NS	1.02	NS	NS	2.09
Variety	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
V_1 (Arka Kalyan)	51.98	54.48	53.23	117.88	121.00	119.44
V_2 (Bhima Dark Red)	48.94	51.75	50.35	111.57	115.05	113.31
V_3 (AFDR)	50.06	53.22	51.64	113.94	118.40	116.17
V_4 (Bhima Super)	53.85	56.85	55.35	121.85	125.51	123.68
V_5 (Bhima Red)	55.31	58.03	56.67	124.50	127.76	126.13
SEd (±)	1.08	1.00	0.66	2.09	2.16	1.35
CD (0.05)	2.21	2.05	1.32	4.27	4.43	2.70

Table 2: Interaction effect of date of sowing and varieties on days to bulb development and days to bulb maturity

Treatment	Days to bulb development			Days to bulb maturity		
	2020-21	**2021-22**	**Pooled**	**2020-21**	**2021-22**	**Pooled**
D_1V_1	52.28	54.77	53.52	118.11	121.55	119.83
D_1V_2	49.49	52.77	51.13	113.50	117.27	115.38
D_1V_3	50.22	53.50	51.86	114.16	118.72	116.44
D_1V_4	54.66	57.44	56.05	123.28	126.55	124.91
D_1V_5	56.50	59.33	57.91	126.83	129.94	128.39
D_2V_1	52.27	55.11	53.69	118.72	121.22	119.97
D_2V_2	50.11	52.66	51.38	113.83	116.55	115.19
D_2V_3	50.33	53.55	51.94	114.05	119.11	116.58
D_2V_4	53.44	56.55	55.00	121.22	125.11	123.16
D_2V_5	54.72	57.94	56.33	123.50	127.50	125.50
D_3V_1	51.38	53.55	52.47	116.83	120.22	118.52
D_3V_2	47.22	49.83	48.52	107.38	111.33	109.36
D_3V_3	49.63	52.61	51.12	113.61	117.39	115.50
D_3V_4	53.44	56.55	55.00	121.05	124.89	122.97
D_3V_5	54.72	56.83	55.77	123.16	125.83	124.50
S.Ed. (±)	1.87	1.73	1.15	3.61	3.75	2.34
CD(0.05)	3.83	3.54	2.29	7.40	7.67	4.67

Table 3: Effect of date of sowing and varieties on premature bolting incidence (%) and bulb doubles (%)

Treatment	Premature bolting incidence (%)			Bulb doubles (%)		
Sowing date	**2020-21**	**2021-22**	**Pooled**	**2020-21**	**2021-22**	**Pooled**
D_1 (25th Aug)	3.37	2.93	3.15	0.64	0.50	0.57
D_2 (5th Sep)	5.79	5.21	5.50	1.69	1.53	1.61
D_3 (15th Sep)	8.21	7.46	7.84	2.75	2.58	2.67
SEd (±)	**0.16**	**0.15**	**0.10**	**0.12**	**0.09**	**0.07**
CD (0.05)	**0.32**	**0.32**	**0.20**	**0.25**	**0.18**	**0.14**
Variety	**2020-21**	**2021-22**	**Pooled**	**2020-21**	**2021-22**	**Pooled**
V_1 (Arka Kalyan)	6.75	6.12	6.44	1.94	1.76	1.85
V_2 (Bhima Dark Red)	5.73	5.15	5.44	1.62	1.57	1.60
V_3 (AFDR)	6.35	5.75	6.05	1.94	1.85	1.90
V_4 (Bhima Super)	4.81	4.24	4.53	1.39	1.11	1.25
V_5 (Bhima Red)	5.30	4.75	5.03	1.57	1.39	1.48
SEd (±)	0.20	0.20	0.13	0.16	0.11	0.09
CD (0.05)	0.41	0.41	0.26	0.32	0.23	0.18

Table 4: Interaction effect of sowing dates and varieties on premature bolting incidence (%) and bulb doubles

Treatment	Premature bolting incidence (%)			Bulb doubles (%)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
D_1V_1	4.49	4.00	4.24	0.83	0.69	0.76
D_1V_2	3.36	2.89	3.12	0.56	0.55	0.55
D_1V_3	3.90	3.43	3.67	0.83	0.55	0.69
D_1V_4	2.29	1.87	2.08	0.42	0.28	0.35
D_1V_5	2.80	2.44	2.62	0.56	0.42	0.49
D_2V_1	6.19	5.61	5.90	2.22	1.94	2.08
D_2V_2	5.79	5.23	5.51	1.67	1.67	1.67
D_2V_3	6.47	5.95	6.21	1.81	1.81	1.81
D_2V_4	5.04	4.41	4.72	1.25	0.97	1.11
D_2V_5	5.47	4.87	5.17	1.53	1.25	1.39
D_3V_1	9.58	8.76	9.17	2.78	2.64	2.71
D_3V_2	8.04	7.32	7.68	2.64	2.50	2.57
D_3V_3	8.68	7.87	8.27	3.19	3.19	3.19
D_3V_4	7.11	6.44	6.77	2.50	2.08	2.29
D_3V_5	7.65	6.93	7.29	2.64	2.50	2.57
S.Ed. (±)	0.35	0.34	0.22	0.27	0.20	0.15
CD (0.05)	0.72	0.71	0.45	0.56	0.41	0.30

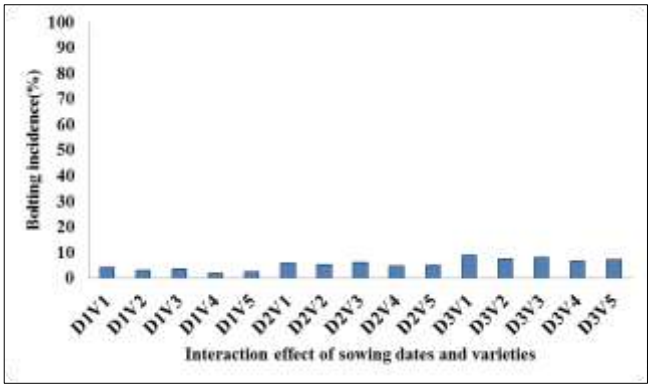

Fig 1: Bolting incidence (%)

Conclusion

The experimental evidence warrants the following specific conclusion which may be adopted for profitable cultivation of onion. On the basis of results of the present investigation it may be concluded that early sowing (25th August) of Bhima Super exhibited minimum premature bolting incidence (2.08%) and double bulbs (0.35%), so this can be grown for quality onion bulb production. D_3V_2 (Bhima Dark Red with 15th September sowing) registered minimum number of days for bulb development (48.52 days) and bulb maturity (109.36 days) so it can be recommended for early bulb harvest. More new varieties with different sowing dates may be evaluated during *kharif* season at various regions of Assam in future.

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