Research Article IJAER (2017); 3(2): 232 - 239

International Journal of Agricultural and Environmental Research
FREE AND OPEN ACCESS
Available online at www.ijaaer.com
ISSN 2414-8245 (Online)
ISSN 2518-6116 (Print)

SEEDLING AGE AND NITROGEN LEVEL ENHANCE VEGETATIVE GROWTH AND YIELD OF ONION (*Allium cepa*)

TAYEB MUHAMMAD[1,2], MUHAMMAD AMJAD[1], MUHAMMAD ALI[2], MUHAMMAD HANIF[2], MAHMOUD ABDALLA MAHMOUD HUSSEIN[2,3], ABDUL HASEEB[4] AND ABAS NOOR[5]

[1]Institute of Horticultural Sciences, Faculty of Agriculture, University of Agriculture, Faisalabad, Pakistan
[2] College of Horticulture, Northwest A&F University, Yangling 712100, Shaanxi, PR China
[3]Department of agriculture Botany, Faculty of Agriculture, Zagazig University, Zagazig, Egypt
[4]Department of Horticulture, The University of Agriculture, Peshawar, Khyber Pakhtunkhwa, Pakistan
[5]Department of Agricultural Extension Education and Communication, The University of Agriculture, Peshawar, Khyber Pakhtunkhwa, Pakistan
Corresponding author's email: tayebmuhammad@aup.edu.pk

Abstract

A field experiment was carried out to study the effect of transplanting ages (40, 50 and 60 days after sowing) and nitrogen levels (0, 40, 80 and 120 kg ha^{-1}) on vegetative growth and yield of onion. It is found that seedling transplanted at 40 days after sowing were able to gain maximum height, leaf number, leaf length, maximum size and weight of bulbs with high yield as compared to other seedling age. There were significant differences in the vegetative and yield parameters between the different levels of nitrogen. Nitrogen application of 120 kg ha^{-1} enhanced vegetative parameters that further contributed to high yield as compared to other levels. Due to more time for standing in the field after transplanting, 40 days seedlings obtained high cull percentage while nitrogen application had no clear effect on the cull percentage. Interaction effect of both factors was significant in the vegetative growth related parameters at the initial growth stage but at maturity effect was non significant. The combined effect showed that application of 120 kg ha^{-1} nitrogen to seedlings transplanted at 40 days enhanced growth and yield of onion with no significant role in cull percentage. The overall results showed that early transplanting and 120 kg ha^{-1} nitrogen were most effective for maximum onion yield.

Key words: Seedling age, Nitrogen, *Allium cepa* and Yield

INTRODUCTION

Onion (*Allium cepa* L.) belongs to genus *Allium* of the family *Alliaceae* and is one of the important commercially grown vegetables crop. It is originated in Central Asia and used as a vegetable or spice both in the raw and mature bulb stages (Barzegar et al., 2008; Mahanthesh et al., 2008), also, considered as second most important horticultural crop after tomatoes (Griffiths et al., 2002). It is valued for its characteristics flavour, pungent taste and medicinal importance (Padmini et al., 2007; Tyagi and Yadav, 2007). Onion is biennial plant but mainly grown for the production of bulb, as it is important storage organ of the plant and considers as overwintering stage of the life cycle (Lancaster and Boland, 1990). In Pakistan, onion is grown throughout the country and consumed in large quantities as an important part

Citation: **Muhammad, T., M. Amjad, M. Ali, M. Hanif, M.A.M. Hussein, A. Haseeb and A.Noor. 2017. Seedling age and nitrogen level enhance vegetative growth and yield of onion (*Allium cepa*). Int. J. Agri and Env. Res., 3(2):232 - 239.**

of daily food. Planting time varies with locality, and variety. Mainly, seedlings are raised in September to October and transplanted in November to January. Onion is a long-day plant and in spite of favorable climatic conditions, productivity is not increasing due to several production constraints. The yield and quality of onion is affected by several factors like variety, sowing, transplanting and harvesting time, nutrients availability, irrigations and other cultural practices. Among these factors, transplanting time and fertilizer application are most important that affect onion production (Amin and Rahim, 1995; Sharma et al., 2003). Earlier studies reported that the seedling age of 30 days produced maximum bulb yield and increasing of seedling age from 30 to 60 days, there was decrease in yield (Vaishnava, 2012). Transplanting date not only affect the number of edible layers and bulb yield (Rastegar and Heidari, 2006) but also plant height and plant stand at maturity (Gautamet al., 2006).

Onion is an exhaustive crop and utilizes large quantities of nutrients from the soil. Nitrogen is a key component of amino acids and chlorophyll that enhance protein components and results in rapid vegetative growth and yield of the crop. Khan et al. (2007) reported that nitrogen application induced leaf length and plant height in onion and similar results were described using organic nitrogen (Aisha et al., 2007). Onion bulb survival percentage was maximum in plants fertilized with 120 to 150 kg nitrogen ha^{-1} (Ghaffooret al., 2003; Jilani et al., 2004) but Muhammad et al. (2016) reported the combined role of both seedling age and nitrogen levels in onion and concluded that nitrogen application significantly influenced the percentage of quality bulbs and marketable yield in different onion transplanting age.

Therefore, keeping in view the above factors, the present experiment was carried out to find the most favorable seedling age and suitable dose of nitrogen in order to obtain better growth and yield.

MATERIALS AND METHODS

The experiment was conducted in the Vegetable Research Area, Institute of Horticultural Sciences, University of Agriculture Faisalabad, Pakistan. The experiment was conducted to find the possible effect of seedling age and nitrogen levels on vegetative growth and yield of onion. Soil of the experimental plots was analyzed for physio-chemical properties. Before the seed bed preparation, samples were taken from randomly selected locations at depth of 15, 30 and 45 cm and for composite samples, soil of same depth was mixed together. The average soil pH (8.1), electrical conductivity (0.37 ds/m), nitrogen (0.03%), phosphorous (2.14 ppm), potash (175.2 ppm) and organic matters (0.91%) were observed. The metrological data was taken from Plant Physiology department metrological station and showed that mean maximum temperature 38.9°C was in month of May and mean minimum temperature 3.2 °C was in Month of January. The maximum relative humidity 75.8% was in month of September while minimum 43.3% in May (Fig. 1). Average rain fall for the whole growing season was 19.92 mm with 155.1mm highest rainfall in month of September.

The experiment was laid out in randamized complete block design (RCBD) with split plot arrangement having three replications. Onion seeds “Phulkara” were taken from “Vegetable Seed Production Lab”, Institute of Horticultural Sciences, University of Agriculture Faisalabad, Pakistan. Nursery was sown on 15th October by sowing the seed in line with 4 cm line to line distance and then covered with silt. Seedlings were transplanted from the nursery at 40, 50, 60 days age and different nitrogen levels 0, 40, 80, 120 kg ha^{-1} were applied in the form of urea. Phosphorous and potassium were applied at rate of 70 kg ha^{-1}and 50 kg ha^{-1} as a constant fertilizer. Half dose of nitrogen and full phosphorous and potash was applied at the time of transplanting and half of the nitrogen after three weeks of transplanting. The seedlings were transplanted to both sides of ridges with 10 cm plant to plant distance and 60 cm ridge to ridge distance. Harvesting maturity was considered when 80% plants had most of their leaves become dried.

Different growth and yield related parameters were measured at vegetative and maturity stages. For vegetative stage, plants were randomly selected after 90 days of sowing. Plant height, and leaf length were measured using measuring tape and total number of leaves was calculated by counting leaf numbers. For plant weight, the whole plant was selected and roots were trimmed from bulbs to measure bulb fresh weight in grams using electric balance. Bulb diameter was measured in mm using digital Vernier Caliper and then converted into cm. Onion bulbs were graded and cull (diseased, split, double, bolted and bulb < 38mm) were counted and the percentage was calculated according to formula (Cramer, 2003). Total yield (t ha^{-1}) was calculated by first estimated plant population per hectare and then total yield from the estimated population using formulas. Collected data were analyzed using Fisher,s analysis of variance (ANOVA) technique and means were compared by using DMR Test (Petersen, 1994)

$$\text{Cull percentage} = \frac{Number of cullbulbs}{Total number of bulbs} X\ 100$$

$$\text{Number of plants/ha} = \text{number of plant per ridge x number ridges per hectar}$$

$$\text{Yield tonnes /ha} = \frac{\text{yield of single bulb (g) x number of plants/ha}}{1000{,}000}$$

Statistical analysis: All data were subjected to statistical analysis for split plot arrangement. The means were compared at 5% probability using MSTAT-C Software

.

RESULTS AND DISCUSSION

Plant height: Data presented in Table 1showed that seedling age and nitrogen application both significantly affected plant height at initial and maturity stage. Plants transplanted after 40 days produced tallest 58.56 cm and 65.38 cm plants at the early and maturity stage respectively. Plant growth was minimum for late transplanted seedlings which remained shorter as compared to early transplanted seedling. The result was in agreement with (Kanton et al., 2003) who reported that tallest plants were obtained when seedlings were transplanted at 40 days after sowing. Similarly, plant height was maximum for 120 kg ha^{-1} nitrogen in both initial and maturity stage but the result of 80 kg ha^{-1} nitrogen was economical at maturity stage because of producing statistically similar plants to that of 120 kg ha^{-1} nitrogen. Nitrogen application induced vegetative growth and application of 80 kg ha^{-1} nitrogen was effective for producing best height (Singh et al., 1994) and weekly nitrogen application to onion induced plant height (De-Vincenzo and Neto, 2003). Interaction of seedling age and nitrogen was significant in the initial growth stage but had no effect at maturity stage. Taller plants were obtained from 120 kg ha^{-1} nitrogen application to 40 days seedling and shorter plants from 60 days seedling with zero nitrogen (Fig. 2). The reason might be that nitrogen is mobile nutrient and easily available to plants soon after the application and plants efficiently use it at early stage, while at maturity stage, most of the nitrogen leach down or evaporate and there is less or no availability. These results revealed that application of proper nitrogen increased the plant height more in young seedlings as compared to old seedlings in onion.

Leaf length (cm): Seedling age and nitrogen levels both significantly affected leaf length at initial and maturity stage. For initial and maturity stage, maximum leaf length (30.63 and 35.76, respectively) was observed when seedlings were transplanted after 40 days while minimum was in later seedling age. Nitrogen study shows that maximum leaf length was observed in plots applied with nitrogen at the rate of 120 kg ha^{-1} while minimum leaf length was recorded in plots received no nitrogen at both the growth stages. At maturity stage, it was also observed that application of nitrogen up to 80 kg ha^{-1} was enough to increase the final leaf length as further application was not economical. The reason for this might be that nitrogen play a key role in vegetative growth and leaf length is a vegetative character which responds to certain level of nitrogen and further application has no advantage to increase leaf length. For quality production of onion, it is necessary to supply optimum dose of nitrogen (Abu-Rayyan and Al-Hadidi, 2005). Khan et al. (2007) reported that maximum leaf length was obtained from plot fertilized with 100 kg nitrogen ha^{-1}. Interaction of seedling age and nitrogen has significant effect on leaf length at initial growth stage but at later stage the interaction was not significant. From the Fig.3 it is clear that application of 120 kg ha^{-1} to young seedling increased the average leaf length as compared to old seedling with no nitrogen. Nitrogen is the major component of proteins thus high nitrogen ultimately increases the synthesis of proteins that result in increase in the size of leaves.

Leaf number plant^{-1}: Data on number of leaves plant^{-1}showed that both seedling age and nitrogen levels significantly affected the leaf number at initial stage. The results revealed that more numbers of leaves (5.96) were produced by 40-days seedling and minimum number of leaves (5.05) by 60-days seedling. Ibrahim (2010) reported that there was significant difference in leaves number per plant among seedlings transplanted at different time. In case of nitrogen, more number of leaves (6.00) were produced by applying nitrogen at the rate of 120 kg ha^{-1}and lesser number of leaves (5.00) were from control plots. Kumar et al. (1998) also reported that 150 kg ha^{-1} nitrogen gave best result for number of leaves per plant in onion and application of organic nitrogen increased number of leaves plant^{-1} and vigor of onion crop (Aisha et al., 2007). The interaction of seedling age and nitrogen was non-significant for leaf number at initial growth stage. While leaves number at maturity stage showed that seedling age had no significant effect on number of leaves but nitrogen and its interaction with seedling age significantly affected number of leaves. Maximum number of leaves (9.75) were produced when plots applied with nitrogen at the rate of 120 kg ha^{-1} while minimum number of leaves (8.51) were recorded in plots received no nitrogen (Fig. 4). At maturity stage, leaf number was more when 120 kg ha^{-1} nitrogen was applied to 60-days transplanting plots. The reason might be that high nitrogen application increased the number of leaves but leaf drying and falling is one of maturity sign in onion. Early transplanting plants mature early having less number of leaves due to leaf falling as compare to late transplanting plants.

Plant weight: Transplanting onion seedlings at different age and application of various levels of nitrogen has significant response on the plant weight at early and maturity stages. Seedling age and nitrogen interaction have no significant role in the plant weight. Results showed that 40-days seedlings gained maximum (26.29g) plant weight at early stage, while at maturity stage the result was statistically similar for both the 40 and 50-days seedlings, nonetheless 60 days old seedling were unable to gain more plant weight at early and maturity stages. The results indicated that younger seedling gained more weight as compared to older after transplanting and as the seedling age increased there was decrease in plant weight. Welsh onion transplanted in April gained more weight because of large leaf number as compared to direct seeding (Tendaj and Mysiak, 2011). In case of nitrogen levels, plant weight enhanced with increase in nitrogen levels, maximum 21.65g and 261.61g plant weight were obtained at early and maturity stage, respectively by 120 kg ha^{-1} nitrogen application. Gamiely et al. (1991) evaluated that nitrate form of nitrogen increased vegetative growth and leaf-root fresh weight. The increases in vegetative characters ultimately affect total weight of the plant.

Bulb diameter: Data regarding bulb diameter showed that seedling age significantly affect the bulb diameter at the early growth stage and bulb size was more (1.57 cm) in 40-days transplanting plants. At the maturity stage, no significant variation was observed among different seedling ages, however the bulb size was maximum in 40 and 50-days seedlings. In both the growth stages, small size bulbs were produced from the 60-days old transplanted seedlings. The reason might be that early transplanted seedlings had good initial vegetative growth and were able to harvest more photosynthate as compared to old seedlings. The result was similar to Leilah et al. (2003) and Zahira (1999) who reported that early transplanting results in large size bulbs as compare to late transplanting. Nitrogen levels also significantly affect the onion bulb diameter but its interaction with seedling age showed non-significant results. In case of nitrogen application at early stage, all levels induced the bulb size at same amount and it is because of the fewer requirements and equal availability of nitrogen but the results was significant compared to nitrogen free plot. On the other hand, more application of nitrogen enhanced the bulb size at maturity stage as compared to other levels. At maturity stage, large size (7.41cm) bulbs were produced from the plants that received 120 kg ha^{-1} nitrogen and bulb size was smaller for plants without nitrogen doze. Aliyu et al. (2008) reported that nitrogen application significantly affected onion bulb diameter and highest was recorded at100 kg N ha^{-1}.

Bulb weight: Bulb weight is an important trait that is directly related to the quality and yield of onion. In our results, it was observed that seedling age have significant effect on the fresh bulb weight at maturity stage, large heavy bulbs (164.32g) were produced by the seedling that were transplanted at 40 days after sowing, as the seedling age increased reduction in the weight of the bulb was occurred. 60-days seedlings developed the bulbs with low weight as compared to young seedling. Early transplanting date enhanced fresh weight of tubular blades might be due to the higher capacity of metabolism as a result of favorable climatic conditions and sufficient bulbing time. Kanton et al. (2003) concluded the significant effect of transplanting age on the bulb fresh weight. Nitrogen alone had significant results, while interaction of nitrogen with seedling age gave non-significant effect on the bulb fresh weight. Study on nitrogen showed that maximum (175.04g) bulb fresh weight was obtained by applying nitrogen at the rate of 120 kg ha^{-1} and minimum (121.71g) was from zero kg nitrogen. The result shows that as the amount of nitrogen increases the accumulation of photosynthate in bulb also increases. The result was similar to Khan et al., 2007 that maximum bulb fresh weight was observed at 100 kg ha^{-1} of nitrogen.

Yield: Data regarding yield showed that seedling age and its interaction with nitrogen had significant effect on the total bulb yield of onion. Seedlings transplanted at 40 days gave maximum (17.85 t ha^{-1}) yield and minimum yield (14.13 t ha^{-1}) was obtained from the 60-days seedlings. The high yield related with younger transplants might be due to more and longer leaves produced after transplanting which intercept more light leading to accumulation of higher photosynthate and dry matter in bulbs. Plants developed from young seedlings produced more yield as compared to older one (Kanton et al., 2003). Nitrogen application significantly increased the yield while minimum yield (12.66 t ha^{-1}) was obtained from the plot having no N application , as the level of nitrogen increased the yield was also increased and 120 kgha^{-1} nitrogen was the best for obtaining higher yield (18.22 t ha^{-1}). Higher dose of nitrogen resulted in increase in diameter and weight of the bulb which are directly related to the yield of the crop. Our result is also in conformity with Khan et al. (2007) who concluded that 100 kg ha^{-1} nitrogen gave highest yield.

Cull %: Onion is a biennial crop and during growth period temperature fluctuations occur, accompanied with some nutrients factors cause many physiological disorders particularly related to onion bulbs. The physiological disorders like, bolting, splitting and doubling (Supplementary Fig.1) not only reduce the quality but also the marketable yield. Results showed that transplanting age have significantly affected the cull % of onion bulbs. Early transplanting seedlings have more percentage of unmarketable bulbs as compared to later transplanting. The reason was that early transplanted seedlings produced large size bulbs that were easily split and due to more time in the soil these started decaying and rottening. Khokhar et al. (2002) also reported the significant effect of seedling age on the cull% of the onion bulbs. Nitrogen alone and its interaction with seedling age have no significant contribution in cull%.

Table 1. Plant height, number of leaves and leaf length affected by seedling age and nitrogen levels

	Plant height (cm)		**Leaf no. plant^{-1}**		**Leaf length (cm)**	
	90 days	Maturity	90 days	Maturity	90 days	Maturity
Seedling Age						
40 days	58.56a	65.38a	5.96a	8.73	30.63a	35.76a
50 days	52.64b	62.10b	5.70a	8.91	26.35b	31.73b
60days	43.67c	61.50b	5.05b	8.86	21.80c	32.76ab
						3.28
LSD at 0.05	1.46	2.95	0.56	Ns	1.61	
Nitrogen kg ha^{-1}						
0	45.49c	55.82c	5.00c	8.51b	23.64c	31.09b
40	52.02b	61.95b	5.68ab	8.44b	26.16b	31.92b
80	53.25b	66.47a	5.60b	8.64b	26.29b	35.15a

Continued table 1….

120	55.74a	67.73a	6.00a	9.75a	28.94a	35.51a
LSD at 0.05	1.54	1.93	0.38	0.86	1.11	2.79
Interaction						
LSD at 0.05	**	ns	ns	*	**	ns

Means in each category followed by different letters are significantly different from each other at 0.05 level of probability.
ns = non significant, *=Significant , **= Highly significant

Table 2. Plant weight, bulb diameter, bulb weight, yield and cull percentage affected by seedling age and nitrogen levels

	Plant weight (g)		**Bulb diameter (cm)**		**Bulb weight (g)**	**Yield ton ha^{-1}**	**Cull %**
	90 days	Maturity	90 days	Maturity			
Seedling Age							
40 days	26.29a	236.09a	1.57a	7.01	164.32a	17.85a	16.85a
50 days	16.43b	233.00a	1.13b	7.15	152.17ab	15.08ab	8.90b
60days	10.76b	204.18b	1.09b	6.63	135.84b	14.13b	8.18c
LSD at 0.05	9.65	26.7	0.29	Ns	18.06	1.88	5.52
Nitrogen kg ha^{-1}							
0	13.29c	172.82c	1.14b	6.43c	121.71c	12.66c	9.09
40	17.75b	209.36b	1.27a	6.91b	149.63b	15.57b	11.36
80	18.61ab	253.92a	1.31a	6.97b	156.72ab	16.31ab	12.87
120	21.65a	261.61a	1.32a	7.41a	175.04a	18.22a	11.91
LSD at 0.05	3.32	35.25	0.09	0.36	19.17	1.99	NS
Interaction							
LSD at 0.05	ns	ns	ns	ns	ns	ns	ns

Means in each category followed by different letters are significantly different from each other at 0.05 level of probability.
ns = non significant, *=Significant , **= Highly Significant

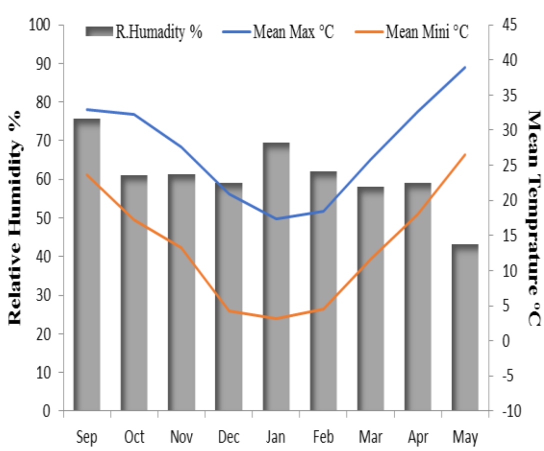


Fig 1. Mean monthly temperature (maximum and minimum) and relative humidity

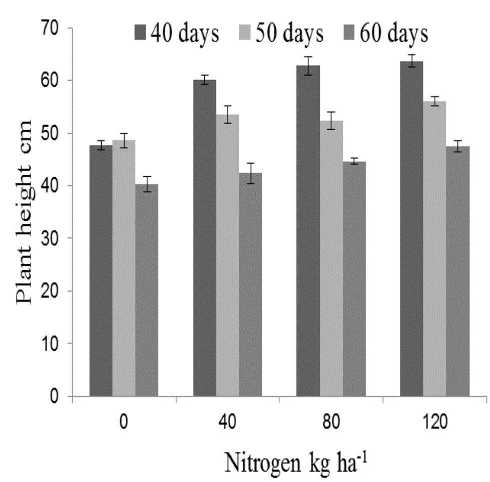


Fig 2. Effect of seedling age and nitrogen on plant height (cm) after 90 days of seed sowing

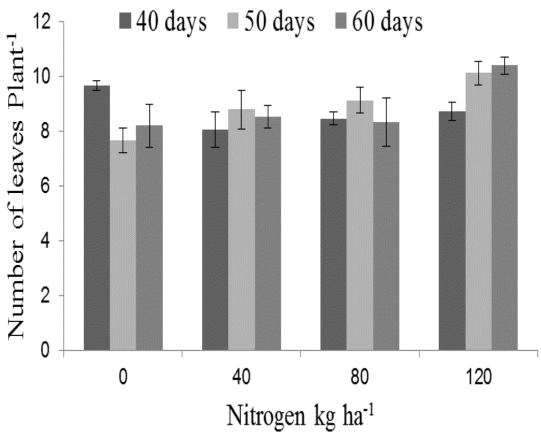


Fig 3. Effect of seedling age and nitrogen on number of leaves plant-1 at maturity

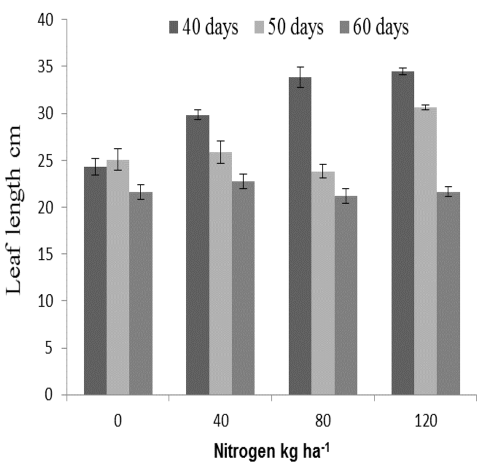
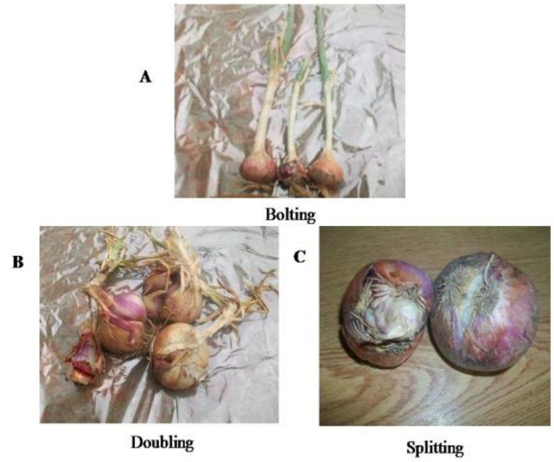


Fig 4. Effect of seedling age and nitrogen on leaf length (cm) after 90 days of seed sowing

CONCLUSION

Onion is a bulbous crop and food reserves are stored in underground part (bulb) of the plant. Better vegetative growth is important for production of more photosynthetic products that are essential for inducement in storage organs of plants. In our results, we found that early transplanting age and 120 kg ha^{-1} N application promoted the initial vegetative growth of onion and that lead to the production of better yield.



Supp Fig 1. Physiological disorders of onion bulb
A. Bolting B. Doubling C. Splitting

ACKNOWLEDGEMENT

I am thankful to Mr. Muhammad Hanif as editor author of the paper who worked a lot for proof reading of the manuscript.

REFERENCES

Abu-Rayyan, A.M and N.A. Al-Hadidi. 2005. Onion production and nitrogen uptake in response to different doses of urea fertilizer at two different plant populations. J. King Saud Uni. Agric Sci., 18(1): 19-34.

Aisha, A.H., F.A. Rizk, A.M. Shaheen and M.M. Abdel-Mouty. 2007. Onion plant growth, bulbs yield and its physical and chemical properties as affected by organic and natural fertilization.Res. J. Agric. Biol. Sci., 3(5): 380-388.

Aliyu, U., A.U. Dikko, M.D. Magaji and A. Singh. 2008. Nitrogen and intra-row spacing effect on growth and yield of onion (*Allium cepa* L.). J. Plant Sci., 3(3): 188-193.

Amin, M.M.U and M.A. Rahim. 1995. Effect of plant density, planting time and nitrogen on the growth and yield of onion. Progress. Agric., 6(2): 69-75.

Barzegar, M., A. Rajabi, M.R. Hassandokht and A. Jabbari. 2008. Chemical composition of different cultivars of onion (*Allium cepa* L.) produces in Iran. Hort Environ Biotech., 49(2): 121-127.

Cramer, C.S. 2003.Performance of fall-sown onion cultivar using four seeding dates.J. Am. Soc. Hortic. Sci., 128(4): 472-478.

De-Vincenzo, M.C.V and J.T. Neto. 2003. Onion seedling production in styrofoam trays under controlled environment, as summer planted onions. Scientia Agricola., 60(1): 65-69.

Gamiely, S., W.M. Randle, H.A. Mills, D.A. Smittle and G.I. Banna. 1991. Onion plant growth, bulb quality and water uptake following ammonium and nitrate nutrition. Hort. Sci., 26(8): 1061-1063.

Gautam, I.P., B. Khatri and G.P. Paudel. 2006. Evaluation of different varieties of onion and their transplanting times for off-Season production in Mid Hills of Nepal.Nepal Agric. Res. J., 7: 21-26.

Ghaffoor, A., M.S. Jilani, G. Khaliq and K. Waseem. 2003. Effect of different NPK levels on the growth and yield of three onion varieties. Asian J. Plant Sci., 2: 342-346.

Griffiths, G., L. Trueman, T. Crowther, B. Thomas and B. Smith. 2002. Onions- a global benefit to health. Phytotherap Res., 16: 603-615.

Ibrahim, N.D. 2010. Growth and yield of onion (*Allium cepa*L.) in Sokoto, Nigeria.Agric. Biol. J. North Am., 1(4): 556-564.

Jilani, M.S., A. Ghaffoor, K. Waseem and J.I. Farooqi. 2004. Effect of different levels of nitrogen on growth and yield of three onion varieties. Int. J. Agric. Biol., 6(3): 507-510.

Kanton, R.A.L., L. Abbey, R.G. Hilla, M.A. Tahil and N.D. Jan. 2003. Influence of transplanting age on bulb yield and yield components on onion (*Allium cepa*L.). J. Veg.Crop Prod., 8(2): 27-37.

Khan, A.A., M. Zubair, A. Bari and F. Maula. 2007. Response of onion (*Allium cepa* L.) growth and yield to different levels of nitrogen and zinc in Swat valley.Sarhad J. Agric., 23(4): 933-936.

Khokhar, K.M., Hidayatullah, T. Mahmood, S.I. Hussain, M.H. Bhatti and M.H. Laghari. 2002. Effect of seedling/set sizes and planting times on bulb yield and quality in onion cultivar Phulkara during autumn. J. Plant Sci., 1(6): 665-667.

Kumar, J., J.V. Singh, K. Ajay, S. Mahak, A. Kumar and M. Singh.1998. Studies on the influence of nitrogen on the growth and yield of onion cv. Patna Red. Indian J. Agric. Res., 32: 88-92.

Lancaster, J.E and M. J. Boland. 1990. Flavor biochemistry, food science and minor crops.Chapter. 3. p. 33-72. In: Onions and Allied crops, (Ed. J.L Brewster and H.D Rabinowitch).CRC Press BacoRatani Florida.

Leilah, A.A., S.A. El-Kalla, A.K. Mostafa and H.M.A. Afifi. 2003. Performance of some local Egyptian onions strains under different planting dates. Sci. J. of King Faisal Univ. 4(1): 119-136.

Mahanthesh, B., M.R.P. Sajjan, M. Harshavardhan, Vishnuvardhana and G. Janardhan . 2008. Evaluation of different onion (*Allium Cepa* L.) genotypes for yield and processing quality parameters in kharif season under irrigated condition. The Asian J. Hor., 3(1): 5-9.

Muhammad, T., M. Amjad, S. Hayat, H. Ahmad and S. Ahmed. 2016. Influence of nursery sowing dates, seedling age and nitrogen levels on bulb quality and marketable yield of onion (*Allium cepa*L.). Pure Appl. Biol., 5(2): 223-233.

Padmini, K., R.V. Gowda and L.B. Naik. 2007. Studies on parental synchronization in floweirng for hybrid seed production in onion (*Allium cepa* L.) J. Hort. Sci., 2(1): 47-49.

Petersen, R.G. 1994. Agricultural Field Experiments Design and Analysis.Marcel and Dekker, New York.

Rastegar, J and S. Heidari. 2006. Effects of nursering and tranplanting dates on quantitative and qualitative characters of long-day onion (*Allium cepa* L.) cultivars. Seed and Plant., 22(3): 303-317.

Sharma, R.P., N. Datt and P.K. Sharma. 2003. Combined application of nitrogen, phosphorus, potassium and farmyard manure in onion (*Allium cepa*L.) under high hills, dry temperate conditions of north-western Himalayas. Indian J Agric Sci., 73: 225-227.

Singh, D.K., L. Gulshan, P.N. Rai, G.S. Shukla and G. Lal. 1994. Response to nitrogen on yield and keeping quality of onion bulb (*Allium cepa*L.). Annals of Agric. Res., 15(4): 407-409.

Tendaj, M and B. Mysiak. 2011**.** Growth characteristic of welsh onion (*Allium fistulosum*L.) grown from seeds and transplants. Folia Hortic., 23(1): 3-8.

Tyagi, A.K and S.K. Yadav. 2007. Effect of growth regulators on growth and yield of onion (*Allium Cepa* L.) cv. Pusa Red. Plant Archives., 7(1): 371-372.

Vaishnava, D. 2012. Effect of date of nursery sowing and seedling age on growth, yield quality of rabionion in Chhattisgarh plains. M.Sc. Thesis, Dep. Hort., Indira Gandhi Krishi Vishwavidayalaya (IGKV), Raipur, India.

Zahira, M.A. 1999. Effect of onion transplanting date and inter-cropping pattern on cotton-onion association. J. Agric. Sci. Mansoura Univ., 24(3): 899-909.