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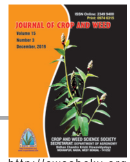

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Impact of cut bulb and weight on seed yield of onion cv. Sukhsagar

S. BANIK, *D.K. GHOSH (LKN), N. CHATTOPADHYAY AND A. BANDYOPADHYAY

Department of Plantation, Spices, Medicinal and Aromatic Crops,Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya,Mohanpur- 741252, Nadia, West Bengal

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ABSTRACT

Reduction of onion seed cost may play an important role in bridging the demand supply gap of onion bulbs. An appropriate cultural manipulation to reduce the mother bulb requirement is the key cost component of onion seed production. Keeping this in view,consecutive two years experiment was carried out at HRS, Mondouri, BCKV, on clay loam soil during rabi seasons of 2017-2019 to evaluate the performance of three different sizes of onion mother bulb (60-80g,80-100g and >100g) and portion of each size mother bulb (whole bulb,$1/_3^{rd}$ circular cut bulb, longitudinally $1/_3^{rd}$ cut bulb and longitudinally ½ cut bulb) of Sukhsagar cultivar in a RCBD with 3 replications in 2mx2.5m plot. The experimental results revealed that, maximum seed weight of 320.29g plot^{-1} was recorded under whole bulbs of >100 g weight and minimum of 185.57g plot^{-1}associated with $1/_3^{rd}$ longitudinally cut bulbs. In case of 80-100g size of bulb maximum seed weight of 284.39 was recorded under whole size bulb and minimum of 164.17g was recorded with $1/_3^{rd}$ longitudinally cut bulb. Similarly in whole bulb of 60-80 g, maximum seed yield of 223.32 g plot^{-1} was found in whole bulbs whereas minimum (136.17g plot^{-1}) was recorded under longitudinally $1/_3^{rd}$ cut bulbs. It was clear that, among the three sizes of mother bulb maximum net return (Rs.402862, Rs.321487 and Rs.194932 ha^{-1} , respectively) and maximum B: C ratio (2.44,2.21 and 1.77 respectively) was only recorded in longitudinally ½ cut bulb of >100g, 80-100g and 60-80g size respectively followed by whole or$1/_3^{rd}$ circular cut bulb. Cost analysis of onion seed production among different sizes shows that expenditure behind procurement of mother bulbs alone contributes maximum share which ranges between 23-58.06% of the total expenditure. Thus, longitudinally portions of ½cut reduced mother bulb requirement by 50%. Net return, benefit cost ratio, benefit in terms of rupees or grams per unit rupee investment in mother bulbs were higher than that of using whole mother bulb of any size. Based on economic considerations, ½cut bulb of any size and weight (60-80g, 80-100g and above 100g) can be recommended instead of using conventional whole bulb of 60 to >100g weight as cost saving onion seed production options with a possibility of doubling the area under seed production of onion.

Keywords: Portion of bulb,productivity,B:C ratio, doubling income, onion seed yield

Onion (*Allium cepa* L, family-Alliaceae) is an important biannual bulbous spice crop of India. Globally India is the second largest producer of onion bulbs after China. Indian onions are famous for their pungency and available round the year. Due to a lot of demand of Indian onion in the world, the country has exported 11,49,896.85 MT of fresh onion worldwide worth of Rs. 2,320.70 crore during the year 2019-20 (Anon, 2020). Due to huge demand of onion in domestic and international market, the areas under onion production need to be increased. Seed is the primary input without which increase in area and production of any crop cannot be expected. Annually India needs around 9400 tons of onion seed for covering 11.73 lakh hectares of area. Organized sector contributes around 40% of the total seed requirement and rest is met by farmers own seed without meeting isolation requirement (ICAR-Directorate of onion and garlic Research, 2021). Non availability of quality seed is the major bottleneck for profitable production program of any crop. Due to lack of adequate information on different aspects of seed production, such as availability of required size of mother bulbs, higher rate of mother bulb during planting times, non-availability of labours, the growers become reluctant in seed production. Low productivity of onion in India could be attributed to the limited availability of quality seeds and associated production technologies used, among the others. Therefore, it becomes essential to produce good quality seeds with high yield potential each year through efficient use of the technology by minimizing the cost of production.

A number of studies on effect of planting time and spacing on yield and quality of onion seed have been carried out by number of researchers. But information related to reduction of onion seed production cost by minimizing the mother bulb requirements through use of portion of onion bulb is very meagre. Scientific literature studies providing an option to reduce the mother bulb requirement through mechanical manipulation is relatively rare, but they are needed for reducing the production cost *vis-a-vis* horizontal expansion of onion area in India. Here, effect of four different portions of mother bulb of different sizes (60->100g) (whole bulb, $1/_3^{rd}$ circular cut bulb, longitudinally ½ cut bulb, longitudinally $1/_3^{rd}$ cut bulb)

Email: dipak_kghosh@yahoo.com

of Sukhsagar variety on growth, productivity and profitability was carried out. Keeping this in view the present investigation was undertaken to find out the most profitable portion of bulbs irrespective of any size for economically successful onion seed production program.

MATERIALS AND METHODS

The experiment was conducted at Horticulture Research Station, Mondouri and Laboratory of the Department of Plantation, Spices, Medicinal and Aromatic Crops, Bidhan Chandra Krishi Vishwavidyalaya, Mohanpur, Nadia,West Bengal during *rabi* seasons of 2017-2019 which is located at a latitude of $23^0 50'$ North, longitude of $80^0 02'$ East and at altitude of 9.75 meters above MSL and at a distance of about 60km from Kolkata. The soil of the experimental field was a very deep well-drained clay loam with 44% sand, 28% silt and 28% clay in the surface layer (0–15 cm) and good water holding capacity having Soil p^H 6.5.The experiment was laid out in Randomizes Complete Block Design (RCBD) with three replications each. Healthy and disease free onion bulbs cv. Sukhsagar were taken as planting materials. It was planted during the 1^{st} fortnight of November in each year at a spacing of 20 cm x 40 cm in 2 m x 2.5 m plot.

Weather during crop season (November to March) was almost stable during the period of experimentation except temperature (Table-1). Higher temperature was recorded during 2017-18 which ranges from 8.09 ^{0}C (minimum) in January to 33.99^{0}C (maximum) in March. Mean daily maximum and minimum relative humidity over the period was 69% and 81%, respectively during 2017-18. Similarly in 2018-19 temperature ranges between 8.21^{0}C - 31.56^{0}C and relative humidity ranges between71.74% and 75.14%.The treatment combinations wereT_1- whole bulb of > 100g weight,T_2- $^1/_3$ circular cut bulb of > 100g weight, T_3- longitudinally ½ cut bulb of > 100 g weight,T_4- longitudinally $^1/_3{}^{rd}$ cut bulb of > 100g weight,T_5- Whole bulb of 80-100g weight,T_6- $1/_3{}^{rd}$ circular cut bulb of 80-100g weight,T_7- longitudinally ½ cut bulb of 80-100 g weight,T_8- longitudinally $^1/_3{}^{rd}$ cut bulb of 80-100g weight,T_9- whole bulb of 60 - 80g weight,T_{10}- $^1/_3{}^{rd}$ circular cut bulb of 60-80g weight,T_{11}-longitudinally ½ cut bulb of 60-80 g weight and T_{12}-longitudinally $^1/_3{}^{rd}$ cut bulb of 60-80g weight used as propagating materials. Experimental plots were ploughed thoroughly to a fine tilth by giving four tractors ploughing followed by levelling. The field was then divided into beds and channels to avoid water logging which affects production and quality of seeds. 25 tons of FYM ha^{-1}was applied at the time of land preparation. Recommended dose of fertilizers (125: 80: 100 @ N: P_2O_5: K_2O kg ha^{-1}) were applied in two split doses. Half dose of nitrogen, full dose of P_2O_5 and half dose of K_2O as basal and rest at 25 days after planting as top dressing was given and earthing up was followed after top dressing. Fungicide (Carbendazim @ 1gl^{-1}) treated mother bulbs were planted within first fortnight of November. Need based irrigation and eco-friendly plant protection measures were given. Diseased and off-type plants were rouged out before flowering for quality seed production. The experimental plots were kept weed free by hand weeding twice at 15 days and 40 days after planting. The bulbs were harvested during April in each year. Five random plants sampled per replication were selected to record the data on different characters of the treatments for each plot like plant height (cm), no. of leaves, umbel diameter (cm), no. of inflorescence, seed weight per umbel (g), seed weight per plot (g), projected seed yield (kg ha^{-1}) and B:C ratio.

Prices of the individual inputs (Diesel @ Rs 63.25 per litre, labour @ Rs170/8hrs/ day, mother bulb @ Rs 40000 per ton, Urea @ Rs. 6.5 per kg, MOP @ Rs 12 per kg, SSP @ Rs 8 per kg, Imidacloprid @ Rs 1400 per litre, Propiconazole @ Rs 800 per litre) were assumed to be stable during the experimental period. Ignoring possible opportunity costs family labour at the mean wage rate of hired labour was included in the cost of production calculations. Treatment wise detailed production costs were reflected in Table 4. Net return or profit was calculated by subtracting production cost from the gross value of the produce. Prices used for harvest products were average prices observed during the experimental period. The benefit: cost ratio (BCR) was calculated by dividing the net return by the production cost. Statistical analysis for each variable was conducted as per the procedure given by Gomez and Gomez (1984). Wherever the results were significant, least significant differences (LSD) were worked out at probability level p 0.05 using the ANOVA.

RESULTS AND DISCUSSION

Growth parameters

Plant height and number of leaves

Two years pooled data presented in Table 2, on height of the plants, number of leaves,umbel diameter and spike length of onion as influenced by different size and portion of cut bulb indicated that out of twelve treatments, T_1 (whole bulb >100g weight) recorded maximum plant height of 40.19cm per plant followed by T_3 (39.87cm) (longitudinally $^1/_2$ cut bulb of>100g weight) and T_2 (39.24 cm) (circular cut from the top $1/_3{}^{rd}$ portion of bulb of >100g weight) which are at par with each other. Similarly, minimum plant height of

Table 1: Meteorological data of 2017-18 and 2018-19

Months	Temp Max (^{0}c)		Temp Min (^{0}c)		Rainfall (mm)		RH (%)	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Nov	28.64	30.27	14.76	14.02	11.07	0	76.5	72.58
Dec	25.57	25.1	11.49	9.14	8.93	13.8	81.0	73.12
Jan	23.34	25.4	8.09	8.21	0	0	74.0	71.91
Feb	29.45	27.88	12.99	10.8	0	12.19	71.5	71.74
March	33.99	31.56	17.36	15.9	0	31.5	69.0	75.14

Table 2: Growth parameters of onion for seed production under different weights and cut portions of mother bulb

Treatments	Plant height (cm)			No of leaves			Umbel diameter (cm)			Spike length (cm)		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T_1	39.61	40.77	40.19	26.15	27.85	27.00	6.15	6.24	6.20	96.25	96.62	96.44
T_2	38.41	40.08	39.24	26.34	27.63	26.98	6.15	6.28	6.22	96.19	97.14	96.67
T_3	39.82	39.92	39.87	26.29	27.20	26.75	6.04	6.16	6.10	88.09	96.72	92.41
T_4	37.40	38.39	37.89	23.88	26.74	25.31	5.95	6.04	6.00	84.19	89.39	86.79
T_5	39.25	39.91	39.58	22.93	26.58	24.76	6.05	6.12	6.09	95.82	93.23	94.53
T_6	39.04	39.87	39.45	23.52	26.50	25.01	6.04	6.11	6.08	93.25	93.20	93.23
T_7	39.10	39.13	39.11	22.60	26.17	24.38	6.03	6.12	6.08	91.04	91.52	91.28
T_8	37.21	38.25	37.73	20.62	21.37	20.99	5.68	5.95	5.82	88.77	85.61	87.19
T_9	38.90	38.94	38.92	21.22	25.58	23.40	5.85	6.05	5.95	90.92	94.43	92.68
T_{10}	38.25	38.89	38.57	21.17	25.70	23.43	5.85	6.05	5.95	90.61	94.56	92.59
T_{11}	37.41	37.69	37.55	18.92	22.41	20.66	5.82	6.02	5.92	89.16	91.56	90.36
T_{12}	35.96	36.23	36.09	16.80	19.32	18.06	5.29	5.65	5.47	78.32	88.47	83.40
SEm (±)	**0.20**	**0.18**	**0.42**	**0.15**	**0.21**	**1.00**	**0.04**	**0.02**	**0.07**	**0.14**	**0.62**	**1.77**
LSD (0.05)	**0.58**	**0.53**	**1.23**	**0.43**	**0.63**	**2.93**	**0.10**	**0.07**	**0.21**	**0.42**	**1.83**	**5.20**

Table 3: Seed yield of onion under different weights and cut portions of mother bulb

Treatments	No. of Inflorescence/ plant			Seed weight (g) umbel^{-1}			Seed weight (g) plot^{-1}			Projected Seed yield (kg ha^{-1})		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T_1	5.20	5.65	5.43	2.70	3.48	3.09	283.86	356.71	320.29	569.80	628.45	599.13
T_2	5.47	5.86	5.67	2.75	3.53	3.14	284.19	355.71	319.95	569.83	626.78	598.31
T_3	4.92	5.19	5.05	2.75	3.16	2.96	277.65	325.19	301.42	548.82	588.55	568.69
T_4	3.12	3.26	3.19	2.79	2.96	2.88	155.49	215.65	185.57	309.72	388.55	349.14
T_5	4.43	4.87	4.65	2.71	3.12	2.92	255.41	313.36	284.39	503.35	553.79	528.57
T_6	3.90	4.80	4.35	2.71	3.26	2.99	248.19	314.60	281.40	487.69	552.79	520.24
T_7	3.96	4.69	4.32	2.62	2.95	2.79	245.19	292.17	268.68	483.09	496.78	489.94
T_8	2.67	2.99	2.83	2.59	2.35	2.47	138.16	190.17	164.17	276.88	345.87	311.38
T_9	3.95	4.26	4.11	2.69	2.87	2.78	180.49	266.65	223.57	360.24	472.77	416.51
T_{10}	3.82	4.36	4.09	2.63	2.67	2.65	178.66	265.98	222.32	356.57	486.10	421.34
T_{11}	3.29	3.97	3.63	2.59	2.53	2.56	172.82	245.58	209.20	343.65	403.44	373.54
T_{12}	2.42	2.65	2.54	1.73	1.75	1.74	126.04	146.3	136.17	241.36	292.92	267.14
SEm (±)	**0.04**	**0.03**	**0.33**	**0.02**	**0.03**	**0.16**	**1.49**	**1.77**	**21.30**	**1.93**	**4.54**	**38.83**
LSD(0.05)	**0.11**	**0.08**	**0.98**	**0.05**	**0.08**	**0.46**	**4.38**	**5.20**	**62.47**	**5.67**	**13.32**	**13.88**

(T_1- whole bulb of more than 100g weight ,T_2- $^1/_3$ circular cut bulb of more than100g weight ,T_3- longitudinally ½ cut bulb of more than100 g weight ,T_4-longitudinally $^1/_3{}^{rd}$ cut bulb of more than100g weight,T_5- whole bulb of 80 - 100g weight,T_6- $^1/_3{}^{rd}$circular cut bulb of 80-100g weight,T_7- longitudinally ½ cut bulb of 80-100 g weight,T_8- longitudinally $^1/_3{}^{rd}$ cut bulb of 80-100g weight.,T_9- Whole bulb of 60 - 80g weight,T_{10}- $^1/_3{}^{rd}$ circular cut bulb of 60-80g weight,T_{11}- longitudinally ½ cut bulb of 60-80 g weight and T_{12}-longitudinally $^1/_3{}^{rd}$ cut bulb of 60-80g weight)

Table 4: Input requirement of onion seed production with different weights and cut portions of bulb

Items	Treatment wise input requirement											
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}
Diesel (l ha^{-1})	84	84	84	84	84	84	84	84	84	84	84	84
Labor (8 hrs./days ha^{-1})	382	438	458	458	382	438	458	458	382	438	458	458
Mother bulb (t ha^{-1})	6	6	3	2.02	5.25	5.25	2.6	1.76	4.5	4.5	2.25	1.5
FYM (t ha^{-1})	25	25	25	25	25	25	25	25	25	25	25	25
Fertilizer N (kg ha-^{1})	125	125	125	125	125	125	125	125	125	125	125	125
Fertilizer P_2O_5 (kg ha-^{1})	60	60	60	60	60	60	60	60	60	60	60	60
Fertilizer K_2O (kg ha^{-1})	90	90	90	90	90	90	90	90	90	90	90	90
Insecticide	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Fungicide	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7

Table 5: Production cost of onion seed with different weights and cut portions of mother bulb (Rs ha^{-1})

Items	Treatment wise input requirement cost											
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}
Diesel (l ha^{-1})	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964
Labor(8-hrs./ days ha^{-1})	115173	132057	138087	138087	115173	132057	138087	138087	115173	132057	138087	138087
Mother bulb (t ha^{-1})	210000	210000	105000	70700	183750	183750	91875	61600	157500	157500	78750	52500
FYM (t ha^{-1})	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
N (kg ha-^{1})	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
P_2O_5(kg ha-^{1})	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
K_2O(kg ha^{-1})	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Insecticide	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400
Fungicide	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400
Total (Rs)	361652	378536	279566	245266	335402	352286	266441	236166	309152	326036	253316	227066

(T_1- whole bulb of more than 100g weight ,T_2- $^1/_3$ circular cut bulb of more than100g weight ,T_3- longitudinally ½ cut bulb of more than100 g weight ,T_4-longitudinally $^1/_3{}^{rd}$ cut bulb of more than100g weight,T_5- whole bulb of 80 - 100g weight,T_6-$^1/_3{}^{rd}$circular cut bulb of 80-100g weight,T_7- longitudinally ½ cut bulb of 80-100 g weight.,T_8- longitudinally $^1/_3{}^{rd}$ cut bulb of 80-100g weight.,T_9- Whole bulb of 60 - 80g weight,T_{10}- $^1/_3{}^{rd}$ circular cut bulb of 60-80g weight,T_{11}- longitudinally ½ cut bulb of 60-80 g weight and T_{12}- longitudinally $^1/_3{}^{rd}$ cut bulb of 60-80g weight)

Table 6: Economics of onion seed production from different sizes and bulb portions (pooled)

Treatments	Expenditure (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
Whole bulb> 100g	361652	718800	357148	1.99
$^1/_3$circular cut bulb>100g	378536	717972	339436	1.90
Longitudinally ½ cut bulb >100 g	279566	682428	402862	2.44
Longitudinally $^1/_3{}^{rd}$ cut bulb >100g	245266	418968	173702	1.71
Whole bulb of 80 - 100g	335402	634284	298882	1.89
$^1/_3{}^{rd}$ circular cut bulb of 80-100g	352286	624288	272002	1.77
Longitudinally ½ cut bulb of 80-100 g	266441	587928	321487	2.21
Longitudinally $^1/_3{}^{rd}$ cut bulb of 80-100g	236166	373656	137490	1.58
Whole bulb of 60 - 80g	309152	499812	190660	1.62
$^1/_3{}^{rd}$ circular cut bulb of 60-80g	326036	505608	179572	1.55
Longitudinally ½ cut bulb of 60-80 g	253316	448248	194932	1.77
Longitudinally $^1/_3{}^{rd}$ cut bulb of 60-80g	227066	320568	93502	1.41

36.09cm was recorded in treatment T_{12} (longitudinally $^1/_3{}^{rd}$ cut bulb of 60-80g weight). But the year wise data on height of the plants clearly revealed that, in the year 2017 longitudinally $^1/_2$cut bulbs of >100g size (T_3) recorded maximum plant height of 39.82cm followed by T_1 (39.61cm), while T_{12} (longitudinally $^{1/3rd}$ cut bulb of 60-80g weight) recorded lowest plant height of 35.96cm. Similarly, during 2018, T_1 recorded maximum plant height of 40.77cm followed by T_2 (40.08cm) which were at par with each other and T_{12} recorded minimum plant height of 36.23cm.

In case of number of leaves per plant, it is clear from the pooled data that the treatment T_1recorded maximum 27 number of leaves/plant followed by T_2(circular cut bulbs from the top $^1/_3$rd portion of bulb of >100g weight) and T_3 (26.98 and 26.75 numbers/plant, respectively) and treatment T_{12} recorded minimum 18.06 number of leaves per plant. In year wise data analysis it is clear that during the year 2017 maximum 26.34 number of leaves per plant was recorded under treatment T_2followed by T_3(26.29) and T_1(26.15) respectively and treatment T_{12}recorded minimum 16.80 numbers of leaves per plant in the year 2017. Similarly, during 2018 treatment T_1recorded maximum 27.85 numbers of leaves followed by T_2 (27.63) and T_{12} recorded minimum 19.32 numbers of leaves per plant. Considering different size of bulb irrespective of any treatment, it is clear from table 2 that among the size of the bulb in > 100g weight of bulb maximum height of 40.19cm was recorded in T_1 followed by T_3(39.87cm) and minimum of 37.89cm was recorded in longitudinally $1/_3$rd cut bulb . Similarly, within the size of 80 to 100g of bulb maximum height of 39.58 cm was recorded by T_5(whole bulb of 80 to 100g size) followed by T_6-$^1/_3$rd circular cut bulb from the top (39.45cm) and T_7- longitudinally$^1/_2$ cut bulb (39.11cm) which were at par with each other. In the size of 60-80g of onion bulb, the same trend was followed. Maximum height of 38.92cm was recorded by whole bulb of 60-80g (T_9) followed by T_{10}(38.89cm) and T_{11} (37.55cm). In case of number of leaves variations among the different sizes of bulbs and treatments were very minimum. But the above parameters among the years showed a clear variation in between two years. It showed better growth in 2018 as compared with 2017 irrespective of any treatments.

Umbel diameter and spike length of onion

Pooled data presented in Table 2 on umbel diameter of onion as influenced bydifferent portions of cut bulb indicated that, maximum umbel diameter of 6.22 cm was associated with the treatment T_2followed byT_1 (6.20cm) which were at par with each other and minimum umbel diameter of (5. 47 cm) was recorded under treatment T_{12}. From year wise data, it is clear that in the year 2017 maximum umbel diameter of 6.15cm was recorded under treatment T_1 and T_2 followed by T_5 , T_3 ,T_6 and T_7 (6.05,6.04, 6.04 and 6.03cm, respectively). However, T_{12} recorded minimum umbel diameter of 5.29cm. Likewise, during 2018 maximum umbel diameter of 6.28 cm was found under T_2 followed byT_1 and T_3 (6.24 and 6.16cm, respectively) and treatment T_{12} recorded minimum umbel diameter of 5.65cm.

In case of spike length of onion two years pooled data presented in Table 1 as influenced by different portion of cut onion bulbs indicated that maximum spike length of 96.67cm was recorded under treatment T_2 followed by T_1 (96.44) which was at par with each other and minimum spike length of 83.40 cm per plant was recorded under treatment T_{12}. From year wise data analysis, it is clear that, in the year 2017, maximum spike length of 96.25cm was noticed under T_1 (whole bulb >100g weight) followed by T_2 (96.19 cm) which were at par with each other and minimum spike length of 78.32 cm was found under T_{12}. On the other hand in 2018, maximum spike length (97.14 cm) was recorded under treatment T_2 followed byT_3 and T_1 (96.72 cm and 96.62 cm, respectively) and minimum spike length of 85.61 cm was associated under T_8. Among the size of the bulb in > 100g weight of bulb, maximum umbel diameter of 6.22cm was found in T_2 followed by T_1 (6.20cm) and T_3 (6.10cm) and minimum of 6.0 cm was recorded in T_4 ($^1/_3$rd longitudinally cut bulb). Similarly, in more than 80-less than100g size of bulb maximum umbel diameter of 6.09 cm was recorded in T_5 followed by $T_6$and T_7 (6.08cm, 6.08cm, respectively) which are at par with each other. In the size of more than 60-80g of onion bulb the same trend was followed. Maximum umbel diameter of 5.95cm was noticed in whole bulb of 60-80g (T_9) and T_{10} followed by T_{11} (5.92cm). In case of spike length per plant, it was recorded maximum (96.67cm) in treatment T_2 followed by T_1 (96.44cm) and T_3 (92.41cm) which were at par with each other's. In more than 80-100g size of bulb maximum spike length of 94.53 cm was associated with T_5 (e.g. whole bulbs >60-80g less than size) followed by T_6 (93.23cm) and minimum was recorded in T_8 (87.19cm). Similarly, in the size of more than 60-80g onion bulb the same trend was followed. In case of year wise data analysis clear variations among the years was observed. It showed better result in 2018 as compared with 2017 irrespective of any treatments.

Number of inflorescences

In case of number of inflorescence per plant (Table 3) the pooled data revealed that maximum 5.67 number of inflorescence was recorded under treatment T_2closely followed by T_1 (5.43) whereas, T_{12}recorded minimum (2.54).The year wise data indicated that maximum numbers of inflorescence were recorded under treatment T_2(5.47) followed by T_1 (5.20) while, minimum in T_{12}(2.42) during 2017. Similarly, in 2018 maximum (5.86) numbers of inflorescence were recorded under treatment T_2followed by T_1 (5.65). However, minimum was observed in T_{12} (2.54).

Yield parameters

Seed weight per umbel, 1000 seed weight per plot and projected seed yield

Two years pooled data presented in Table 3, on yield parameters of onion like seed weight per umbel,1000 seed weight per plot and projected seed yield as influenced by different portion of cut bulbs indicated that, maximum seed weight per umbel (3.14g) was noted under treatment T_2closely followed by T_1 (3.09g) and T_3 (2.96g) . But the minimum seed weight/umbel (1.74g) was recorded under treatment T_{12}. Considering the year wise data, during first year the maximum seed weight / umbel was recorded under T_4(2.79g) followed by T_2 (2.75g) and T_3(2.75g) and minimum under T_{12}(1.73 g). Similarly, in the second year, maximum seed weight per umbel was recorded under treatment T_2(3.53g) closely followed by T_1 (3.48g) and minimum in T_{12}(1.75g). Pooled data presented in the same table on seed weight plot^{-1} reflected that maximum seed weight (320.29g plot^{-1}) was harvested under treatment T $_1$followed by T_2 (319.95g) and minimum in T_{12} (136.17g plot^{-1}).The year wise data analysis clearly indicated that in 2017 maximum seed weight of 284.19g plot^{-1}was recorded in T_2 followed by T_1 (283.86g) and minimum was recorded under treatment T_{12}(126.04g per plot). Similarly in 2018, maximum seed yield (356.71g plot^{-1}) was recorded under treatment T_1 and minimum was noted in T_{12}(146.30g plot^{-1}).In case of projectedseed yield ha^{-1}, pooled data analysis indicated that maximum seed yield of 599.13 kg ha^{-1} was found under treatment T_1followed byT_2 (598.31kg ha^{-1}) while, minimum seed yield of ha^{-1} was recorded under treatment T_{12} (267.14 kg). Year wise data analysis presented in the same table revealed that T_2 recorded maximum seed yield of 569.83 kg ha^{-1} closely followed by T_1 (569.80 kg ha^{-1}) and T_3 (548.82 kg ha^{-1}) and minimum (241.36 kg ha^{-1}) was recorded in T_{12}during 2017. In 2018, maximum seed yield of 628.45 kg ha^{-1}was recorded in T_1closely followed by T_2 (626.78kg ha^{-1}) and minimum (292.92 kgha^{-1}) was recorded under treatment $T_{12.}$

From the above tables it was clear that the productivity or seed yield of onion was in agreement with the growth performance of onion. Equivalent seed yield was recorded between using standard whole bulb of all three sizes (more than 60-80g to more than100g) and its longitudinal ½ cut bulb. Among the three different sizes of bulbs, in year wise onion seed production, it was maximum (0.628 t ha $^{-1}$) during 2018-19 in whole bulb of more than100g weight, followed by T_2 (0.626t ha $^{-1}$) andT_3 (0.588 t ha $^{-1}$) whereas, in 2017-18 it was 0.569 t ha $^{-1}$ recorded by T_1 and T_2, followed by longitudinal½ cut bulb (548.82kg ha $^{-1}$) and the same trend was followed in other size also and the most interesting fact is that among different size of bulbs 1st three treatments like wholebulb, $1/_3$rd circular cut bulb and longitudinally ½ cut bulb were statistically at par with each other. From the 2 years meteorological data presented in Table 1 it was observed that in 2017-18 during reproductive stage maximum temperature was varied between 23.34^{0}C-33.99^{0}C and minimum temperature was 8.09^{0}C-17.36^{0}C and humidity was 69-74% whereas during 2018-19 maximum temperature was varied in between 25.4^{0}C-31.56^{0}C and minimum temperature was ranges between 8.21^{0}C-15.9^{0}C and humidity 71.91-75.14% and this variation in terminal heat condition and humidity may greatly influence the seed development and production. Nikus and Mulugeta, (2010) had reported that temperature ranges between 4.5-14^{o}C with low humidity is favourable for seed stalk formation. Khokhar (2014) also supported the above findings and reported that if this type of temperature prevails for longer periods then each plant will produce more number of flowers in each umbel. Higher temperature prevails long time during flowering season can prevent flowering followed by flower abortion resulted in low seed yield and this was clearly reflected in the year 2017-18 where maximum temperature varied between 23.34^{0}C to 33.99 ^{0}C and humidity 69-74% respectively in comparison with the years 2018-19 where maximum temperature varies in between 25.4- 31.56^{0}C and humidity 71.91 to 75.14% as a result all over vegetative growth of the plants, and seed yield was comparatively low in 2017-18 irrespective of any treatments. On the other hand all three longitudinally 1/3rd cut bulbs of different weights had recorded minimum seed yield irrespective of any year and weight of bulb. Sarnaik *et al*. (1986) reported that in onion seed production, different cut bulbs used as mother seed bulb can influence the seed yield of onion. They also opined that significant variation in seed weight per plant, per plot and per ha under different cutbulb treatments. Half cut bulb recorded maximum seed yield which is at par with the whole bulb yield with the significant reduction of 50% initial bulb cost without any marked loss in the net profit. This is in agreement with the findings of Singh *et al.* (1965). According to Ghosh *et al.* (2018) in seed production of onion longitudinally half cut mother bulb can reduce the mother bulb requirement by 50% and based on economic considerations alone, half cut bulb of 35-40 g weight can be recommended instead of using conventional whole bulb of 70-80g weight as cost saving onion seed production options with a possibility of doubling area. Among the different sizes of bulb yield components and productivity in whole bulbs and longitudinally ½ cut bulb are equivalent. Almost equivalent seed yield recorded in longitudinally ½ cut bulb of any weight as compared with whole bulbs may be due to the removal of dominancy of the apical buds by imposing longitudinal cut which allows auxiliary buds or side buds with better growth and development of more spike and ultimately better seed yield. It was reported by Thimann and Skoog (1934) that apical bud produces plant hormone auxins (IAA) which regulates

Different portion of mother onion bulbs

½ cut bulb

1/3rd cut bulb

1/3rd circular cut bulb

apical dominance by inhibiting the growth of the lateral buds further down on the stem towards the auxiliary bud. The imposition of inhibition of auxins mediated apical dominancy on main bud with longitudinal cut in mother bulb may promote cytokine mediated initiation of more lateral buds. Booker *et al*. (2003) reported that auxins are predominantly produced in the growing shoot apex and diffuses into lateral buds through phloem and prevents elongation. Physiologically, in onion the stem is shortened down to a disc which is often called the basal plate or reduced stem. The leaf bases are attached to the upper surface of the reduced stem and roots arise around the edge. The auxiliary buds or side buds always develop at the node where the leaves attach and in the centre there will be one apical bud or main bud which can grow first due to its better vigour and apical dominancy over auxiliary or side buds. This observation confirms the findings of Razdan (2003) where he had mentioned that the development of auxiliary meristems is inhibited by apical dominance. Burrows (1989) reported that those auxiliary meristems are commonly the source of buds formation in nature especially when the apical shoots are damaged or injured. Singh *et al*.(2011) recorded that in banana macro and micro propagation decapitation and wounding of shoot tips overcome the apical dominance and encourage auxiliary bud proliferation. Hussein (2012) also reported that longitudinally bud splitting technique in banana during tissue culture process increases the number of explants. This is thought to promote buds proliferation by breaking the apical dominance (Wooley and Wareing, 1972).

Economic analysis

In onion seed production, the area coverage of this crop mostly depends on the availability as well as purchasing capacity of this costly propagating material. Here, without compromising the vertical stability, for horizontal expansion different sizes of mother bulb and its portions were utilized to reduce the bulb requirement. Mother bulb is the key cost component in onion seed production ranging from 51-58% alone irrespective of any size (60->100g) followed by labour (32-41%). So, with this mechanical manipulation seed material cost can be reduced. Pooled data analysis (Table 3), clearly reflects that irrespective of any size, net return and BCR were the highest in all longitudinally ½ cut bulb (T_3- Rs. 402862 ha^{-1}, 2.44), (T_7- Rs.321487 ha^{-1} , 2.21) and (T_{11}- Rs.194932 ha^{-1}, 1.77) followed by whole bulb of any size. This is in agreement with the findings of Singh *et al.* (1965) and Sarnaik *et al.* (1986) where they reported that in onion seed production, ½cut bulb recorded maximum seed yield which was at par with the whole bulb yield with the significant reduction of 50% initial bulb cost without any marked loss in the net profit. Ghosh *et al*. (2018) also reported that the mother bulb was the key cost component of onion seed production contributing 70.86% alone followed by labour (18.52%). It was also reported that based on the economic performance longitudinally ½ cut was the best in terms of both net return and BCR (Table 3). In contrast, the lower BCR trend was observed in longitudinally $1/_3{}^{rd}$ cut bulb irrespective of any size which should be noted, however, that the average production costs and economic returns shown in Table 2 and 5 only illustrated the major differences among treatments. Annual price fluctuations are likely to cause significant variation in the economic performance and also varying economic risk.

From the above experiment it is clear that growth, productivity, production cost and net return generally increased with increasing mother bulb size. There is potential for doubling onion seed production area utilizing the presently available mother bulb. It can be concluded that longitudinally ½ cut onion bulb of any size can reduce the mother bulb requirement by 50% and production cost significantly than that of using whole mother bulb and is able to yield almost equivalent quantity of seed with less cost of production as compared with the big whole bulb of 60 to >100g size and may be suggested as suitable mother bulb with reduced cost to be used for large scale onion seed production program.

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