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Influence of direct and staggered sowing of pelleted onion (*Allium cepa*) seeds on various seed yield parameters under Asian mid-hill conditions

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ABSTRACT

The experiment was conducted during 2021–22 and 2022–23 at Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh to study the impact of precision planting (using pelleted seeds) and sowing dates on the numerous attributes of the onion (*Allium cepa* L.) variety Palam Lohit. The study was carried out with the objective to determine whether direct seed sowing would lead to successful seed production in onion under mid-hill conditions (which is not the conventional practice). Also, the staggered sowing dates would help to determine the best sowing time for higher seed production. The experiment was laid in randomized block design (Factorial) (F-RBD) with 3 replications having 19 treatments, including 3 pelleting treatments, viz. P_1 (wood ash); P_2 ($ZnSO_4$ + wood ash); and P_3 (H_3BO_3 + wood ash); 6 sowing dates, viz. D_1 (15th September); D_2 (1st October); D_3 (15th October); D_4 (1st November); D_5 (15th November); and D_6 (1st December); and D_a (traditional bulb planting as control). The study revealed that seed pelleting with $ZnSO_4$ + wood ash and early sowing (15th September) gave best results in terms of emergence (%), plant height, number of seeds/umbel and number of seeds/plant, seed yield and 1000-seed weight. The direct sowing treatments produced seeds in one year as opposed to two years using the conventional bulb planting method, which is traditionally being used in the Asian mid-hills.

Keywords: Direct sowing, Onion, Pelleting, Seed yield, Staggered sowing

The importance of vegetables in boosting the nation's economy and promoting both human health and nutritional security is widely known. Onion (*Allium cepa* L.), one of the most important commercial vegetable crops, is grown and consumed all over the world. It is a member of the Amaryllidaceae family and has its origins in Central Asia. It is a cool-season, monophyletic, cross-pollinated, monocot vegetable crop (Pal *et al.* 2023).

The fact that seeds are not only the most fundamental but also the most significant component of agriculture is well acknowledged. High-quality seeds set the stage for successful performance as the plants grow. Although seed deterioration is unavoidable, permanent, and irreparable, various seed augmentation techniques, such as seed treatment, coating, or pelleting, may be able to reduce the rate of deterioration (Shashibhaskar *et al.* 2009). Seed pelleting entails encapsulating a seed in a very little amount of inert material to create globular units of standardized size from the irregularly shaped seeds along with cutting down on the extra time needed to raise seedlings as these pellets can be placed straight in the field. In crops like onion and carrot, the seed rate can considerably be reduced and operations like thinning and gap filling can be eliminated totally by use of pelleted seeds provided the seed is of high quality (Yogeesha *et al.* 2017).

There has been extensive research and reporting in the literature regarding the time of onion seed sowing for nursery growth and subsequent transplanting. However, there aren't many recommendations available about when to sow onion crops through direct sowing of seeds. A variety of production problems, such as early bolting and delayed harvesting, which may result in loss of yield and quality, can be avoided by choosing the planting season after accounting for all the variables (Panwar *et al.* 2021). Additionally, the onion crop is biennial in nature. However, it might be possible to switch from a biennial to an annual seed production cycle through direct seed planting of pelleted seeds on particular sowing dates. Therefore, an experiment was planned to study the impact of direct and staggered sowing of pelleted onion seeds on seed yield parameters under Asian mid-hill conditions.

MATERIALS AND METHODS

An experiment was conducted during 2021–22 and 2022–23 at Dr. Y S Parmar University of Horticulture and Forestry, Nauni (30° 50' 45" latitude and 77° 88' 33" longitude at an elevation of 1250 m amsl), Solan, Himachal

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Pradesh. The experiment was laid out in randomized block design (Factorial) (F-RBD), replicated thrice. The cultivar used was Palam Lohit. There were 19 treatments which included 3 seed pelleting treatments, viz. P_1 (wood ash); P_2 ($ZnSO_4$ + wood ash); and P_3 (H_3BO_3 + wood ash); 6 sowing dates, viz. D_1 (15th September); D_2 (1st October); D_3 (15th October); D_4 (1st November); D_5 (15th November); and D_6 (1st December); and D_a (traditional bulb planting as control). The micronutrients ($ZnSO_4$ and H_3BO_3) were used in powdered form @300 mg/kg of seeds and wood ash was used @3000 g/kg of seeds. Carboxy methyl cellulose @1% was used as adhesive for all the pelleting treatments. The plot size for all the replications was 2 m × 1 m. The seeds were pelleted, dried and planted in the field at a spacing of 15 cm × 10 cm whereas, the bulbs were planted at a spacing of 45 cm × 45 cm.

Observations recorded

Emergence (%): Both pelleted seeds and bulbs were manually planted in a raised seed bed that had been well-prepared, and the soil was kept at the ideal moisture level for emergence. Following seeding, the quantity of seedlings that emerged above the soil surface was counted and converted to a percentage that represented the total field emergence.

Plant height (cm): Plant height was measured from the soil line to the main axis' tip (or the umbel's tip in the case of flowering plants), and the mean height was expressed in centimeters (cm).

Bolting (%): The total number of plants with floral umbels in each replication and treatment were tallied and expressed as a percentage.

Number of seeds/umbel: The total numbers of seeds were counted from 10 umbels of randomly selected plants, and average value was calculated to determine the number of seeds per umbel in each replication of the treatment combination.

Number of seeds/plant: To determine the number of seeds per plant in each replication of the treatment combination, the total number of seeds from 5 randomly selected plants were counted, and the average value was calculated.

Seed yield/plant (g): The ripe seeds were harvested from 5 randomly taken plants. The seeds were then dried up to 8% moisture content, weighed and averaged to work out seed yield per plant. The moisture content of seeds was worked out by using digital moisture meter.

Seed yield/ha (kg): Seed yield/plot was worked out from seed yield/plant.

$$\text{Seed yield (g/plot)} = \text{Seed yield (g/plant)} \times \text{Number of surviving plants}$$

$$\text{Seed yield (g/m}^2\text{)} = \frac{\text{Seed yield/plot (g)}}{\text{Size of the plot (/m}^2\text{)}}$$

Then, seed yield/ha was worked out on the basis of seed yield/m^2:

$$\text{Seed yield (kg/ha)} = \frac{\text{Seed yield (g/m}^2\text{)} \times 10000 \times 0.80}{1000}$$

While calculating the seed yield/ha 20% was considered as depreciation for construction of channels in the experimental field.

1000-seed weight (g): The observation was made by weighing 1000-dried seeds drawn randomly from each treatment using an electronic balance. The seed counter was used for this purpose.

Statistical analysis: All the parameters were statistically analyzed with the standard procedure as suggested by Gomez and Gomez (1984). The level of significance for different variables was tested at 5% value of significance.

RESULTS AND DISCUSSION

Emergence of onion: The bulb planting had the highest emergence rate (Table 1). The low rate of onion seed germination may be responsible for the low emergence in case of direct seed sowing treatment. On the other hand, the bulbs resumed growth after planting, which resulted in a higher emergence (%). Among the pelleting treatments, $ZnSO_4$ + wood ash had the highest emergence rate whereas, in H_3BO_3 + wood ash, the lowest emergence rate was observed. The fact that zinc sulphate preserves the structural integrity and protects cells from the harms caused by reactive oxygen species may be the source of the increased emergence brought on by pelleting with zinc sulphate and wood ash (Cackmak 2000). Additionally, only zinc is a metal that is present in all six categories of enzymes (oxydoreductases, transferases, hydrolases, lyases, isomerases, and ligases). These enzymes are in charge of releasing the seed's food stores, which may have finally caused the seed to germinate (Broadley *et al.* 2007). Since zinc is a component of many proteins, it is also essential for cellular metabolism (Hall 2002). In case of sowing dates, maximum emergence was seen in seeds sown on 15th September whereas, the lowest rate of emergence was recorded in 1st December seed sowing. Higher emergence (%) in earlier sowing dates could be as a result of the growth conditions being more favourable at the initial planting dates as opposed to the latter ones. These findings are in agreement with those of Panwar *et al.* (2021) who observed that earlier sowing resulted in higher emergence in onion.

Growth attributes of onion: The tallest plants were produced by the bulb planting technique (Table 1). This may be because, despite the fact that the plants from the first two sowing dates in case of direct seed sowing were relatively tall, those from the subsequent four treatments were shorter, which decreased the total mean and caused it to drop below the mean of the bulb planting treatment. Also, the fact that bulbs store food reserves and provide them to the plants as and when they grow may have led to an increased growth in plants grown from bulbs. In case of pelleting treatments, $ZnSO_4$ + wood ash had the tallest plants on record. Plants of the treatment H_3BO_3 + wood ash had the lowest height. Taller plants could occur as a result of zinc's involvement in a number of structural and catalytic processes that support plant development and other physiological functions. The synthesis of proteins,

Table 1 Effect of pelleting, sowing dates and direct seed sowing on emergence, growth and seed yield parameters of onion cv. Palam Lohit (Pooled mean: 2021–22 and 2022–23)

	Emergence (%)	Plant height (cm)	Bolting (%)	No. of seeds/umbel	No. of seeds/plant	Seed yield (g/plant)	Seed yield (kg/ha)	1000-seed weight (g)
P_1	77.33 (62.04)	58.98	40.89[b] (39.37)	705.46	705.46	2.24	633.92	3.15
P_2	78.78[a] (63.14)	62.89[a]	41.36[a] (39.69)	721.37[a]	721.37[a]	2.43[a]	687.68[a]	3.31[a]
P_3	73.72 (59.56)	54.88	38.73 (37.83)	689.58	689.58	2.12	592.37	3.01
CD (*P*=0.05)	0.66	0.50	0.47	1.16	1.24	0.02	9.24	0.02
D_1	87.50[a] (69.43)	93.42[a]	100.00[a] (90.00)	861.28[a]	861.28[a]	3.13[a]	1244.20[a]	3.69[a]
D_2	85.72 (67.93)	89.97	100.00[a] (90.00)	837.61	837.61	2.86	1132.08	3.45
D_3	80.89 (64.17)	60.23	26.70 (30.94)	685.22	685.22	1.98	139.17	2.93
D_4	75.22 (60.20)	46.01	15.28 (22.84)	437.77	437.77	1.09	36.52	2.57
D_5	68.11 (55.64)	34.27	0.00 (0.00)	--	--	--	--	--
D_6	62.22 (52.09)	29.62	0.00 (0.00)	--	--	--	--	--
CD (*P*=0.05)	0.94	0.71	0.67	1.34	1.44	0.03	10.67	0.02
DS	76.61 (61.58)	58.92	40.33 (38.96)	705.47	5660.80[a]	2.26	637.99[a]	3.16[a]
D_a	100.00[a] (90.00)	83.55[a]	100.00[a] (90.00)	948.80[a]	948.80	17.46[a]	605.37	3.10
CD (*P*=0.05)	1.18	0.90	0.84	1.70	1.83	0.03	13.60	0.02

Figures in parenthesis represent angular transformation; [a] represents significant values in the parameter; [b] represents values statistically at par with the significant value for that parameter; DS, Direct sowing. Treatment details are given under Materials and Methods.

the production of chlorophyll, and the production of growth hormones like auxin in plants are just a few of the critical growth processes that zinc stimulates. These activities all result in an increase in growth and plant height (Broadley *et al.* 2007). These results are consistent with those of Choudhary *et al.* (2023) who found that application of zinc resulted in significantly higher plant height in onion. Masuthi *et al.* (2009) also reported that cowpea plants grew to their maximum height when seeds were pelleted with $ZnSO_4$ + Borax + *Arappu* leaf powder. In addition, Manjunath *et al.* (2009) found that seed pelleting with $ZnSO_4$ + captan + imidacloprid produced the tallest paprika plants. Sowing seeds on 15th September reported the highest plant height, while seeds sown on 1st December produced plants with the lowest height. The earlier sowing may have given plants ample time to complete their juvenile or vegetative phase under better climatic conditions, resulting in taller plants. These findings concur with those made by Kumar *et al.* (2015), who found that planting earlier (15th October) led to a rise in scape height.

Bulb planting saw the highest bolting whereas, direct sowing had the lowest bolting rate (Table 1). This may be explained by the fact that, despite 100% bolting on the first two sowing dates, there was less bolting on the following two sowing dates, and there was no bolting on the final two sowing dates, which decreased the overall mean of the factorial treatments and made it lesser than the bulb planting treatment. Among the pelleting treatments, maximum bolting was observed in pelleting with $ZnSO_4$ + wood ash. The least amount of bolting was seen in H_3BO_3 + wood ash. Zinc plays a crucial role in the growth and development of plants by taking part in their structural and catalytic processes. In addition, zinc sulphate promotes increased photosynthetic activity, which in turn causes the production of hormones that influence floral behaviour and actively participate in a variety of physiological and biochemical processes in plants. Therefore, zinc sulphate may have resulted in higher bolting. Seeds sown on 15th September and 1st October produced plants that had maximum bolting (%). Minimum bolting, besides no or 0.00% case of 15th November and 1st December sowing, was recorded in plants produced from seeds sown on 1st November. The earlier sowing allowed the plants to mature and enter the reproductive phase in the ideal environment, whereas later planting prevented the plants from maturing and, as a result, prevented them from producing flowers. These findings are in line with those of Khokhar (2008), who found that late planting reduced the onion crop's bolting per cent. Since the last two sowing dates15th November and 1st December, did not bolt and produce blooms, they were excluded from the study of any of the ensuing factors.

Seed yield attributes of onion: Bulb planting produced the maximum number of seeds /umbel and number of seeds/ plant, which was significantly more than the direct sowing treatment (Table 1). This may be attributed to the fact that the bulbs in bulb planting treatment had a higher reserve of food materials resulting in production of multiple (5–7) and much larger umbels whereas, the direct sown treatments produced a single and smaller umbel. Seed pelleting had a substantial impact on the number of seeds/umbel (Table 1). Pelleting of seeds with $ZnSO_4$ + wood ash resulted in highest number of seeds/umbel as well as number of seeds/plant whereas, H_3BO_3 + wood ash reported the lowest number of seeds/umbel and seeds/plant. Zinc is involved in the synthesis of sugar and aids in the efficient translocation of this sugar for the formation and development of seeds, which may explain the increased number of seeds per umbel and per plant in the case of seeds pelleted with zinc sulphate. These findings concur with those made by Kumar *et al.* (2013), who found that sesame seed pelleting using $ZnSO_4$ produced maximum number of seeds per capsule. Similar to this, Manjunath *et al.* (2009) found that seed pelleting with $ZnSO_4$ + captan + imidacloprid increased the number of seeds/plant in the instance of paprika. The plants of 15th September seed sowing had the highest number of seeds/ umbel and number of seeds/plant. In case of seed sowing on 1st November, the lowest number of seeds per umbel and per plant were noted. The fact that the plants had plenty of time to finish their vegetative phase in an appropriate environment before entering the reproductive phase may be the reason for the increased number of seeds per umbel and per plant in early seed sowing. In addition, compared to plants with later sowing dates, these plants also generated larger umbels.

Bulb planting recorded the highest seed yield/plant (Table 1). However, the seed yield/ha was higher in case of direct seed sowing. Higher seed yield/plant in case of bulb planting could be explained by the fact that this treatment led to a higher number of umbels/plant well as number of seeds/plant. But the number of plants/ha were substantially larger in direct sowing treatment (due to different spacing) and although the number of umbels and seeds per plant were higher in bulb planting, the number of seeds/ha were much higher in case of direct sowing treatments. Among the pelleting treatments, $ZnSO_4$ + wood ash had the highest seed yield per plant and per ha. The least seed yield per plant and per hectare was recorded in case of H_3BO_3 + wood ash. The higher number of seeds per umbel and per plant may be responsible for the higher seed yield of plants grown from seeds pelleted with zinc sulphate. Zinc is essential for auxin metabolism, which plays a key role in seed growth and development. Zinc is necessary for the second stage of seed development because it increases the amount of auxin needed for seed growth. These findings concur with those of Manjunath *et al.* (2009) who found that seed pelleting with $ZnSO_4$ + captan + imidacloprid increased paprika's seed yield. Similar to this, Shashibhaskar *et al.* (2009) found that seeds pelleted with zinc sulphate produced plants with increased seed yields. Kumar *et al.* (2013) found similar outcomes in sesame. Sowing dates had a substantial impact on the seed yield per plant and per hectare. The seeds sown on 15th September produced plants that had the highest seed yield per plant as well as per hectare. In 1st November seed sowing, the lowest seed yield per plant and per hectare was noted. The fact that there were more seeds per plant and per umbel in early sowing compared to the latter ones may be the cause of the higher seed production. These results are consistent with those of Kumar *et al.* (2015), who found that earlier planting increased onion seed yield.

Maximum 1000-seed weight was observed in direct sowing treatment. This could be explained by the fact that the direct seeded plants may have had better photosynthetic activity, which resulted in higher photosynthate accumulation and efficient translocation of these photosynthates from source to sink, leading to good quality seeds having larger test weights. Additionally, in direct sowing treatments, there was only one umbel per plant, and all of the reserve food was made available to it. This allowed for the development of bolder seeds, whereas in bulb planting, there were 6–7 umbels/plant, and the reserve food had to be divided among them. The pelleting of seeds with $ZnSO_4$ + wood ash resulted in highest 1000-seed weight whereas, the treatment H_3BO_3 + wood ash reported the lowest 1000-seed weight. Zinc promotes better sugar production and accumulation, which may have resulted in bold seeds with higher test weights. It was discovered in an experiment by Manjunath *et al.* (2009) that paprika seeds pelleted with $ZnSO_4$ + captan + imidacloprid produced seeds with much higher 1000-seed weight. These results are in accordance with Shashibhaskar *et al.* (2009), who discovered that seed pelleting with zinc sulphate produced seeds with the highest test weight. Sowing on 15th September led to production of seeds with maximum 1000-seed weight, whereas it was minimum in case of 1st November sowing. The fact that earlier seeding allowed the plants to accumulate more carbohydrates, aiding in the generation of seeds with increased boldness may have contributed to higher 1000-seed weight (g) in case of plants of earlier sowing date.

Interaction effect of pelleting and sowing dates: Emergence, growth and seed yield attributes were impacted significantly by the interaction of pelleting and sowing dates (Table 2). Seed pelleting with $ZnSO_4$ + wood ash and sowing on 15th September resulted in maximum emergence and led to significantly higher values of all the growth and seed yield attributes, namely, plant height, bolting, number of seeds per umbel and per plant, seed yield per plant and per hectare as well as 1000-seed weight.

Table 2 Interaction effect of pelleting and sowing dates on emergence, growth and seed yield parameters of onion cv. Palam Lohit (Pooled mean: 2021–22 and 2022–23)

	Emergence (%)	Plant height (cm)	Bolting (%)	No. of seeds/ umbel	No. of seeds/ plant	Seed yield (g/ plant)	Seed yield (kg/ha)	1000-seed weight (g)
P_1D_1	87.67 (69.50)	92.93	100.00* (90.00)	858.05	858.05	3.05	1220.05	3.65
P_2D_1	90.17 (71.78)	97.13*	100.00* (90.00)	877.02*	877.02*	3.40*	1350.93*	3.89*
P_3D_1	84.67 (67.02)	90.20	100.00* (90.00)	848.77	848.77	2.93	1161.60	3.52
P_1D_2	86.50 (68.50)	89.73	100.00* (90.00)	836.07	836.07	2.85	1128.48	3.45
P_2D_2	87.50 (69.46)	93.88	100.00* (90.00)	852.77	852.77	3.00	1189.32	3.56
P_3D_2	83.17 (65.85)	86.28	100.00* (90.00)	823.98	823.98	2.72	1078.43	3.34
P_1D_3	81.67 (64.70)	62.47	29.17 (32.59)	687.13	687.13	1.97	149.54	2.94
P_2D_3	82.83 (65.57)	65.80	30.56 (33.45)	697.70	697.70	2.16	166.80	3.14
P_3D_3	78.17 (62.23)	52.43	20.37 (26.78)	670.83	670.83	1.80	101.16	2.72
P_1D_4	75.67 (60.51)	45.70	16.20 (23.64)	440.60	440.60	1.09	37.61	2.57
P_2D_4	77.00 (61.37)	49.70	17.59 (24.72)	457.98	457.98	1.17	43.68	2.65
P_3D_4	73.00 (58.71)	42.62	12.04 (20.18)	414.73	414.73	1.01	28.27	2.48
P_1D_5	69.17 (56.28)	34.05	0.00 (0.00)	--	--	--	--	--
P_2D_5	70.33 (57.00)	38.48	0.00 (0.00)	--	--	--	--	--
P_3D_5	64.83 (53.64)	30.27	0.00 (0.00)	--	--	--	--	--
P_1D_6	63.33 (52.74)	29.02	0.00 (0.00)	--	--	--	--	--
P_2D_6	64.83 (53.63)	32.37	0.00 (0.00)	--	--	--	--	--
P_3D_6	58.50 (49.90)	27.48	0.00 (0.00)	--	--	--	--	--
CD (*P*=0.05)	NS	1.24	1.16	2.31	2.49	0.05	18.48	0.03

Figures in parenthesis represent angular transformation; * represents, Significant values in the parameter. Treatment details are given under Materials and Methods.

The present study showed that seed pelleting with $ZnSO_4$ + wood ash and sowing on 15th September resulted in improving various plant attributes namely, emergence (%); plant height; number of seeds/umbel and number of seeds/ plant; seed yield and 1000-seed weight of onion cv. Palam Lohit. This treatment also resulted in production of seeds in one year as opposed to the traditional seed production cycle which is biennial in nature. Therefore, seed pelleting with $ZnSO_4$ + wood ash and sowing on 15th September may be used for annual seed production in onion cv. Palam Lohit after multilocation testing.

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