Indian Journal of Agricultural Sciences **85** (12): 1578–85, December 2015/Article
https://doi.org/10.56093/ijas.v85i12.54310

Effect of planting time and density on plant growth, seed yield and quality attributes in onion (*Allium cepa*) cv. Pusa Riddhi

SANJAY KUMAR[1], B S TOMAR[2], S K JAIN[3], NAVEEN SINGH[4], RAJENDER PARSAD[5] and A D MUNSHI[6]

Indian Agricultural Research Institute, New Delhi 110 012

Received: 15 June 2015; Accepted: 25 June 2015

ABSTRACT

The present experiment was conducted to investigate the effect of planting time and density on plant growth, seed yield and quality attributes in onion (*Allium cepa* L.) cv. Pusa Riddhi at SPU, IARI, New Delhi during *rabi* 2013-14 and 2014-15. The experiment consists of three different planting dates, i.e. 15 October (T_1), 25 October (T_2) and 5 November (T_3) with three spacings, viz. 60×10 cm (S_1) 60×20 cm (S_2) 60×30 cm (S_3). The experimental results revealed that the date of planting and plant spacing had significant influence on growth attributes, flowering, yield and quality characters. The planting on 15 October (T_1) showed significant higher, seed scape height (101.4 cm), umbel diameter (6.54 cm), productive umbellates/umbel (414.73), seed setting (83.69%), seed yield/plant (8.71 g) and yield/ha (6.86 q), germination (%) (88.43), seedling length (9.48 cm), seedling dry weight (1.9 mg) and vigour index-I and II (8.33.32 and 167.08) than 25 October and 5 November planting. The plant spacing 60×30cm (S_3) showed higher number of leaves/plant (40.89) seed scape height (102.26 cm), scape diameter (1.88 cm), total scapes/plant (11.72), umbel diameter (6.58 cm), productive scapes/plant (8.35), umbellates/umbel (503.52), productive umbellates/umbel (419.4), yield/umbel (3.48 g), seed yield/plant (12.43 g), seed yield/ha (6.22 q), 1000 seed weight (3.01 g), germination (%) (89.76) and seed vigour-I and II (918.56 and 172.96) than closer spacing. The incidence of disease, disease severity index and scape lodging (%) were significantly lower in 15 October (T_1) and 60×30 (S_3).

Key words: Onion, Planting time and density, Pusa Riddhi, Quality, Seed scape, Seed yield/ha, Umbellates

At present, in India onion (*Allium cepa* L.) seed production is largely concentrated in the state of Maharashtra, Karnataka, Gujarat and Madhya Pradesh and unable to meet the market demand of supply of quality seed. Hence, development of new alternative locations for onion seed production is a need of the hour. North India could be one of the potential onion growing regions but onion seed production in this region is greatly affected by biotic and abiotic factors and resulting lower seed yield and quality. The planting time is playing important role since,onion is a photo thermo sensitive plant (Jones and Mann 1963) and a small fluctuation in environment can affect the yield and quality of seed. The early planting of bulbs for seed production affects the emergence of seed head from bulb which demands low temperature conditions (Peters 1990) and delay in planting will have more incidences of disease, viz. *Stemphylium* blight, purple blotch and pest attack. The planting time also affects the seed setting percentage because perfect matching of honey bee activities for pollination and anthesis of flowers is required for better seed setting, which is highly depends on range of temperatures prevailing in seed production areas (Teshome *et al*. 2014). High temperature during pollination and seed maturation, leads to more abortion of flowers resulting into less seed yield and quality. Many researchers observed that early planting of bulbs gave significant higher seed yield and quality than late planting (Ibrahim *et al.* 1996, Mosleh 2008 and Anisuzzaman *et al*. 2009). Planting density is other important factor which affects the seed yield and quality. Brewster (1994) reported that optimum plant spacing and high quality seeds were considered important for optimum plant growth, high yield and quality in *Allium* species. Ayoub and Hala (2013) suggested that wider spacing of bulbs for onion seed production had given higher germination % and emergence percentage than closest spacing and similar results were reported by other workers (Narendra and Ahmed 2005, Mirshekari *et al*. 2008 and Asaduzzaman *et al.* 2012). In order to harvest higher bulb yield and enhance production, it is imperative to improve the availability of seed quality to the growers. However, the investigations were reported on various aspects and variety but the standardized seed production technology on new released onion cv. Pusa Riddhi is not available. Therefore, the present study was conducted to standardize the planting time and density for quality seed

[1]PhD Scholar (e mail: sanjaykumar10187@gmail.com) Division of Seed Science and Technology, [2]Principal Scientist (e mail: bst_spu_iari@rediffmail.com), Seed Production Unit,[3]Professor, Division of Seed Science and Technology, [4]Senior Scientist, Division of Genetics, [5]Principal Scientist, Division of Plant Physiology, [6]Head, Division of Experimental Design, IASRI, [7]Professor, Division of Vegetable Science

production of onion cv. Pusa Riddhi under North Indian conditions.

MATERIALS AND METHODS

The present experiment was conducted for two consecutive years during *rabi* season of 2013-14 and 2014-15 at Seed Production Unit Farm, Indian Agricultural Research Institute, New Delhi. The treatment consist of three planting dates (T_1-15 October, T_2-25 October and T_3-5 November) as main plot and three spacing (S_1- 60 cm×10 cm, S_2- 60 cm×20 cm, S_3-60 cm×30 cm) as sub plot with plot size of 3 m×3 m (9 m^2). The medium size (60-80 g) bulbs of onion cv. Pusa Riddhi which were produced in previous season and stored under farm conditions were planted according to the combinations of treatments. The treatment plots were uniformly fertilized with 100:50:50 kg/ha (N: P: K) and full amount of P and K and half amount of N was applied as basal dose. The remaining half N was applied as ridge dressing. The necessary plant protection measures were adopted for control of pests and diseases. Fipronil (reagent) @ 10 kg/acre as basal application and imidacloprid (30.5%) @ 0.5ml/liter of water and jump (Fipronil) @40g/ha were applied to control thrips and other insects. Two spray of nativo (Tebuconazole 50% + Trifloxystrobin 25% WG) @ 100g/acre was applied at 25 DAP and at bolting stage to avoid the fungal diseases (stemphylium blight and purple blotch). Earthing up was practiced in each plot at 75 DAP to avoid lodging of seed scapes in later stages, i.e. flowering and maturation. The observations on number of leaves, scape height, diameter, productive seed scape, PDI and umbel traits were recorded from randomly selected 10 plants. The seed yield attributes was recorded on plot basis after harvesting. The seed quality attributes were evaluated as per the guidelines of ISTA, 2012 while, seed vigour-I and II and EC were calculated as suggested by Abdul-Baki and Anderson (1973) and Agrawal and Dadlani (1987), respectively. Total leaf chlorophyll was measured as method suggested by Hiscox and Israelstam (1979) by using dimethyl sulfoxide (DMSO). The disease severity on seed scape was scored based on 0-4 scales (Behera *et al.* 2013) as follows; 0= No disease symptoms, 1=1-25% seed scape area infected, 2=25-50% seed scape area infected, 3=50-75% seed scape area infected, 4=57-100% seed scape area infected and percentage disease index (PDI) was calculated by the formula given by Wheeler (1969).

$$PDI=\frac{\text{Total sum of numerical ratings}}{\text{Number of observations}}\times\frac{100}{\text{Maximum disease rating}}$$

The data on quantity observations recorded were subjected to statistical analysis by adopting split plot design using SAS 9.3 and the percentage data were transformed into arcsine value for analysis.

RESULTS AND DISCUSSION

Effects on growth attributes

The experimental results presented in Table 1 showed that planting density had significant effect on number of leaves/plant and S_3 has produced more number of leaves (40.89) as compared to S_2 (37.05) and S_1 (34.12) which might be due to the availability of higher nutrients and light under lower density of plants and resulting into better number of leaves/plant. The results are in agreement with Asaduzzaman *et al.* (2012). The T_3 has taken less period (55.72) for seed scape emergence than T_1 (66.44) and T_2 (60.33) (Table 1) which could be due to low temperature conditions during December and January and promoted the bolting of seed scape and its development. The spacing and interaction (T×S) did not have any significant effect on seed scape emergence. The planting time and density had significant effect on seed scape height and maximum height was recorded under T_1 (101.74 cm) than T_2 and T_3 (101.74, 100.61cm) (Table 1), respectively, which could be attributed to conducive climatic condition, that promoted the higher photosynthesis and more mobilization of assimilates.

The significant higher seed scape height was observed under S_3(102.26 cm) followed by S_2(101.17cm) and S_1(99.36) which could be due to limited competition for nourishment of plants at wider spacing than closer. The results are in agreements with Helaly and Karam (2012) and Pandey *et al.* (1992).

However, nonsignificant interaction was recorded between planting time and density. The seed scape diameter was significantly superior under S3 (1.88) followed by S2 and S1 (1.83 cm and 1.80 cm) (Table 1). The higher seed scape diameter in S3 might be due to better availability of nutrition's and photo synthetically active radiations (Helaly and Karam 2012).

Effects on flowering and seed scape traits

The significantly higher days was taken by T_1 (126.0) for initiation of flowering than T_2 (122.65) and T_3 (120.50) (Table 2) due to the rising temperature at the end of February which favoured initiation of flowering in late plantings than 15 October. The umbel diameter had significantly affected by changing in planting density. The maximum umbel diameter was recorded under S_3 (6.58) and gradual reduction was noted with high density (S_2; 6.31 and S_3; 6.05) (Table 2). Similarly, higher number of scapes/plant was observed under S_3 (11.72) (Table 2) followed by S_2 and S_1 (10.06 and 9.23), respectively. The higher seed scapes/plant in S_3 is associated with more number of leaves under wider spacing (S_3) which might be converted more light energy into chemical energy and influenced more number of seed scapes per plant (Pandey *et al.* 1992).The numerically higher seed scapes was produce in T_3 (10.44) but it is statistically at par with others. Planting density had significant effect on productive seed scape and 60×30 cm had given highest value (8.35) than 60×20 cm (6.82) and 60×10 cm (5.01) which might be due to low disease incidence and severity under wider spacing (Table 3). The interaction between T×S showed nonsignificant effect for productive seed scapes/plant.

Table 1 Effect of planting time and density on growth attributes in onion cv. Pusa Riddhi (Pooled data of 2013-14 and 2014-15)

DOP	Number of leaves/plant				Seed scape emergence (days)				Seed scape height (cm)				Seed scape diameter (cm)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
T_1	35.41	38.13	42.28	38.61	66.0	66.16	67.16	66.44^{a}	99.81	102.10	103.30	101.74^{a}	1.83	1.85	1.93	1.87
T_2	33.86	36.98	40.78	37.21	60.6	60.16	60.16	60.33^{b}	98.98	100.75	102.10	100.61^{b}	1.79	1.85	1.85	1.83
T_3	33.10	36.03	39.61	36.25	55.3	56.0	55.83	55.72^{c}	99.30	100.65	101.37	100.44^{c}	1.79	1.79	1.84	1.80
Mean	34.12^{c}	37.05^{b}	40.89^{a}		60.6	60.7	61.05		99.36^{c}	101.17^{b}	102.26^{a}		1.80^{b}	1.83^{b}	1.88^{a}	
		Significance (5%)				*Significance (5%)*				*Significance (5%)*				*Significance (5%)*		
T		NS				S*				S*				NS		
S		S*				NS				S*				S*		
T × S		NS				NS				NS				NS		

DOP- Date of planting, T_1- 15 October, T_2- 25 October, T_3- 5 November, NS- Non significant, S- significant, S_1- Spacing 60 ×10cm, S_2- 60 × 20cm, S_3- 60 × 30cm, *Significant effects are sown with group letters

Table 2 Effect of planting time and density on flowering and seed scape traits in onion cv. Pusa Riddhi (Pooled data of 2013-14 and 2014-15)

DOP	Initiation of flowering (Days)				Total seed scape/plant				Productive seed scape /plant				Umbel diameter (cm)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
T_1	126.16	126.83	126.00	126.00^{a}	9.28	10.01	11.76	10.35	5.1	6.78	8.48	6.78	6.28	6.43	6.92	6.54^{a}
T_2	122.33	122.83	121.33	122.65^{b}	9.13	9.98	11.56	10.22	4.88	7.0	8.43	6.77	5.88	6.31	6.61	6.27^{b}
T_3	119.50	121.16	120.66	120.50^{c}	9.30	10.20	11.83	10.44	5.07	6.7	8.15	6.63	6.00	6.18	6.23	6.13^{b}
Mean	122.65	123.60	122.66		9.23^{c}	10.06^{b}	11.72^{a}		5.01^{c}	6.82^{b}	8.35^{a}		6.05^{c}	6.31^{b}	6.58^{a}	
		Significance (5%)				*Significance (5%)*				*Significance (5%)*				*Significance (5%)*		
T		S*				NS				NS				S*		
S		NS				S*				S*				S*		
T × S		NS				NS				NS				NS		

DOP- Date of planting, T_1- 15 October, T_2- 25 October, T_3- 5 November, NS- Non significant, S- significant, S_1- Spacing 60 ×10cm, S_2- 60 × 20cm, S_3- 60 × 30cm, *Significant effects are sown with group letters

Table 3 Effect of planting time and density on disease incidence and lodging percentage in onion cv. Pusa Riddhi (Pooled data of 2013-14 and 2014-15)

DOP	Disease infected plant (%)				Percentage disease index (PDI)				Seed scape lodging (%)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
T_1	56.71	31.92	25.54	38.06	8.00	6.00	6.22	6.74	45.46	30.16	24.16	33.26
	(48.85)	(34.38)	(30.34)	(37.85)	(23.97)	(22.16)	(19.44)	(21.86)	(42.38)	(33.29)	(29.40)	(35.02)
T_2	54.72	37.51	24.05	38.76	8.41	6.33	5.25	6.66	46.43	28.29	22.08	32.27
	(47.70)	(37.73)	(29.35)	(38.26)	(23.89)	(22.11)	(20.96)	(22.32)	(42.93)	(32.03)	(27.99)	(34.32)
T_3	58.40	40.13	27.36	41.96	8.75	6.33	5.97	7.01	43.75	29.22	21.06	31.34
	(51.08)	(40.53)	(32.56)	(41.39)	(23.10)	(21.43)	(20.12)	(21.55)	(41.36)	(32.68)	(27.21)	(33.75)
Mean	58.61	38.52	27.65		8.38	6.22	5.81		45.21	29.23	22.43	
	(51.21)[a]	(39.55)[b]	(32.75)[c]		(23.65)[a]	(21.9)[b]	(20.17)[c]		(42.22)[a]	(32.67)[b]	(28.20)[c]	
	Significance (5%)				*Significance (5%)*				*Significance (5%)*			
T		NS				NS				NS		
S		S*				S*				S*		
T × S		NS				NS				NS		

DOP- Date of planting, T_1- 15 October, T_2- 25 October, T_3- 5 November, NS- Non significant, S- significant, S_1- Spacing 60cm × 10cm, S_2- 60cm × 20cm, S_3- 60cm × 30cm, *Significant effects are sown with group letters

Effects on disease incidence and seed scape lodging (%)

The results presented in Table 3 showed that, planting density had significant effect on disease incidence, PDI and scape lodging %. The percentage of disease infected plants was low in S_3 (27.65) as compared to S_2(38.52%) and S_1(58.61). The severity of disease (PDI) was also low under S_3 (5.81) followed by S_2 (6.22) and S_1 (8.38). The enhanced disease infection and severity mainly; stemphylium blight and purple blotch was due to less interception of light and air under higher density which provide congenial conditions for fungal growth and development at closer spacing than wider spacing. The closer spacing (S_1) showed significant higher seed scape lodging (45.21%) and reduction trend was observed along with increase in spacing as recorded in S_2 and S_3 (29.33% and 22.43%) respectively, which might be due to the higher level of disease incidence and severity under closely spaced plants.

Effect on number of umbellates/umbel and seed setting (%)

Plant spacing had significant effect on number of umbellates/umbel (Table 4) and S_3 (503.4) had given higher number of umbellates/umbel than S_2 (491.4) and S_1 (471.68) due to better availability of photosynthates and less competition for nutrients, moisture and light source (Anisuzzaman *et al.* 2009). The effect of planting time and interaction between planting time and density were found statistically at par.

The productive umbellates/umbel significantly influenced from change in planting time and density. The higher productive umbellates/umbel was recorded under T1 (414.73) planting followed by T2 (378.67) and T3 (367.97) (Table 4). The low productive umbellates/umbel in late planting attributed to lower umbel diameter and number of umbellates/umbel, more number of aborted flowers, reduced pollen viability and stigma receptivity due to prevailing high temperatures at flowering. Secondly, low activity of honeybees under higher temperature resulting into less pollination. Among different plant spacing, S_3 (419.73) had given significantly higher number of productive umbellates per plant than S_2 (391.48) and S_1 (350.49) due to more number of umbellates/umbel at wider spacing. The interaction between T×S showed significant effect on productive umbellates/umbel and highest productive umbellates/umbel were recorded in T_1S_3 (450.97) followed by T_1S_2 (418.73) and T_2S_3 (413.50) with lowest number was recorded in T_3S_1 (335.97) (Table 4). Similar result was reported by Asaduzzaman *et al.* (2012). The results presented in (Table 4) showed that seed setting % have marked differences with respect to planting time, density and their interaction effect. Significantly highest and lowest seed setting % was noted in T_1 (83.69) and T_3 (75.61) respectively. Significantly highest seed setting % was recorded in S_3 (83.24), followed by S_2 (79.62) and S_1 (74.35) and trend was in agreement with Teshome *et al.* (2014). The delaying in planting and close spacing showed

Table 4 Effect of planting time and density on umbellates/umbel, productive umbellates/umbel and seed setting % in onion cv. Pusa Riddhi (Pooled data of 2013-14 and 2014-15)

DOP	Total umbellates/umbel				Productive umbellates/umbel				Seed setting (%)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
T_1	476.87	495.33	512.50	494.90	374.50	418.73	450.97	414.73^a	78.55 (62.49)	84.52 (66.90)	88.01 (69.75)	83.69 (66.38)a
T_2	465.67	488.67	501.67	486.37	341.00	381.50	413.50	378.67^b	73.29 (58.91)	78.03 (62.03)	82.43 (65.20)	77.61 (62.05)^b
T_3	472.50	490.20	496.40	485.33	335.97	374.20	393.73	367.97^b	71.23 (57.61)	76.31 (60.88)	79.29 (62.92)	75.61 (60.47)^b
Mean	471.68^c	491.40^b	503.52^a		350.49^c	391.48^b	419.4^a		74.35 (59.67)^c	79.62 (63.27)^b	83.24 (65.96)^a	
		Significance (5%)				*Significance (5%)*				*Significance (5%)*		
T		NS				S*				S*		
S		S*				S*				S*		
T × S		NS				S*				S*		

DOP- Date of planting, T_1- 15 October, T_2- 25 October, T_3- 5 November, NS- Non significant, S- significant, S_1- Spacing 60cm × 10cm, S_2- 60cm × 20cm, S_3- 60cm × 30cm, *Significant effects are sown with group letters

reduction trend in seed set % was due to higher pollination and optimum time for seed development. Significant differences were also observed for T × S interaction and highest seed setting (%) was noticed in T_1S_3 (88.01%), followed by T_1S_2 (84.52%) and lowest in T_3S_1 (71.23%).

Effect on seed yielding attributes

Planting density had significant effect on seed yield/umbel and maximum yield/umbel was recorded in S_3 (3.48g) followed by S_2 (3.31g) and S_1 (3.14g) (Table 5). The seed yield/umbel was higher due to bigger umbel diameter, more productive umbellates/umbel and higher seed setting (%) (El-Aweel and Ghobashi 1999). The interaction between T×S was non-significant for this trait.

The significantly higher seed yield/plant was recorded in T_1(8.71g) and S_3 (12.43g) while, minimum was recorded in T_3(8.21g) and S_1 (5.31g) (Table 5). The higher seed yield/plant under early planting and wider spacing was due to less disease severity, higher number of productive seed scape, higher seed setting (%) and less lodging % and results are in conformity with Teshome *et al.* (2014). The planting time and density had also significant effect on seed yield/plot and per ha (Table 5). The higher seed yield/plot was recorded in T_1 (685.01g) and S_1 (716.72g) than other planting time and spacing. The highest seed yield/ha was recorded under T_1 (6.86q) and S_1 (7.17q) while lowest was found in T_3 (6.4q) and S_3 (6.22q). The higher seed yield/ha under closer spacing was due to higher plant population under S1 than S2 and S3. The results are in agreement with Atif (2004) which had also reported higher seed yield/ha under closer spacing.

Effects on seed quality attributes

Planting density had significant effect on 1000 seed weight and electrical conductivity (EC). The S_3 had given higher 1000 seed weight (3.01g) than S_2 (2.76g) and S_1 (2.91g). The EC of seed leachates was lower in S_3 (21.95uS/cm/g) followed by S_2 (23.93uS/cm/g) and S_1 (25.39uS/cm/g). However, numerically it was higher in T_3 (23.44 uS/cm/g) than T_2 (23.65 uS/cm/g) and T_1 (24.18 uS/cm/g).

Time of planting and density showed significant effect on germination (%) and higher germination was recorded in T_1 (88.33 %) and S_3 (89.76%). The lower germination (%) was recorded in late planting (85.63 %) and closer spacing (84.64%). The planting time had significant effect on seedling length and higher seedling length was noted in T_1 (9.48cm) followed by T_2 (9.02cm) and T_3 (8.51cm). The maximum seedling length was recorded in S_3 (10.37cm) than S_1 (7.78cm).The higher seedling dry weight was noted in T_1 (1.90 mg) and S_3 (1.95 mg) and lower seedling dry weight was observed in T_3 (1.67 mg) and S_1 (1.63 mg) (Table 6).

The planting time and density had significant effect on seed vigour index and T_1 showed significantly higher seed vigour index-I (833.32) and vigour index-II (167.08) than late planting (Table 7). The wider spacing (S_3) had showed higher seed vigour index-I (918.56) and vigour index-II (172.96) followed by S_2 (754.32 and 148.88) and S_1

Table 5 Effect of planting time and density on seed yield contributing attributes in onion cv. Pusa Riddhi (Pooled data of 2013-14 and 2014-15)

DOP	Seed yield/umbel (g)				Seed yield/plant (g)				Seed yield/plot (gm)				Seed yield/ha (q)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
T_1	3.29	3.51	3.71	3.50	5.58	7.86	12.70	8.71^{a}	753.50	668.33	635.00	685.61^{a}	7.54	6.68	6.35	6.86^{a}
T_2	3.11	3.22	3.41	3.25	5.30	7.59	12.42	8.43^{b}	715.00	645.00	620.83	660.28^{b}	7.15	6.45	6.21	6.6^{b}
T_3	3.01	3.21	3.32	3.18	5.05	7.41	12.18	8.21^{b}	681.67	630.00	609.17	640.28^{c}	6.82	6.30	6.09	6.4^{c}
Mean	3.14^{c}	3.31^{b}	3.48^{a}		5.31^{c}	7.62^{b}	12.43^{a}		716.72^{a}	647.78^{b}	621.67^{b}		7.17^{a}	6.48^{b}	6.22^{b}	
		Significance (5%)				*Significance (5%)*				*Significance (5%)*				*Significance (5%)*		
T		NS				S*				S*				S*		
S		S*				S*				S*				S*		
T × S		NS				NS				NS				NS		

DOP- Date of planting, T_1- 15 October, T_2- 25 October, T_3- 5 November, NS- Non significant, S- Significant, S_1- Spacing 60cm × 10cm, S_2- 60cm × 20cm, S_3- 60cm × 30cm, *Significant effects are sown with group letters

Table 6 Effect of planting time and density on seed quality traits in onion cv. Pusa Riddhi (Pooled data of 2013-14 and 2014-15)

DOP	1000 seed weight (g)				Germination (%)				Seedling length (cm)				Seedling dry weight (mg)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
T_1	2.80	2.99	3.13	2.97	85.72 (67.78)	88.0 (69.79)	91.28 (72.28)	88.33 (70.14)^{a}	8.17	9.25	11.03	9.48^{a}	1.72	1.81	2.18	1.9^{a}
T_2	2.79	2.89	2.97	2.88	84.55 (66.85)	86.05 (68.06)	89.89 (71.47)	86.83 (68.8)^{b}	7.87	8.91	10.29	9.02^{b}	1.64	1.75	1.89	1.76^{b}
T_3	2.71	2.85	2.94	2.83	83.66 (66.15)	85.11 (67.29)	88.11 (69.83)	85.63 (67.76)^{c}	7.30	8.46	9.79	8.51^{c}	1.54	1.69	1.78	1.67^{b}
Mean	2.76^{c}	2.91^{b}	3.01^{a}		84.64 (66.93)^{c}	86.38 (68.38)^{b}	89.76 (71.39)^{a}		7.78^{c}	8.87^{b}	10.37^{a}		1.63^{c}	1.75^{b}	1.95^{a}	
		Significance (5%)				*Significance (5%)*				*Significance (5%)*				*Significance (5%)*		
T		NS				S*				S*				S*		
S		S*				S*				S*				S*		
T × S		NS				NS				NS				NS		

DOP- Date of planting, T_1- 15 October, T_2- 25 October, T_3- 5 November, NS- Non significant, S- significant, S_1- Spacing 60cm × 10cm, S_2- 60 cm × 20cm, S_3- 60cm × 30cm, *Significant effects are sown with group letters

Table 7 Effect of planting time and density on germination (%), Seed Vigour Index-I and II in onion cv. Pusa Riddhi (Pooled data of 2013-14 and 2014-15)

DOP	Seed vigour index-I				Seed vigour index-II				EC (uS/cm/g)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
T_1	690.09	807.77	1002.1	833.32^a	144.81	158.35	198.08	167.08^a	25.06	23.59	21.68	23.44
T_2	634.66	744.42	914.90	764.66^b	135.16	148.40	168.00	150.52^b	25.10	23.62	22.23	23.65
T_3	595.02	710.78	838.67	714.82^c	122.26	139.87	152.80	138.31^b	26.00	24.60	21.94	24.18
Mean	639.92^c	754.32^b	918.56^a		134.08^c	148.88^b	172.96^a		25.39^a	23.93^b	21.95^c	
	Significance (5%)				*Significance (5%)*				*Significance (5%)*			
T	S*				S*				NS			
S	S*				S*				S*			
T × S	S*				S*				NS			

DOP- Date of planting , T_1- 15 October, T_2- 25 October, T_3- 5 November, NS- Non significant, S- significant, S_1- Spacing 60cm × 10cm, S_2- 60cm × 20cm, S_3- 60cm × 30cm, *Significant effects are sown with group letters

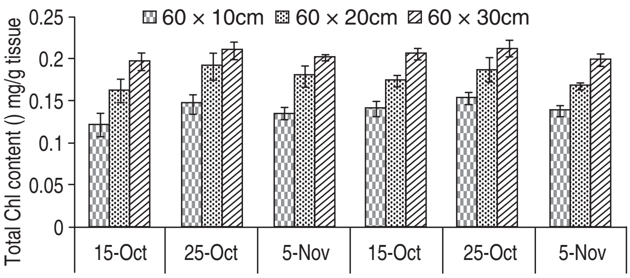

Fig 1 Effect of planting time and density on total chlorophyll content

(148.88 and 134.08), respectively. The interaction between T ×S also showed significant effect on vigour index-I and II and higher vigour index-I and II was recorded in T_1S_3 (1000.2 and 198.08) followed by T_2S_3 (914.90 and 168), respectively, which could be due to better development of seed under optimum temperature for different seed metabolic activities and better accumulation of seed storage materials under wider spacing. The similar results for seed quality attributes were recorded by Helaly and Karam (2012) and Teshome *et al.* (2014).

Effect on leaf chlorophyll content

The total chlorophyll content was also found minimum under closer spacing than wider spacing (Fig 1). This was due to shading effect to lower canopy of plants, causing poor transmission of the photosynthetically active radiation (PAR).

Based upon the results recorded in this experiment it could be concluded that for attaining better plant growth, seed setting, higher seed yield and quality attributes, the seed production of onion cv. Pusa Riddhi should be undertaken at 15 October with 60×30 cm spacing in Delhi condition.

REFERENCES

Abdul-Baki A A and Anderson J D.1973. Vigour determination in soybean by multiple criteria.*Crop Science***13:** 630–7.

Anisuzzaman M, Ashrafuzzaman M, Mohd R I, Uddin M K and Rahim M A. 2009. Planting time and mulching effect on onion development and seed production. *African Journal of Biotechnology* **8 (3)**: 412–6.

Asaduzzaman M, Mainul M H, Mahmudul M H, Moniruzzaman M and Mohammad H K H. 2012. Effect of bulb size and plant spacing on seed production of onion (*Allium cepa L.*).*Bangladesh Journal of Agricultural Research* **37(3)**: 405–14.

Atif Y M. 2004. Effect of bulb size and plant density on onion seed production under rainfed conditions.*Minufiya Journal of Agricultural Research* **29**: 1 339–46.

Ayoub Z E and Hala M O. 2013. Effect of plant spacing on onion (*Allium cepa* L.) seeds quality. *Universal Journal of Applied Science* **1(2)**: 52–5.

Behera S, Santra P, Chattopadhyay S, Das S and Maity T K. 2013.Variation in onion varieties for reaction to natural infection of *Alternaria porri* (Ellis*)* Ciff. and *Stemphylium vasicarium* (Wallr.). *Bioscan* **8(3)**: 759–61.

Brewster J L.1994. *Onions and Other Vegetable Alliums*. CAB International, Wallingford, UK, p 236.

Dadlani M and Agrawal P K.1987.*Techniques in Seed Science and Technology,* pp 103–4. South Asian Publishers, New Delhi.

El-Aweel M A T and Ghobashi A A. 1999.Seed production in onion as influenced by dates of planting in the Sultanate of Oman.*Assiut Journal of Agricultural Sci*ence **30**: 43–53.

FAO.2013. Current world agriculture production 2011/2012. Food and Agricultural Organization of the United Nations, Rome.

Helaly M A and Karam S S.2012**.**Influence of planting date on the production and quality of onion seeds**.** *Journal of Horticultural Science and Ornamental Plants* **4(3)**: 275–9.

Hiscox J D and Israelstam G F. 1979.A method for the extraction of chlorophyll from leaf tissue without maceration.*Canadian Journal of Botany.***57:** 1 332–4.

Ibrahim M Y, Mostafa A K, HegazyA M and El-Kafoury A K. 1996. Flowering behavior of Egyptian onion cv. Giza 20 affected by planting date. *Proceedings of 7th Conference on Agronomy*, 9-19 Sept, pp 635–42.

ISTA. 2012. Seed testing rules, Publ. *The International Seed Testing Association*, 8303.barsserssorf, CH-Switzerland.

Jones H A and Mann L K. 1963.Onions and Their Allies. Leonard Hill, London, p 169.

Mirshekari B, Mobasher M and Biroonara A. 2008.Determination of best sowing time, bulb diameter and intra row spacing of azarshahr red onion, a new variety in Iran.*Acta Horticulturale* **771**.

Mosleh M D. 2008. Effect of mother bulb size and planting time on growth, bulb and seed yield of onion. *Bangladesh Journal of Agricultural Research* **33(3)**: 531–7.

Narendra S and Ahmed Z. 2005. Influence of bulb size and spacing on onion seed production in leh (ladakh). *Vegetable Science* **32(1)**: 101–2.

National Horticulture Board. 2013-14. Indian Horticulture Data Base, Ministry of Agriculture, Gurgaon, Haryana.

Pandey U B, Panwar D S and Sharma V P. 1992. Effect of spacing and levels of nitrogen on growth and seed yield of *kharif* onion. *Seed Research* **20(2)**:147–8.

Peters R J. 1990.Seed production in onion and other *Allium* species. (*In*) *Onion and Allied Crops, Volume 1: Botany, Physiology and Genetics, pp* 103–24. Rabinowitch, H D and J L Brewester (Eds.). CRC Press, Boca Raton, FL, USA.

Teshome A, Derbew B, Sentayehu A and Yehenew G. 2014. Effect of planting time and mother bulb size on onion (*Allium cepa* L.) seed yield and quality at Kobo Woreda, Northern Ethopia. *International Journal of Agricultural Research* **9(5)**: 231–41.

Wheeler B E. 1969. *An Introduction to Plant Disease*, pp 43–6. John Wiley and Sons Ltd, London, UK.