Research Article

Influence of nursery sowing dates, seedling age and nitrogen levels on bulb quality and marketable yield of onion (*Allium cepa* L.)

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Abstract

Research was conducted at Vegetable Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, to study the Influence of nursery sowing dates, seedling ages and nitrogen levels on bulb quality and marketable yield of onion (*Allium cepa* L.) var. Pulkara. Seed of onion were sown in two different nurseries, from each nursery seedlings were transplanted at three different ages (40, 50, 60 days) and four nitrogen levels (0, 40, 80, 120 kg ha⁻¹) were applied. Results revealed that sowing dates significantly affect all the parameters except splitting % and Total soluble solids (% Brix). Seed sown on 15th September have significantly high bulb diameter (6.937 cm), bulb neck diameter (1.07 cm), bulb fresh weight (150.78 g), bulb dry weight (15.665 g), bolting (41.10%) and marketable yield (13.869 ton ha⁻¹) while seed sown on 15th October have significantly high bulb dry matter (12.98%). Seedling transplanted after 50 days have high bulb diameter (6.6838 cm), bulb fresh weight (137.46 g), bulb dry weight (15.37 g) with medium bulb dry matter (11.55%), bolting (29.89%) and splitting (9.79%). Nitrogen application also significantly affected most of the parameters. Plots treated with Nitrogen 120 kg ha⁻¹ produced maximum bulb diameter (6.82 cm), bulb neck diameter (1.09 cm), bulb fresh weight (141.37 g), bulb dry weight (15.61g) and marketable yield (12.81 ton ha⁻¹) with reducing bolting (24.72%). Interaction between the nursery sowing dates, seedling age and nitrogen levels showed that 50 days seedling from 15th September nursery with application of 120 kg N ha⁻¹ produced maximum bulb diameter, fresh weight, dry weight and good marketable yield but increase neck diameter. 50 days seedling from 15th September also increased the incidence of bolted bulbs which were found to be reduced by 120 kg ha⁻¹ nitrogen. It is recommended that application of 120 kg N ha⁻¹ to 50 days seedling transplanted from 15th September nursery gave best results as compared to others in geographical area of Faisalabad-Pakistan.

Key words: Nursery; Seedling age; Nitrogen; Bulb quality; Marketable yield; *Allium cepa* L.

Introduction

Onion is one of the most important commercial vegetable crop grown in Pakistan and believed to be originated in Central Asia. It is valued for its distinct pungent flavor and is an essential ingredient for the cooking in many regions. Onion is the queen of the kitchen [1]. Onion is a biennial plant, but in terms of crop production, grown as annual crop. Bulb is a storage organ and considers overwintering stage of the life cycle [2]. When bulb initiation occurs, the leaf sheaths swell and initiation of bladeless bulb scales occur. These bulb scales form the storage tissue of the bulb. As the bulb matures, two or three foliage leaf initials are produced at the base [3]. Bulbs will grow more rapidly in older plants while young plants will not initiate bulbing unless they have at least 4 leaves [4].

In Pakistan area under onion cultivation is 143.7 thousand ha with a production of 1892 thousand tones during 2010-11 [5]. Planting time varies with locality, type of onion and propagation. For early planting, seedling are raised in June and September and transplanted from July to October. In plains for winter crop, seed is sown from middle of October to end of November and transplanted in December and January. The low production of onion is mainly due to poor cultural practices, planting and harvesting time [6], method of transplant production [7] and fertilizer [8] affects the onion production.

Scientists studied different sowing time to check its effect on onion growth, maturity time, physiological disorder and yield. Faruq *et al.* [9] reported that among the three planting dates (22nd November, 7th December and 22nd December) maximum bulb diameter (5.31cm), bulb fresh weight (59.60 g) and bulb dry matter content was obtained from November 22 planting. Pandey *et al.* [10] found that neck thickness problem

was more in early (June) sowing onion, similarly neck height was more in 1st October planting (early) as compare to 15th and 31st October planting [11]. Jackson *et al.* [12] planted onion at different time from February to June and concluded that splitting problem was more in March and April plantings while in June planting problem was less. Similarly bolting was more in early planting and absent in late plantings.

In onion the use of transplants of varying age is one of cause for low yields. Currah [13] concluded that in the tropics for onion production transplanting method is more efficient and Islam [14] reported that seedlings age at transplanting time affects onion production. Transplanting date significantly affects the bolting and splitting in onions. Sweet Vidalia onion produced more seed stems (bolters) for early transplant date while less for later transplant, but splitting problem was less in early transplant and increased in later transplant [15]. Early transplanting resulted decreased in quality of onion bulb by producing thick neck bulb [16].

Nitrogen is one of the basic nutrient and important element of chlorophyll and amino acids which promotes protein content and effect growth and yield of the crop. Abdissa *et al.* [17] studied the effect of nitrogen on different parameters of onion and found that nitrogen application reduced bolting percentage in onion and also extended days to physiological maturity. Ghaffoor *et al.* [18] reported that bulb survival percentage in onion was maximum when nitrogen is applied at 150 kg ha⁻¹ but Jilani *et al.* [19] studied that 95.22% bulb survive at 120 kg ha⁻¹ and this level is best for growth and yield of onion. The basic aim of the study was to find the best time for planting, proper transplanting age and most suitable dose of nitrogen to minimize physiological disorders in onions and get good quality bulb.

Materials and methods

The study was conducted at Vegetable Research Area, Institute of Horticultural Sciences, University of Agriculture Faisalabad, Pakistan during the year 2011-12. Soils of the experimental plots were examined and were analyzed for physio chemical properties. Soil samples were randomly taken at various locations of the field at three different depths before the bed preparation and the same depths samples were mixed together to make composite samples. Soil pH ranging from 7.95 to 8.24,

electrical conductivity 0.34 to 0.43 ds/m, nitrogen 0.03%, Phosphorous 2.14 ppm, potash 175.2 ppm and organic matter % was 0.91 (Table 1). The metrological data showed that the average season was 20.5°C, 61.04% and 19.92mm respectively. Minimum temperature (10.2°C) was in the month of January while maximum in the month of May (32.7°C). Highest and lowest relative humidity was in the months of May (43.3%) and September (75.8%). Highest rain fall was in the month of September (155.1mm).

Table 1. Soil characteristics at experimental plot

Soil Characteristic	Soil Depth		
	15cm	30 cm	45cm
pH	8.24	8.2	7.95
EC(ds/m)	0.36	0.34	0.43
N%	0.05	0.03	0.03
P(ppm)	3.03	2.2	1.2
K(ppm)	175	174.16	178.3
O.M %	1.21	0.77	0.76

The experiment was laid out in split plot design (RCBD) with three replications. Two nursery sowing dates (15th September and 15th October), three seedlings age (40, 50, 60 days) and four nitrogen levels (0, 40, 80, 120 kg ha⁻¹) in the form of urea were used to study its effect on onion. Phosphorous (70 kg ha⁻¹) and potassium (50 kg ha⁻¹) were applied as constant fertilizers. For nursery raising seeds were sown at 15th September and 15th October in lines with distance of 4 cm (line to line) and then covered with silt. Seedlings age was kept in main plot while the nitrogen levels as a sub plot. Seedling were transplanted to ridges (60 cm wide) and planted with 10 cm plant to plant distance on both side of ridges. Half of nitrogen and full dose of phosphorous and potash was applied at the time of transplanting and half of the nitrogen after three weeks of transplanting. Bulbs were harvested when 80% of plants have dried

most of the leaves. The leaves and roots of randomly selected plants were trimmed and bulbs were weighted in grams using electric weighing balance. The already weighed bulbs were chopped into small pieces and placed in sun for 5-7 days for partial drying. After sun drying the dried bulbs were shifted to oven and kept at 70°C for 48 hours to measure bulb dry weight and dry matter percentage. Bulb and neck diameter was measured at maturity by using digital Vernier Caliper in mm and then it was converted to cm. Bolting and splitting % were fined by counting bolted and splitted bulbs from each treatment and then percentage was calculated from formula. To find the marketable yield, small and unwanted bulbs were removed and yield was calculated. TSS was determined by using hand refractrometer (RHB-0-80). First the instrument was calibrated with distilled water, then a drop of juice was put on the

prism and led was closed. Reading was noted at 20°C by looking towards the light through refractometer. Collected data were analyzed using Fisher's analysis of variance (ANOVA) technique and means was compared by using DMR Test [20].

Bulb dry matter percentage=

$\frac{\text{Bulb dry weight (g)}}{\text{Bulb Fresh weight (g)}} \times 100$

Bolting percentage=

$\frac{\text{Number of bolted blubs}}{\text{Total number of blubs}} \times 100$

Splitting percentage=

$\frac{\text{Number of splitted blubs}}{\text{Total number of blubs}} \times 100$

Results and discussion

Bulb diameter (cm)

Analysis of data revealed that sowing dates, seedling ages and nitrogen levels have significant effect on bulb diameter while non-significant effect of all the interaction (Table 2). Plants sown on 15th September produced large bulbs (6.94 cm) as compare to 15th October. The seedlings transplanted at 50 days after sowing produced large size bulbs (6.68 cm) which was statistically at par with that 40 days seedling results while small size bulbs (6.02cm) were produced at late transplanting age. The finding is an agreement with Zahira [21] who reported that early seeding and transplanting result in large size bulbs as compare to late. Maximum bulb diameter (6.83 cm) was noted when nitrogen was applied at 120 kg ha⁻¹ and minimum (6.11 cm) was at 0 kg ha⁻¹. The results were similar with finding of [22]. Overall, onion bulbs were large in size when seed were sown in September, transplanted at 50 days and 120 kg ha⁻¹ nitrogen was applied.

Bulb neck diameter (cm)

Neck diameter is an important character in onion because it indicates storage ability.

Thin neck diameter bulbs store better as compare to thick neck diameter. Data obtained for bulb neck diameter revealed that neck thickness was significantly affected by sowing dates, nitrogen levels and interaction of sowing dates and seedling age while non-significant results was showed by seedling age and other interactions (Table 2). Results show that maximum neck diameter (1.16 cm) was found in bulbs that were sown on 15th September and minimum (0.97 cm) in 15th October sowing. The result was similar to Pandey *et al.* [10] who found greater neck thickness to early sowing as compare to later. Comparing the mean table for nitrogen it was evident that 120 kg ha⁻¹ nitrogen gave the maximum (1.09 cm) neck diameter while minimum (0.95 cm) was at 0 kg ha⁻¹ nitrogen. The results were similar to the Jilani [23] who reported that increasing nitrogen fertilization results thick necks of onion bulb. The interaction between sowing dates and seedling age shows that with the increase of seedling size the neck diameter was also increased while an opposite phenomena was observed in later sowing dates (Figure 1). Maximum neck thickness was found when seed was sown on 15th September and transplanted after 60 days and minimum was for 15th October of same size seedling. The reason was neck develops from base of leaves and its diameter depends on number and complete drying of the leaves at maturity. In first sowing entire seedling type produced more leaves but time for complete drying of leaves base for 60 days was less and in case of second sowing date the old age seedling produced less number of leaves. Therefore the neck diameter varies among the seedling of sowing dates.

Table 2. Onion bulb diameter (cm), neck diameter (cm), bulb fresh weight (g), bulb dry weight and bulb dry matter % affected by sowing dates, seedling age and nitrogen levels

Treatment	Bulb Diameter (cm)	Neck Diameter (cm)	Bulb fresh weight (g)	Bulb dry weight (g)	Bulb dry matter%
Sowing Dates (D)					
15-Sep	6.9375a	1.0763a	150.78a	15.665a	10.526b
15-Oct	5.9428b	0.9792b	100.47b	12.851b	12.987a
Seedling Age (A)					
40 days	6.6127a	1.0434	132.76a	14.890a	11.430b
50 days	6.6838a	1.0389	137.46a	15.375a	11.556b
60 days	6.0240b	1.0434	106.65b	12.509b	12.283a
Nitrogen (kg ha⁻¹) N					
0	6.1115c	0.9593b	108.58c	12.285c	11.602
40	6.3507b	1.0243ab	121.76b	14.185b	12.021
80	6.4733b	1.0315ab	130.78ab	14.945ab	11.852
120	6.8251a	1.0960a	141.37a	15.617a	11.551
Interaction					
D x A	ns	*	ns	ns	ns
D x N	ns	ns	*	ns	*
A x N	ns	ns	ns	ns	ns
D x A x N	ns	ns	ns	ns	ns

Means in the same category followed by different letters are significantly different at $P \leq 0.05$ levels. ns = non-significant

Figure 1. Bulb neck diameter affected by sowing dates and seedling ages

Bulb Fresh Weight

Maximum (150.78 g) bulb fresh weight was obtained from plants that were sown on 15th September and minimum (100.47 g) from 15th October sowing. Seedling transplanted after 50 days of sowing produced heavy bulbs (137.46 g) as compare to 40 and 60 days. From results it was observed that bulb from medium size seedling gain maximum weight than small and larger seedling. Kanton *et al.* [24] concluded the significant effect of transplanting age on the bulb fresh

weight. Study on nitrogen show that maximum (141.37 g) bulb fresh weight was obtained by applying nitrogen at the rate of 120 kg ha⁻¹ and minimum (108.58 g) was from zero nitrogen. The result was similar to finding of Khan *et al.* [25] who evaluated that increasing the nitrogen level resulted in the increased onion bulbs weight. The combine effect of sowing dates and nitrogen level shows that crop planted on 15th September with application 120 kg ha⁻¹ N produced maximum (175.04 g) bulb fresh weight as compared other sowing date and nitrogen application (Figure 2).

Figure 2. Bulb fresh weight affected by sowing dates and nitrogen levels

Bulb dry weight (g)

Mean values show significant results for sowing dates, seedling ages and nitrogen application but non-significant results for interaction. Maximum (15.66 g) bulb dry weight was recorded when seed were sown on 15th September and minimum (12.85 g) for 15th October sowing. In case of seedlings age highest value (15.37 g) was obtained for 50 days transplants and lowest value (12.50 g) for 60 days transplants. This must be due to that medium size seedling produced larger bulb which results in maximum dry weight. The results are in line with Singh and Singh [26] who described that early sowing and 7 weeks old seedlings have significantly higher dry weight. Study on nitrogen shows that maximum (15.61 g) bulb dry weight was obtained by applying nitrogen at the rate of 120 kg ha⁻¹ and minimum (12.28 g) were from no application of nitrogen. Nitrogen application increased bulb fresh weight in return bulb dry weight also increased. Similar result was reported that nitrogen fertilization significantly affects bulb dry weight and maximum dry weight was obtained by application of 115 kg ha⁻¹ nitrogen [17].

Bulb Dry Matter %

Mean value illustrate significant results for sowing dates, seedling age and interaction of sowing dates and nitrogen while non-significant results for nitrogen and other interaction. Bulb dry matter percentage was maximum (12.98%) when seeds were sown on 15th October and minimum (10.52%) in 15th September sowing. The seedling transplanted after 60 days have high (12.28%) dry matter percentage as compared to the seedling transplant in early stage. The results indicated that as the bulb size decreased quantity of water contents also decreased that result in high percentage of dry matter. So, early sowing date produced large size bulb having low dry matter percentage as compare to late sowing.

Interaction of sowing dates and nitrogen shows that when seeds were sown at 15th October and 80 kg ha⁻¹ nitrogen was applied bulbs gain high (13.41%) dry matter percentage as compared to other application (Figure 3). The result shows that main factor of dry matter was sowing dates while high nitrogen doze mainly maintain proper growth of plant and no direct role in the dry matter contents. Woldetsadik & Workneh [27] reported that nitrogen applications have no significant effect on the dry matter content of bulb (Table 3).

Figure 3. Bulb dry matter % affected by sowing dates and nitrogen levels

Bolting %

Maximum bolting percentage (41.10%) was recorded when nursery was raised on 15th September as compare to 15th October. These results are in line with those of Khokhar *et al.* [28] who reported that seed sown in September produced more bolted bulbs than other sowing dates. Seedlings transplanted early have more (33.52%) bolting percentage than medium and late transplanting. Similar result was obtained by Boyhan *et al.* [15] who found that early transplants produced more bolters as compared to late. Effect of nitrogen shows that maximum bolting (36.36%) was found in plants with zero application of nitrogen while minimum (24.72%) at 120 kg ha⁻¹

nitrogen. Result was similar to Yamasaki and Tanaka [29] who reported that low nitrogen promoted bolting in onion plants. Among interaction of sowing dates and seedling age, maximum bolting percentage (41.85%) was recorded when nursery was raised on 15th September and transplanted after 40 days while minimum (9.65%) was in 60 days seedling of 15th October sowing (Figure 4). In both sowing dates as seedling age increased problem of bolting decreased but the effect was clear in late sowing. Sowing dates and nitrogen interaction shows that no application of nitrogen to early sowing dates cause maximum (52.27%) problem of bolting as compared to high nitrogen and late sowing (Figure 5).

Figure 4. Bolting % affected by sowing dates and seedling age

Figure 5. Bolting % affected by sowing dates and nitrogen levels

Splitting %

Splitting percentage was significantly influence by seedling age, as the seedling age increased number of split bulbs reduced. Maximum (12.97%) splitting percentage was recorded in 40 days seedling while minimum (7.481%) was in 60 days seedling. Nourai [30] also reported that high incidence of splits was occur in early transplanted onion as compared to the late transplanted. Sowing dates and seedling age interaction shows that maximum split bulbs (15.53%) were formed when seed were sown on 15th September and transplanted after 40 days, while minimum (5.11%) were when seed sown on 15th September and transplanted after 60 days (Fig. 6). It was observed that in both sowing dates the late seedling have minimum problem of splits bulbs as compared to early.

Total soluble solids (%Brix)

Sowing dates, seedling age, nitrogen and interaction of all these factors have no significant affect on total soluble solid of onion bulbs. This may be due that TSS percentage mainly influence by cultivar and sulfur amount not these experimental factors. Leilah *et al.* [31] found that total soluble solid difference was not reached to the significant level among different seedling age and similarly Woldetsadik & Workneh [27] also reported non-significant effect of nitrogen on total soluble solids of onion.

Figure 6. Splitting % affected by sowing dates and seedling age

Table 3. Bolting %, splitting %, Tss and marketable yield of onion as affected by sowing dates, seedling age and nitrogen levels

Treatment	Bolting %	Splitting %	Tss (%Brix)	Marketable yield ton ha ⁻¹
Sowing Dates (D)				
15-Sep	41.104a	9.371	9.9182	13.869a
15-Oct	17.903b	10.795	9.2682	9.079b
Seedling Age (A)				
40 days	33.522a	12.973a	9.593	11.725b
50 days	29.897b	9.795b	10.007	12.720a
60 days	25.092c	7.481c	9.180	9.978c
Nitrogen (kg ha⁻¹) N				
0	36.363a	8.641	9.383	10.037c
40	30.482b	9.469	9.287	11.141b
80	26.449c	11.111	10.277	11.901ab
120	24.721c	11.111	9.426	12.818a
Interaction				
D x A	*	*	ns	*
D x N	*	ns	ns	ns
A x N	ns	ns	ns	*
D x A x N	ns	ns	ns	ns

Means in the same category followed by different letters are significantly different at $P \leq 0.05$ levels. ns = non-significant

Marketable yield (ton ha⁻¹)

Data recorded for marketable yield shows result for all the factors and interaction of seedling age with sowing dates and nitrogen. It is evident that high marketable yield (15.51 tons) was obtained from plants sown on 15th September and transplanted after 50 days and minimum (6.96 tons) from 60 days seedling of 15th October sowing (Figure 7). The marketable yield of 40 days seedling of September nursery was reduced due high cull percentage while in October nursery as the seedling age increase the marketable yield decrease due low yield and large number of small non marketable bulbs. September sowing gave high (13.86 tons) marketable yield as compare to October sowing. The results are in line with those of Khokhar et al, [28] who reported that significant high marketable yield of onion can be obtained when plants sown in September and translated at proper seedling age. Data regarding nitrogen higher marketable yield (12.81 tons) was from 120 kg ha⁻¹ and minimum (10.03 tons) was from control. Marketable yield gradually

increased as the amount of nitrogen increased. Result was in accordance with the finding of Maier et al, [32] who reported that marketable yield was significantly increased as the rate of nitrogen increased. In case of seedling age and nitrogen interaction maximum (13.924 tons) marketable yield was obtained from application of 120 kg ha⁻¹ nitrogen to 50 days seedling and minimum (8.210 tons) from 60 days seedling with no nitrogen application (Figure 8).

Figure 7. Marketable yield (ton ha⁻¹) affected by sowing dates and seedling age

Figure 8. Marketable yield (ton ha⁻¹) affected by seedling age and nitrogen levels

Conclusion

Nursery sowing time, age of transplanting seedling and nitrogen levels have important role in overcoming physiological disorder in onion. Early nursery sowing and normal size seedling produce good size bulbs but having more bolting problem. 50 days old seedlings from 15 September nursery with application of 120 kg ha⁻¹ produced more marketable yield and high nitrogen level also reduce the chance of bolting without any role in splitting.

Authors' contributions

Conceived and designed the experiments: T Muhammad & M Amjad, Performed the experiments: T Muhammad, Analyzed the data: T Muhammad & S Hayat, Contributed reagents/ materials/ analysis tools: T Muhammad H Ahmad & S Ahmad, Wrote the paper: T Muhammad.

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