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Nisha Jangre
Department of Vegetable Science, COA, IGKV, Raipur, Chhattisgarh, India

Vijay Kumar
Department of Vegetable Science, COA, IGKV, Raipur, Chhattisgarh, India

Laxmi Prasad Bhardwaj
Department of Vegetable Science, COA, IGKV, Raipur, Chhattisgarh, India

Vandana Yadav
Department of Vegetable Science, COA, IGKV, Raipur, Chhattisgarh, India

Corresponding Author:
Nisha Jangre
Department of Vegetable Science, COA, IGKV, Raipur, Chhattisgarh, India

Influence of pruning, gibberellic acid and planting densities on growth and yield parameters of onion (*Allium cepa* L.) Var Agrifond Light Red

Nisha Jangre, Vijay Kumar, Laxmi Prasad Bhardwaj and Vandana Yadav

Abstract
The experiment was undertaken to determine the growth and yield parameters of *rabi* onion as effected by different pruning methods, GA_3 foliar spray and transplant densities at Research field of Sant Kabir College of Agriculture and Research Station, Kabirdham (C.G.) during *rabi* season 2017 -18 and 2018-19 under Chhattisgarh plains. The treatments comprised of three factors *i.e.* Pruning (P_0- no pruning, P_1- leaf pruning, P_2- root pruning and P_3- leaf and root pruning), two level of GA_3 (G_0- no GA_3 application and G_1- GA_3 at 150 ppm), and three level of transplant densities (D_1- 20X15 cm, D_2- 20x10 cm and D_3- 15X10 cm). The result demonstrated that pruning methods, GA_3 application and transplant densities had significant effects on growth, yield component and yield of onion. The interaction effect of $P_1G_1D_1$ *i.e* leaf pruning, GA_3 150 ppm and spacing D_1- 20X15 cm was effective in increasing plant height, number of leaves per plant, equatorial diameter, neck diameter and weight of bulb, while the minimum plant height, number of leaves per plant, equatorial diameter, neck diameter and weight of bulb was recorded in minimum planting densities (D_3- 15X10 cm) without pruning and no GA_3 application.

Keywords: Onion, pruning, GA_3, yield, growth

Introduction

Onion (*Allium cepa* L.) belongs to the family Alliaceae (Hanelt, 1990) [9]. Onion is most important of the bulb crops cultivated commercially in most parts of the world. The crop is grown for consumption both in the green state as well as in mature It is one of the richest sources of flavonoids in the human diet and flavonoid consumption has been associated with a reduced risk of cancer, heart disease and diabetes. In addition it is known for anti-bacterial, antiviral, anti-allergenic and anti-inflammatory potential. One onion quality parameter, the percentage of single-center bulbs, has become important to meet demands of both processing and fresh market buyers (Brewster *et al.*, 1980) [4]. Yield and quality of bulbs can be influenced by cultural practices and growing methods. Pruning is the direct way of orienting different parts of the plant for providing and dispersal of food materials into foliage or reproductive mechanism (Gardner, 1966) [7]. Pruning is done mainly for balancing and influencing the nutrients and hormones. GA_3 is one of the important growth stimulating substances which promote cell elongation and cell division thus help in the growth and development of many plants. However, the improvement in the yield and quality of the crops mainly depends on the concentration of plant growth regulator and time of application (Singh, 1995) [20]. The control of plant spacing is one of the cultural practices to control bulb size, shape and yield (Geremew *et al.*, 2010). The higher yield and better control of over or under bulb size could be obtained if plants are grown at optimum density. Bulb neck diameter, mean bulb weight and plant height decreased as population density increased. Total bulb yield can be increased as population density increases (Kantona *et al.*, 2003) [10]. Similar result was also noted by (Purewal and Dargan, 1962; Badarudin and Haque, 1977 and Rahim *et al.*, 1983) [18, 3, 19]. Therefore, the present investigation was carried out to study the effect of seedling pruning, Gibberellic acid and transplant densities on quality attributes of onion in Chhattisgarh plains.

Materials and Methods
The experiment was conducted at experimental field of Sant Kabir college of Agriculture and research station, Kabirdham (C.G.) during *rabi* season 2017-18 and 2018-19. The experiment was Statistical analysis for all parameters by adopting the procedures of Gomez and Gomez (1984) [8] in Factorial Randomize Block Design (FRBD) with three replication, keeping four pruning level *i.e* (no pruning, leaf pruning, root pruning and leaf and root pruning), two level of GA_3 (without GA_3 application and GA_3 at 150 ppm) and three level of transplant densities (20X15 cm, 20x10 cm and 15X10 cm).

Growth and yield parameters
The growth and yield parameters of onion *i.e.* plant height, number of leaves per plant, equatorial diameter, neck diameter and average weight of bulb are described with the help of data given in Table 1-2 and shown in Fig 1-2.

Plant height (cm)
For recording observations, five randomly selected plants from each and every treatment have been tagged. Plant heights were measured from ground level up to the tip of the tallest leaf with the help of scale and mean values were calculated, data given in Table1 and shown in Fig1.

Effect of pruning
The result observed that significant difference among different pruning methods during first and second year and pooled mean. The maximum plant height of onion was observed under P_1 *i.e.* Leaf pruning (55.74, 56.56 and 56.15 cm, respectively) in first, second year and pooled mean data. The minimum plant height of onion was recorded in P_0 *i.e.* no pruning (45.37, 45.76 and 45.56 cm, respectively) in first, second year and pooled mean. The improvement in plant height under present investigation due to leaf pruning could be due to early establishment of plant which subsequently resulted in increase in plant height. The lower plant height under leaf and root pruning followed by no pruning could be attributed due to delayed plant establishment which took more time to take the vegetative growth. The finding of present investigation may further be supported by the revelation of Edmond *et al.* (1957) [6] who stated that root pruning removes certain portion of the root system.

Effect of GA_3
The Gibberellic acid showed significant influence on plant height. Treatment G_1 *i.e.* GA_3 at 150 ppm as foliar spray recorded significantly higher plant height (51.04, 51.93 and 51.48 cm respectively) during both years (2017-18 and 2018-19) and on the basis of mean data. However, the lowest plant height was noted under treatment G_0 *i.e.* no GA_3 spray (48.60, 49.42 and 49.01 cm respectively) during both the years and on the basis of mean data. The improvement in plant height due to Gibberellic acid as foliar spray could be due to the higher metabolic activities of the plant attributed to the higher cell division as well as elongation of cell. These results are in close conformity with the findings of Singh *et al.* (1995) [20] who reported that GA_3 increased the plant height at 150 ppm concentration.

Table 1: Effect of seedling pruning, Gibberellic acid and transplant densities on Plant height (cm), No of leaves and Equatorial diameter (cm) in onion

Treatment	Plant height (cm)			No of leaves Plant^{-1}			Equatorial diameter (cm)		
	2017-18	2018-19	Mean	2017-18	2018-19	Mean	2017-18	2018-19	Mean
Pruning methods									
P_0	45.37	45.76	45.56	7.23	7.42	7.33	4.55	4.62	4.58
P_1	55.74	56.56	56.15	9.16	9.32	9.24	5.69	5.77	5.73
P_2	50.35	51.41	50.88	8.31	8.52	8.42	5.55	5.63	5.59
P_3	47.81	48.98	48.39	7.88	8.07	7.97	5.08	5.39	5.24
SE±	0.72	0.73	0.73	0.12	0.12	0.12	0.29	0.28	0.29
CD (5%)	2.05	2.08	2.04	0.34	0.34	0.34	0.83	0.80	0.80
Gibberellic acid concentration									
G_0	48.60	49.42	49.01	7.21	7.08	8.05	4.61	4.74	4.67
G_1	51.04	51.93	51.48	8.34	8.51	8.42	5.82	5.97	5.89
SE±	0.51	0.52	0.51	0.08	0.09	0.08	0.21	0.20	0.20
CD (5%)	1.45	1.47	1.44	0.24	0.24	0.24	0.58	0.57	0.57
Transplant densities									
D_1	50.68	51.53	51.10	8.33	8.51	8.42	5.38	5.51	5.44
D_2	49.82	50.68	50.25	8.14	8.33	8.23	5.17	5.34	5.25
D_3	48.96	49.82	49.39	7.97	8.16	8.06	5.10	5.22	5.16
SE±	0.62	0.63	0.13	0.10	0.10	0.02	0.25	0.24	0.24
CD (5%)	1.78	1.80	0.36	0.29	0.30	0.06	0.71	0.70	0.70

P_0 - (No pruning), P_1 -LP (Leaf pruning), P_2- RP (Root Pruning), P_3- LP+R (Leaf+Root Pruning), G_0 - (No GA3 spray), G_1- (GA3 150 ppm), D_1 - (20X15cm), D_2- (20X10cm), D_3 - (15x10 cm)

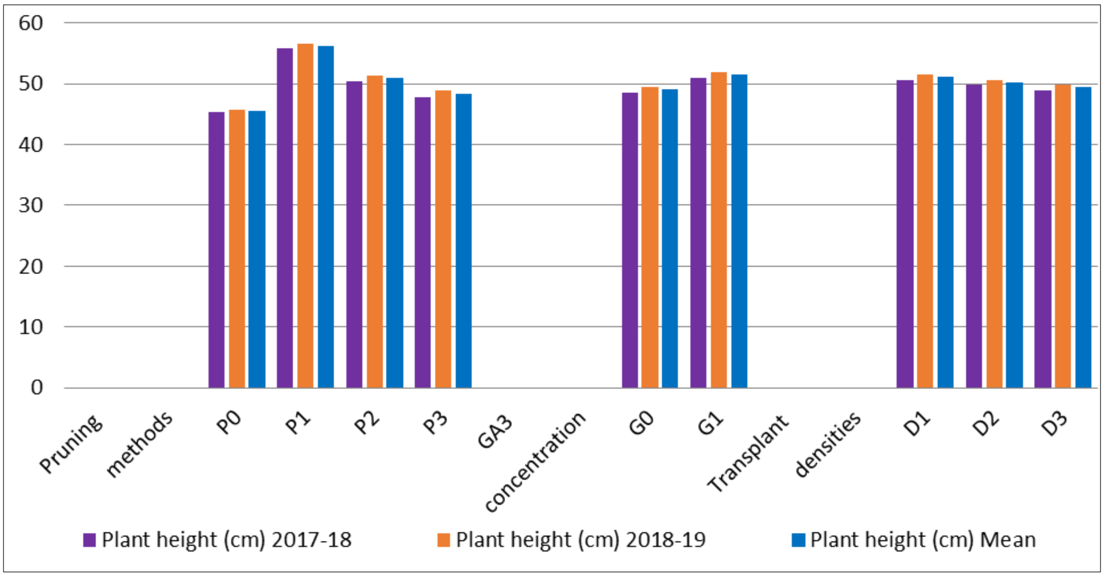

Fig 1: Effect of seedling pruning, Gibberellic acid and transplant densities on Plant height (cm) in onion

Effect of transplant densities

Among transplant densities, treatment D_1-20 x 15 cm produced significantly taller plants (50.68, 51.53 and 51.10 cm respectively) in both years (2017-18 and 2018-19) and on the basis of mean data. The shortest plant height noted under treatment D_3-15 x 10 cm (48.82, 49.82 and 49.39) during both the years and on mean basis. The increase in plant height at the medium intra-row spacing may be due to less interplant competition for the growth factors like water, nutrient and light, which may lead to better growth and significantly taller plant height as compared to narrow intra-row as explained by Khan *et al.* (2002) [11]. Similarly, a study conducted on garlic revealed that plant height, diameter, bulb size and number of cloves were greater with cloves planted at the widest spacing (Om and Srivastava, 2000).

Interaction effect

The data indicated significant increase in plant height in different combination of pruning, Gibberellic acid and transplant densities in comparism to treatments combination of all planting densities without pruning and GA_3 application. It was observed that P1-leaf pruning X G1- GA_3 150 ppm X D1-20x15 produced maximum plant height (59.56, 61.67 and 60.62 cm respectively). The minimum plant height was recorded in all planting densities without pruning and GA_3 application.

Number of leaves per plant

Total number of green leaves (functional leaves) of five randomly selected plants in each and every treatment was counted and average values were computed, data given in table1.

Effect of pruning

Among pruning method, during the investigation significantly maximum number of leaves was recorded in P_1 *i.e.* leaf pruning (9.16, 9.32 and 9.24) during both years (2017-18 and 2018- 19) and on the basis of mean data followed by root pruning. The minimum number of leaves was recorded in P_0 *i.e.* no pruning (7.23, 7.42 and 7.33 respectively) followed by leaf and root pruning at all stages of plant growth during both years (2017-18 and 2018-19) and on the basis of mean data. In the present investigation, the improvement in number of leaves due to leaf pruning might be attributed to enhancement in some physiological process which might have influenced the maximum number of leaves productions. Similar results were reported by Nahar (2007) [14] in onion.

Effect of GA_3

The Gibberellic acid showed significant influence on number of leaves. Treatment G_1 *i.e.* GA_3 at 150 ppm as foliar spray recorded significantly number of leaves (8.34, 8.51 and 8.42 respectively) during both years (2017-18 and 2018-19) and on the basis of mean data. However, the lowest number of leaves was noted under treatment G_0 *i.e.* no GA_3 spray (7.95, 8.15 and 8.05 respectively) during both the years and on the basis of mean data. These results are with the close agreements with the findings of Moore (1989), Hye *et al*. (2002) [1] and Tyagi and Yadav (2007) [22] and Patel *et al.* (2010) [17].

Effect of transplant densities

Among transplant densities D_1-20 x 15 cm produced significantly number of leaves (8.33, 8.51 and 8.42 respectively) in both years (2017-18 and 2018-19) and on the basis of mean data. However, the lowest number of leaves was noted under treatment D_3- 15 x 10 cm in both years (2017-18 and 2018-19) and on the basis of mean data. The findings are in agreement with the work of Nawab *et al.* (1998) [16] who showed that wider plant spacing resulted in more number of leaves plant^{-1} at the widest spacing produced more number of leaves probably due to less competition for nutrients, light, space, and moisture.

Interaction effect

The data indicated significant increase in number of leaves in different combination of pruning, Gibberellic acid and transplant densities. It was observed that P1-leaf pruning X G1- GA_3 150 ppm X D1-20x15 produced maximum number of leaves(10.08, 10.20 and 10.14 respectively) which was significantly higher then the next best treatments *i.e* P1-leaf pruning X G1- GA_3 150 ppm X D2-20x15. However latter both treatments are statistically at par with treatment combination of all planting densities with root pruning and GA3 application.

Equatorial diameter (cm)
Equatorial diameter of bulb was of five randomly selected plants in each plot was measured with the help of Vernier caliper and noted in centimeter on scale and the average was calculated, data given in table1.

Effect of pruning
Among pruning treatments, P_1 *i.e.* leaf pruning obtained significantly maximum equatorial diameter (5.69,5.77 and 5.73 cm) during both years (2017-18 and 2018- 19) and on the basis of mean data and this trend was followed by root pruning during the respective years while the minimum equatorial diameter was noted under treatment P_0 *i.e.* No pruning(4.55,4.62 and 4.58 cm) followed by P_3 *i.e.* root and leaf pruning (5.08, 5.39 and 5.24 cm) during both years (2017-18 and 2018- 19) and on the basis of mean data.

Effect of GA_3
Among Gibberellic acid, perusal of data indicated that treatment G_1 *i.e.* GA_3 at 150 ppm as foliar spray recorded significantly maximum equatorial diameter (5.82, 5.97 and 5.89 cm) during both years (2017-18 and 2018-19) and on the basis of mean data. While, the minimum equatorial diameter was noted under treatment G_0 *i.e.* no GA_3 spray (4.61, 4.74 and 4.67 cm) in respective years and on the basis of mean data. Nandekar and Sawarkar (1992) [15] reported that GA_3 at 40 ppm significantly increased the vegetative characters of onion like number of leaves, bulb length and diameter of bulb.

Effect of transplant densities
Among transplant densities, treatment D_1-20 x 15 cm recorded significantly higher equatorial diameter (5.38, 5.51 and 5.44) as compared to treatment D_2-20 x 10 cm, D3-15 x 10 cm in both years (2017-18 and 2018-19) and on the basis of mean data. However, the minimum equatorial diameter was noted under treatment D_3-15 x 10 cm (5.10, 5.22 and 5.16) in both years (2017-18 and 2018-19) and on the basis of mean data.
The reason for decrease in bulb size under high plant population density could be due to numbers of leaves plant^{-1} which might have negatively affected the amount of assimilate produced resulting in reduced the bulb size. This result is in line with the finding of Mcgeary (1985) who reported that size in onion bulbs grown in high densities were smaller and irregular in shape.

Interaction effect
The interactions among P_1 *i.e.* leaf pruning X G_1 *i.e* GA_3 150 ppm X D_1-20 x 15 cm recorded significantly higher Equatorial diameter (6.93,7.11 and 7.02 cm) followed by P_1 *i.e.* leaf pruning XG_1 *i.e* GA_3 150 ppm XD_2-20 x 10cm. Minimum equatorial diameter was found under treatment, P_0 *i.e.* no pruning XG_0 *i.e* no GA_3 spray X D_3-15 x 10 cm.

Neck- diameter (mm)
The neck diameter of five randomly selected bulbs was measured with the help of vernier caliper and average was calculated, data given in Table2.

Effect of pruning
The data revealed that P_1 *i.e.* Leaf pruning had maximum value of neck- diameter (11.38, 11.31and 11.35 mm respectively) in bulbs in both years (2017-18 and 2018-19) and on the basis of mean data followed by P_1 *i.e.*root pruning (11.05, 10.84 and 10.94 mm). The minimum value of neck-diameter was obtained under the treatment P_0 i.e. no pruning (10.31, 10.31 and 10.31 mm) followed by P_3 *i.e.* Leaf and root pruning (10.76, 10.55 and 10.65 mm respectively) during both years (2017-18 and 2018-19) and on the basis of mean data.

Effect of GA_3
Among, Gibberellic acid treatment G_1 *i.e.* GA_3 at 150 ppm as foliar spray recorded significantly higher neck- diameter (10.97,10.84 and 10.91 mm) during both years (2017-18 and 2018-19) and on the basis of mean data. However, the lower neck- diameter was noted under treatment G_0 *i.e.* no GA_3 spray (10.78, 10.66 and 10.72 mm) in respective years and on the basis of mean data. This may be attributed to greater bulb diameter in the present investigation. Anwar (1995) [2] reported that Gibberellic acid had marked influence on bulb diameter and neck thickness besides other vegetative growth and yield parameter were also improved in garlic.

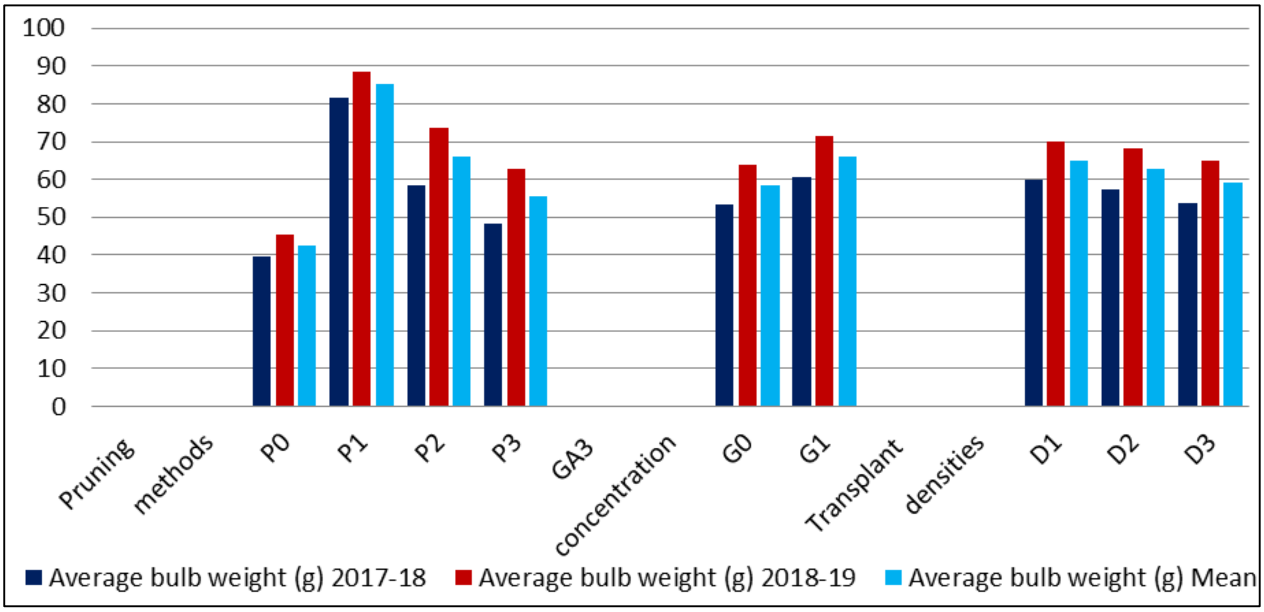

Fig 2: Effect of seedling pruning, Gibberellic acid and transplant densities on Average bulb weight (g) in onion

Table 2: Effect of seedling pruning, Gibberellic acid and transplant densities on Neck diameter (cm) and Average bulb weight (g) in onion

Treatment	Neck diameter (cm)			Average bulb weight (g)		
	2017-18	2018-19	Mean	2017-18	2018-19	Mean
Pruning methods						
P_0	10.31	10.31	10.31	39.70	45.58	42.64
P_1	11.38	11.31	11.35	81.66	88.57	85.11
P_2	11.05	10.84	10.94	58.40	73.66	66.03
P_3	10.76	10.55	10.65	48.25	62.91	55.58
SE±	0.15	0.15	0.15	0.85	1.00	0.92
CD (5%)	0.44	0.44	0.43	2.41	2.83	2.60
Gibberellic acid concentration						
G_0	5.85	10.66	10.72	53.38	63.82	58.60
G_1	6.06	10.84	10.91	60.62	71.54	66.08
SE±	0.05	0.11	0.11	0.60	0.70	0.65
CD (5%)	0.31	0.31	0.31	1.71	2.00	1.84
Transplant densities						
D_1	10.93	10.80	10.86	60.05	69.92	64.99
D_2	10.88	10.76	10.82	57.22	68.15	62.69
D_3	10.82	10.69	10.76	53.73	64.96	59.34
SE±	0.13	0.13	0.03	0.73	0.86	0.79
CD (5%)	0.38	0.38	0.08	2.09	2.45	2.27

P_0 - (No pruning), P_1 -LP (Leaf pruning), P_2- RP (Root Pruning), P_3- LP+R (Leaf+Root Pruning), G_0 - (No GA3 spray), G_1- (GA3 150 ppm), D_1 - (20X15cm), D_2 - (20X10cm), D_3 - (15x10 cm)

Effect of transplant densities

Among transplant densities, treatment D_1-20 x 15 cm gave significantly highest neck- diameter (10.93, 10.80 and 10.86 mm respectively) than other treatments in both years (2017-18 and 2018-19) and on the basis of mean data. However, the lowest neck-diameter (10.82, 10.69 and 10.76 mm respectively) was recorded in treatment D_3-15 x 10 cm in both years (2017-18 and 2018-19) and on the basis of mean data. These results are similar to those obtained by (Dawar *et al*, 2007) [5] generally as planting density decreased the neck thickness was increased. The reason might be due to less competition of onion plants in wider spacing for different growth factors like moisture and nutrients.

Interaction effect

The interactions among P_1- leaf pruning XG_1 -GA_3 150 ppm XD_1-20 x 15 cm recorded significantly higher neck- diameter (11.49, 11.42 and 11.46 mm). Minimum neck- diameter was found under treatment combination of all planting densities without pruning and no GA_3 application during both the year (2017-18 and 2018-19) and on the basis of mean data.

Average bulb weight (g): Weight of five randomly selected bulbs in each plot was recorded with the help of weighing balance in gram and the average value was calculated, data given in Table2 and shown in Fig2.

Effect of pruning

Among pruning treatments, P_1 *i.e.* leaf pruning obtained significantly maximum bulb weight (81.66, 88.57 and 85.11 g) during both years (2017-18 and 2018-19) and on the basis of mean data and this trend was followed by root pruning while the minimum bulb weight was noted under treatment P_0 *i.e* no pruning (39.70, 45.58 and 42.64 g) followed by P_3 *i.e.* root and leaf pruning (48.25, 62.91 and 55.58 g) in respective years (2017-18 and 2018-19) and on the basis of mean data.

The result corroborate the finding of Maiti and Sen (1968) [13] who reported that leaf pruning of seedling at the time of transplanting augmented the start of onion and increased the size of bulb.

Effect of GA_3

Among Gibberellic acid, the perusal of data indicated that treatment G_1 *i.e.* GA_3 at 150 ppm as foliar spray recorded significantly maximum bulb weight (60.62, 71.54 and 66.08 g) during years (2017- 18 and 2018-19) and on the basis of mean data. However, the minimum bulb weight was noted under treatment G_0 *i.e.* no GA_3 spray (53.38, 63.82 and 58.60 g) in respective years and on the basis of mean data. Similar findings have also been obtained by Tomar and Ramgiry (1997) [21].

Effect of transplant densities

Among transplant densities, treatment D_1-20 x 15 cm gave significantly highest bulb weight (60.05, 69.92 and 64.99 g respectively) than other treatments in both years (2017-18 and 2018-19) and on the basis of mean data. However, the lowest bulb weight (53.73, 64.96 and 59.34 g respectively) was recorded in treatment D_3-15 x 10 cm in both years (2017-18 and 2018-19) and on the basis of mean data. Wider row spacing produced heavier bulbs and this might be due to effective utilization of environmental resources due to little competition as compared to the closely spaced plants. Similar results were showed by Khan *et al.* (2002) [11], Khan *et al.* (2003) [12] who also stated that wider plant spacing in onion, resulted in heavier bulb production.

Interaction effect

The interactions among P_1 *i.e.* leaf pruning X G_1 *i.e* GA_3 150 ppm X D_1-20 x 15 cm recorded significantly higher bulb weight (94.27 95.65 and 94.96 g), however it was *at par* to interaction P_1 *i.e.* leaf pruning X G_1 *i.e* GA_3 150 ppm X D_2-20 x 10 cm followed by P_1 *i.e.* leaf pruning X G_1 *i.e* GA_3 150 ppm XD_3-15 x 10 cm. Minimum bulb weight was found under treatment, P_0 *i.e.* no pruning X G_0 *i.e* no GA_3 spray X D_3-15 x 10 cm.

Conclusion

The results obtained during the present investigation revealed that leaf pruning and GA_3 at 150 ppm as of foliar spray and transplant densities of D_1 20X15 cm is highly beneficial for improving growth, plant height, number of leaves per plant, equatorial diameter, neck diameter and weight of bulb as compared to other treatment combinations.

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