International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(5): 2137-2140

Received: 11-07-2018
Accepted: 15-08-2018

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Effect of age of seedling and plant density on growth, yield and quality of onion (*Allium cepa* L.)

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Abstract
A field experiment was conducted at the AKS University, Satna (M.P.) during *rabi* season 2016-17 to study the effect of age of seedling and plant density on growth, yield and quality of onion. Amongst the plant densities, 20x20 cm recorded significantly higher growth parameters, yield-attributes, bulb yield, TSS and protein contents in bulb and economical gain from onion var. Pusa Red. The maximum bulb yield was 274.40q/ha, TSS 11.80 ^{0}Brix, bulb protein 3.25%. The net income was up to Rs. 84898/ha with B: C ratio 2.62. Transplanting of 45-days old seedlings recorded significantly higher bulb yield 290.47q/ha. TSS 12.42 ^{0}Brix, bulb protein 3.19%. The net income was up to Rs. 92935/ha with B: Cratio 2.77. Amongst the treatment interactions, the crop grown under plant density of 20x20 cm combined with transplanting of 45-days age of seedlings resulted in highest bulb yield up to 294.45 q/ha, TSS 12.84 ^{0}Brix, bulb protein 3.31%. The net income was up to Rs. 94925/ha with B: C ratio 2.81.

Keywords: age, seedling, plant density, onion

Introduction
Onion (*Allium cepa* L.) is one of the important vegetable crop of Amaryllidaceae (Alliaceae) Family, which have got 2n=16 chromosome number. In Madhya Pradesh, area under onion crop is 257.6 hectares with production of 5807.8 Mt. The production of onion is influenced by a large number of agronomic practices such as, time and period of planting, planting density, age of seedling and judicious use of fertilizer application. The plant density the age of seedlings caused paramount influence in pushing-up the production of onion crop. Further it has also been noticed that density of planting affects seriously to growth and other yield attributing characters (Maurya and Singh, 1997) [8].

The yield reduction due to increasing the age of nursery plant may, however, be compensated with manipulation of planting density in onion. It could be attributed to the lack of adaptation of proper planting density and cultivated of unsuitable varieties for the specific locality. Planting density greatly influenced quality, texture, taste and yield of onion even within a particular variety.

The density between plants is one of the important factors which ultimately affects nutrients uptake, growth and yield of plants. Increase in plant spacing, the total plant population/ha decreases, but with more nutrition, the individual plant grows better and yields more and vice-versa. The increase or decrease of plant population/ha had a definite pattern relation to the crop yield. In view of the facts it was essential to find out the most suitable age of seedlings and plant density for onion Var. Pusa Red under the agro-climatic conditions of Kymase plateau of Madhya Pradesh.

Materials and Methods
The experiment was carried out at the AKS University, Satna (M.P.) during rabi season of 2016-17.

The soil of the experimental field was silty clay-loam having pH 7.5, electrical conductivity 0.16 dS/m, organic carbon 0.43%, available N, P_2O_5 and K_2O 176.60, 12.50 and 200.0 kg/ha, respectively. The total rainfall received during the cropping season was 207.7 mm. The treatments comprised three plant densities (20x10, 20x15 and 20x20 cm) and three age of seedlings for transplanting (25, 35 and 45-days). Thus the nine treatment combinations were laid out in the field in a factorial randomized block design keeping three replications. Onion var. Pusa Red was transplanted on 18 November, 28 November and 8 December.

Uniform does of FYM @ 20 t/ha along with 50 kg P_2O_5 and 60 kg K_2O was applied as basal in all the treatments. The crop was grown as per recommended package of practices. The crop was harvested in the end of March 2017. The total soluble solids in onion bulb was estimated by ERMA hand refractometer. The protein content was determined by micro-kjeldahl distillation method to obtain total N-content the sample. The N-content was multiplied by 6.25 to obtain % protein content (A.O.A.C., 1997) [1].

Results and Discussion

Growth parameters

The periodical observations recorded on onion var. Pusa Red indicated that the plant height, number of leaves/plant, length of leaves, width of leaves, fresh and dry weight of leaves/plant were enhanced significantly with the increased plant density up to 20x20 cm. At harvest stage, the significantly maximum plants height was 42.58 cm, number of leaves 7.84/plant, length of leaves 40.38 cm, width of leaves 1.07 cm, fresh weight of leaves 83.34 g and dry weight of leaves 16.79 g summary (Table-1). The significantly higher growth parameters under widest plant density (20x20 cm) may be as inbred to the fact that the wider spacing. between plants provider less competition among the plants or most favorable conditions viz. increased space between rows, enough supply of nutrients and soil moisture and increate inter caption of solar radiation (sunlight) essential for the actively growing plants. In the present findings, number of leaves and leaves area/plant were enhanced significantly due to wider spacing's. These functional leaves and photosynthesizing area increased the photosynthesizing that to encourage growth parameters of onion. The present findings corroborate with those of many researches (Singh *et al.*, 2000; Dereje *et al.*, 2012 and Muhammad *et al*., 2015) [13, 3, 9].

Amongst the age of seedlings, 45-days old seedlings at harvest stage brought about significantly higher plant height (44.92cm), number of leaves (8.74/plant), length of leaves (42.68cm), width of leaves (1.29cm), fresh weight of leaves (97.71g) and dry weight of leaves (21.20g). The significantly higher growth parameters under transplanting of 45-days old seedlings may be owing to the fact that under favourable temperature, the transplanting of 45-days older seedlings performer active growth which might have contributed to more vigorous growth and development of plants and thus improvements in the pseudo stem. These results are in consonance with those of other workers (Kanton *et al.*, 2002; Fathi, 2009; Vaishnav, 2012 and Singh *et al.*, 2016) [7, 4, 15, 14].

Yield-attributing parameters

The higher plant density (20x20 cm) brought about significantly higher fresh weight and diameter of bulb (81.41 g and 5.53 cm) as compared to the lower plant densities (20x10 and 20x15 cm). On the other hand, the fresh weight and diameter of bulb was significantly lowest (67.17 and 4.66 cm, respectively).

The maximum increase in yield-attributes under 20x20 cm (widest) plant spacing might be as a results of maximum inverse in the growth parameters, where in wider spacing provider increase space between plants, sufficient sunlight, nutrients and soil moisture for better plants growth. That means the increased synthesis of photosynthesised and its translocation (partitioning) through leaves and stem towards the sink *i.e.* reproductive organs. The present findings are in agreement with those of Patel, (2008) [12]; Naik and Hosamani, (2003) [10]; Jan *et al.*, (2003) [6]; Dereje *et al.*, (2012) [3]; and Muhammad *et al.*, (2015) [9].

The transplanting 45-days old seedlings resulted in significantly higher fresh weight of bulb (99.89 g) as well as diameter of bulb (6.67 cm) in comparison to the transplanting of 25 and 35 days old seedlings. This may be absorbed to the fact that 45-days old seedlings synthesized much more photosynthates which translocated towards the reproductive organs (bulbs). The similar results have also been obtained by Bhonde *et al.*, (2001) [2]; Kanton *et al.* (2002) [7]; Fathi (2009) [4]; Ibrahim (2010) [5]; Vaishnav (2012) [15] and Singh *et al.*, (2016) [14].

Productivity parameters

The widest plant spacing (20x20 cm) resulted in significantly higher bulb yield (274.40 q/ha) as compared to 20x10 and 20x15 cm spacing's. The significantly lowest bulb yield 266.15 q/ha) was notes from the closest 20x10 cm spacing between plants. The maximum productivity of onion bulb under widest spacing between plants might be onion to the maximum increase in yield-attributes under these treatments. It is well known fact that the plant spacing are the important factors which influence the growth and development of plants based on the availability of more space and light, nutrients and moisture. Under widest spacing between plants, adequately supplied nutrients and moisture night have synthesized more photosynthetic which were translocated and stored in bulbs thus resulting higher bulb yield per hectare. These findings agree with those of Naik and Hosamani (2003) [10]; Dereie *et al.*, (2012) [3] and Muhammad *et al.*, (2015) [9].

The transplanting of 45-days old seedlings brought about significantly higher bulb yield (290.47q/ha) over 25 and 35 days old seedlings. The productivity parameters are exactly in accordance with the yield-attributing characters responsible for such deviations. These findings are in close agreement with those of Vaishnav (2012) [15] and Singh *et al.*, (2016) [14].

Nutritional quality of bulb

The widest spacing (20x20 cm) resulted in significantly higher TSS (11.80 ^{0}Brix) as well as protein content (3.25%) in bulb as compared to the closer plants spacing's. The widest spacing between plants provided increased availably of nutrients which ultimately translocated towards the storage organs in terms of total soluble solids. The variation in bulb protein content amongst the plant densities might be attributed to the differences in the synthesis of protein through onion acids as a results of N-metabolism. The protein synthesis was also closely associated with the supply of nutrients. Increased supply of nutrients therefore resulted in greater protein content of bulbs. The results are in agreement with the findings of Pachauri *et al.*, (2005) [11].

The transplanting of 45-days old seedlings resulted in significantly higher TSS (12.42^{0}Brix) as well as protein content 3.19% in onion bulb as compared to the transplanting of 25 and 35-days old seedlings. The respective lowest values (10.64 ^{0}Brix and 3.11% protein) noted in case of 25-days old seedlings. The Transplanting of 45-days old seedlings appeared to have much more root and shoot developed over the younger seedlings. This allowed increased associated biochemical reactions in the plant to lead improved chemical qualities of the onion bulb. Similar observations have also been made by Bhonde *et al.*, (2001) [2], Kanton *et al.*, (2002) [7], Ibrahim (2010) [5], Vaishnav (2012) [15] and Singh *et al.*, (2016) [14].

Economical gain

The maximum net income Rs.84898/ha. with B:C ratio (2.62) were received from the increased plant density (20x20 cm). This was followed by Rs. 82908/ha and B:C ratio 2.58 from 20x15 cm plant density.

The maximum increase in economical gain under 20x20 cm plant density was due to maximum bulb yield in this treatment which gave highest net income per hectare.

The transplanting of 45-days old seedlings resulted in highest net income of Rs. 92935/ha with B: C ratio 2.77. This was followed by use of 35-days old seedlings.

Table 1: Growth parameters of onion var. Pusa Red as influenced by different plant densities and age of seedlings

Treatments	Plant height (cm) at harvest	No. of leaves /plant at harvest	Length of leaf (cm) at harvest	Width of leaf (cm) at harvest	Width of neck (cm) at harvest	Fresh Wt. of leaves (g) at harvest	Dry Wt. of leaves (g) at harvest
Plant density (cm)							
20x10	39.80	6.87	37.56	0.88	1.99	73.28	13.55
20x15	41.40	7.42	38.97	0.93	2.11	78.00	15.15
20x20	42.58	7.84	40.38	1.07	2.16	83.34	16.79
S.Em±	0.35	0.04	0.34	0.02	0.05	0.41	0.42
C.D. (P=0.05)	1.05	0.13	1.02	0.06	0.15	1.23	1.27
Age of seedlings							
25 days	37.71	6.07	35.34	0.75	1.58	58.62	10.69
35 days	41.24	7.34	38.89	0.84	2.23	78.29	13.59
45 days	44.92	8.74	42.68	1.29	2.45	97.71	21.20
S.Em±	0.35	0.04	0.34	0.02	0.05	0.41	0.42
C.D. (P=0.05)	1.05	0.13	1.02	0.06	0.15	1.23	1.27
Interaction	NS	NS	NS	Sig	NS	NS	NS

Table 2: Yield-attributes, yield, quality and economical gain under different plant densities and age of seedlings.

Treatments	Fresh Wt. of bulb (g)	Diameter of bulb (cm)	Yield (q/ha)	TSS content (^{0}Brix)	Protein content (%)	Net income Rs./ha)	B:C ratio
Plant density (cm)							
20x10	67.17	4.66	266.15	11.20	3.07	80775	2.54
20x15	73.96	5.18	270.42	11.48	3.13	82908	2.58
20x20	81.41	5.53	274.40	11.80	3.25	84898	2.62
S.Em±	0.72	0.10	0.16	0.03	0.01	-	-
C.D. (P=0.05)	2.17	0.31	0.49	0.11	0.03	-	-
Age of seedlings							
25 days	48.63	3.54	250.20	10.64	3.11	72798	2.39
35 days	74.02	5.17	270.30	11.42	3.15	82848	2.58
45 days	99.89	6.67	290.47	12.42	3.19	92935	2.77
S.Em±	0.72	0.10	0.16	0.03	0.01	-	-
C.D. (P=0.05)	2.17	0.31	0.49	0.11	0.03	-	-
Interaction	Sig	NS	NS	NS	NS	-	-

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