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EFFECT OF PLANTING GEOMETRY AND PACLOBUTRAZOL ON GROWTH AND YIELD OF ONION (*Allium cepa* L.)

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ABSTRACT

The present investigation was conducted to evaluate the influence of planting geometry and paclobutrazol on the growth, seed yield and economic performance of onion (*Allium cepa* L.) under semi-arid conditions. The experiment was carried out during the *Rabi season* of 2024-25 at the Horticulture Agricultural Research Farm of Nirwan University, Jaipur, Rajasthan using a Factorial Randomized Block Design with three replications. Twelve treatment combinations consisting of three planting geometries (45 × 15 cm, 45 × 30 cm, and 45 × 45 cm) and four paclobutrazol levels (control, 250 ppm, 500 ppm and 750 ppm) were evaluated. Results revealed that wider spacing significantly enhanced vegetative growth, reproductive traits, seed yield and seed quality. The planting geometry of 45 × 45 cm produced the tallest plants, higher number of leaves, delayed bolting and superior seed yield. Paclobutrazol application further improved yield attributes with 750 ppm recording the highest seed yield and economic returns. The combined effect of wider spacing and higher paclobutrazol concentration demonstrated a synergistic advantage by reducing inter-plant competition and improving assimilate partitioning toward reproductive structures. Economic analysis confirmed that this treatment combination generated the maximum net return and benefit-cost ratio. The study concludes that optimizing planting geometry along with appropriate paclobutrazol application can significantly enhance onion seed productivity, quality and profitability.

Key words : Onion seed production, Planting geometry, Paclobutrazol, Seed yield, Growth regulator, Spacing, Economic returns, *Allium cepa*.

Introduction

Onion belongs to the Amaryllidaceae family and is widely recognized for its culinary importance, nutritional value, and medicinal properties. Its characteristic flavor is mainly attributed to sulfur-containing compounds such as allyl propyl disulfide, while its antioxidant and antimicrobial potential is linked to flavonoids and organosulfur compounds (Nissa *et al.*, 2026; Dantas *et al.*, 2025). In addition to its dietary benefits, onion cultivation supports global food security and provides income to millions of farmers, emphasizing the need for sustainable productivity enhancement (Agsure, 2025). Globally, onion is cultivated in more than 170 countries, with China and India leading production. Recent estimates indicate that global production has reached approximately 106 million metric tonnes from about 5.5 million hectares (Thombare *et al.*, 2026). India ranks second in production but first in cultivated area, producing around 242.15 lakh tonnes during the 2023-24 financial year (APEDA, 2024). This extensive production base also supports exports, with about 2.60 lakh tonnes exported during the early months of the 2024-25 financial year (PIB, 2024).

Within India, major onion-producing states include Maharashtra, Madhya Pradesh, Karnataka, and Gujarat, forming the backbone of the national supply chain (Dataful, 2025). Rajasthan has recently emerged as a

rapidly growing contributor, particularly during the rabi season. The state recorded an estimated production of 1,716.10 thousand metric tonnes from 100.16 thousand hectares, largely due to improved irrigation facilities and adoption of superior varieties (CEIC, 2025; Singh *et al*., 2025). However, the arid and semi-arid climate of Rajasthan presents unique challenges, making the optimization of agronomic practices essential for consistent yield and quality.

The manuscript should emphasize the importance of agronomic management in improving onion productivity. Crop performance is influenced by a complex interaction of genetic potential, environmental conditions and cultivation practices. Among these, bulb size, planting geometry, and the application of plant growth regulators represent three critical factors that require integrated evaluation (Ashrafuzzaman *et al*., 2025).

Planting geometry is another essential non-monetary input that regulates inter-plant competition and resource utilization. Proper spacing allows plants to efficiently capture sunlight, water, and nutrients, thereby improving growth performance (Gelaye, 2024). Inadequate spacing often results in leaf etiolation, reduced light interception, and smaller bulbs (Jamkar, 2018). Although, closer spacing increases plant population and total yield per hectare, it may reduce individual bulb size and encourage disease due to poor air circulation (Sureshrao, 2018). Conversely, wider spacing promotes the development of larger and higher-quality bulbs but may underutilize available land. Hence, optimizing spacing is a strategic decision that balances total yield with market-preferred bulb size.

The manuscript should also address the role of plant growth regulators, particularly paclobutrazol (PBZ), in modifying plant architecture and improving yield. Paclobutrazol is a triazole compound that inhibits gibberellin biosynthesis, thereby reducing excessive vegetative growth (Kamboj, 2016). Treated plants tend to be shorter, with thicker leaves and stronger root systems, reducing lodging risks and improving harvest efficiency (Nissa *et al*., 2026). Moreover, PBZ promotes assimilate partitioning toward bulb development, potentially enhancing bulb weight and dry matter content (Mudhalifah, 2025). Additional benefits include improved chlorophyll content, better water-use efficiency, and increased tolerance to environmental stresses. However, determining the appropriate dosage is essential because excessive application may suppress growth and reduce yield.

Materials and Methods

The present investigation was conducted to evaluate the combined effects of bulb size, planting geometry and paclobutrazol application on the growth, seed yield and economic returns of onion. The experiment aimed to determine the optimum planting configuration and growth regulator dose for maximizing productivity under the prevailing agro-climatic conditions**.** The field experiment was carried out during the *Rabi* season of 2024-25 at the Horticulture Research Farm of Nirwan University, Jaipur. The site is located approximately 30 km from Jaipur at 26°55' N latitude and 76°02' E longitude, with an elevation of about 395 m above mean sea level. The region receives an average annual rainfall of nearly 1073 mm, with around 80% occurring during the southwest monsoon (July-September). The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three replications. A total of 12 treatment combinations were evaluated, consisting of three planting geometries (45 × 15 cm, 45 × 30 cm, and 45 × 45 cm) and four growth retardant treatments: control, paclobutrazol 250 ppm, paclobutrazol 500 ppm and paclobutrazol 750 ppm. The onion variety 'NHRDF Red-4' was used for the study.

Land preparation, Planting and Nutrient management

The field was prepared by one deep ploughing followed by three harrowings to achieve a fine tilth. Crop residues and weeds were removed and the land was leveled to ensure uniform irrigation. Well-stored onion bulbs were planted manually at the prescribed spacings and light irrigation was applied immediately after planting to promote proper establishment. Well-decomposed farmyard manure was incorporated into the soil at 250 q ha^{-1} during land preparation. Phosphorus and potassium were applied as basal doses through single superphosphate and muriate of potash, respectively, while nitrogen was supplied in three equal split applications at different growth stages. Standard plant protection measures were adopted, including the application of imidacloprid and fipronil to control insect pests, and prophylactic sprays of difenoconazole and chlorothalonil to manage fungal diseases.

Observations recorded and Economic and Statistical analysis

Growth parameters such as plant height, number of leaves, seed scapes per plant, and bolting behaviour were recorded from randomly selected plants at different stages. Yield attributes including umbel diameter, number of umbellets, thousand-seed weight, seed yield per plant, seed yield per plot and seed yield per hectare were measured at maturity. Economic evaluation involved calculating cost of cultivation, gross return, net return,

and benefit-cost ratio for each treatment. Data were statistically analyzed using analysis of variance (ANOVA) and treatment differences were tested using the F-test at a 5% level of significance. Critical differences were computed to compare treatment means.

Results and Discussion

Effect of spacing and paclobutrazol on plant height

Plant height of onion increased progressively from 30 DAP to harvest under all spacing and paclobutrazol treatments (Table 1). Among spacing treatments, S3 recorded the maximum plant height at all growth stages (23.18 cm at 30 DAP, 49.63 cm at 60 DAP and 56.91 cm at harvest), followed by S2, while S1 consistently showed the lowest values. With respect to growth retardants, G4 resulted in significantly higher plant height at all stages, registering 24.17 cm at 30 DAP and 57.54 cm at harvest, whereas G1 recorded the minimum plant height. These effects are likewise consistent with findings of (Miyazaki *et al.*, 2025; Illo *et al.*, 2025).

Effect of spacing and paclobutrazol on number of leaves per plant

The number of leaves per plant increased progressively from 30 DAP to harvest under all spacing and paclobutrazol treatments (Table 2). Among spacing treatments, S3 recorded the highest number of leaves at 30 and 60 DAP (21.87 and 26.38, respectively), while S2 produced the maximum number of leaves at harvest (33.72). S1 consistently recorded the lowest values. Regarding growth retardants, G4 resulted in the maximum number of leaves at all stages, particularly at harvest

Table 1 : Effect of spacing and paclobutrazol levels on plant height (cm) of onion at various days.

Symbol	30 DAP	60 DAP	At harvest
S1	18.42	40.85	48.26
S2	20.96	44.92	53.74
S3	23.18	49.63	56.91
S.Em ±	0.46	1.12	1.36
CD (P=0.05)	1.34	3.28	3.98
Growth retardants			
G1	19.12	43.68	47.11
G2	20.63	45.96	51.64
G3	21.72	47.84	54.71
G4	24.17	48.07	57.54
S.Em ±	0.53	1.29	1.57
CD (P=0.05)	1.55	3.79	4.60
S.Em ±	0.92	2.24	2.72
CD (P=0.05)	NS	NS	NS

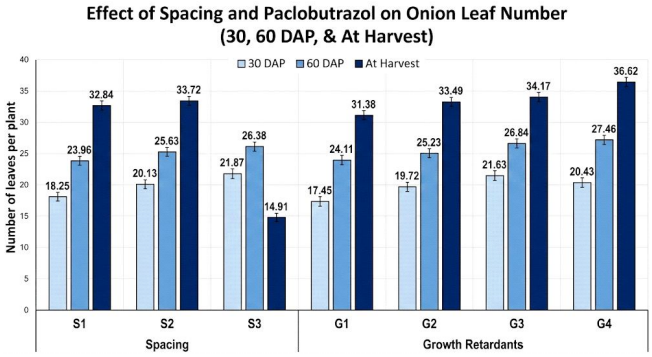


Fig. 1 : Effect of spacing and paclobutrazol levels on plant height (cm) of onion at various days.

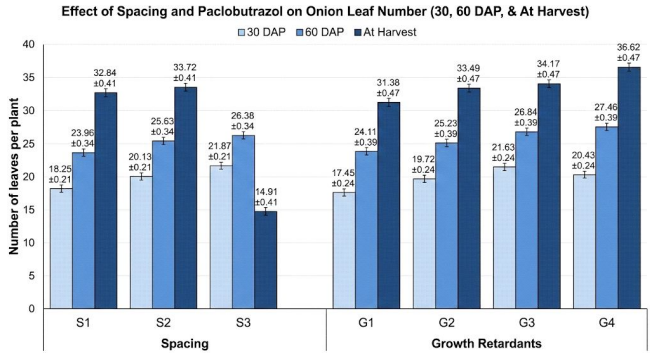


Fig. 2 : Effect of spacing and paclobutrazol levels on number of leaves per plant 30, 60 and 90 days of planting in onion.

(36.62), whereas G1 showed the minimum. Differences were statistically significant as indicated by S.Em and C.D values. The results are in agreement with in onion (Nissa *et al.*, 2026; Dantas *et al.*, 2025).

Effect of paclobutrazol and planting density on economics of seed production in onion

The economics of onion seed production were markedly influenced by planting density and paclobutrazol application, as presented in Table 3. Among spacing treatments, **S1** (45 × 15 cm) recorded a seed yield of 568.32 kg ha^{-1} with a cost of cultivation of ` 2,90,000 ha$^{-1}$, resulting in a gross return of ` 4,54,656 ha^{-1} and a net return of ` 1,64,656 ha$^{-1}$. The corresponding benefit-cost (B:C) ratio was 1.57. S2 (45 × 30 cm) produced a higher seed yield (590.68 kg ha$^{-1}$) with a slightly reduced cost of cultivation (` 2,85,000 ha^{-1}), leading to improved gross (` 4,72,544 ha$^{-1}$) and net returns (` 1,87,544 ha^{-1}) and a B:C ratio of 1.66. The widest spacing, S3 (45 × 45 cm), recorded the highest seed yield among spacing treatments (612.90 kg ha^{-1}) along with the lowest cost of cultivation (` 2,80,000 ha$^{-1}$). Consequently, this treatment resulted in the maximum net return (` 2,10,320 ha^{-1}) and the highest B:C ratio (1.75) among spacing levels. The improved economic performance under wider spacing may be attributed to reduced transplanting cost, lower

Table 2 : Effect of spacing and paclobutrazol levels on number of leaves per plant 30, 60 and 90 days of planting in onion.

Symbol	30 DAP	60 DAP	At harvest
S1	18.25	23.96	32.84
S2	20.13	25.63	33.72
S3	21.87	26.38	14.91
S.Em±	0.21	0.34	0.41
CD (P=0.05)	0.62	1.01	1.20
Growth retardants			
G1	17.45	24.11	31.38
G2	19.72	25.23	33.49
G3	21.63	26.84	34.17
G4	20.43	27.46	36.62
S.Em±	0.24	0.39	0.47
CD (P=0.05)	0.70	1.15	1.38
S.Em±	0.29	0.338	0.857
CD (P=0.05)	0.863	0.997	1.726

inter-plant competition, and better seed development.

With respect to growth regulator treatments, the control (G1) recorded the lowest seed yield (558.25 kg ha^{-1}) and net return (` 1,61,600 ha$^{-1}$), with a B:C ratio of 1.57. Application of paclobutrazol significantly enhanced economic returns. Paclobutrazol 250 ppm (G2) produced a seed yield of 611.63 kg ha$^{-1}$ and a net return of ` 2,02,304 ha^{-1}, resulting in a B:C ratio of 1.71. Further increase in paclobutrazol dose to 500 ppm (G3) improved seed yield to 650.93 kg ha^{-1} and net return to ` 2,32,244 ha$^{-1}$, with a B:C ratio of 1.80. The highest economic benefit was obtained with paclobutrazol 750 ppm (G4), which recorded the maximum seed yield (663.06 kg ha$^{-1}$), highest gross return (` 5,30,448 ha^{-1}), and net return (` 2,40,448 ha^{-1}), along with the highest B:C ratio (1.83). Overall, the results clearly indicate that wider spacing (S3) and higher paclobutrazol dose (G4) were economically superior for onion seed production. The differences among treatments were statistically significant at the 5 per cent level. These findings are consistent with those reported (Nissa *et al.*, 2026; Dantas *et al.*, 2025), who concluded that closer spacing led to the highest seed yield.

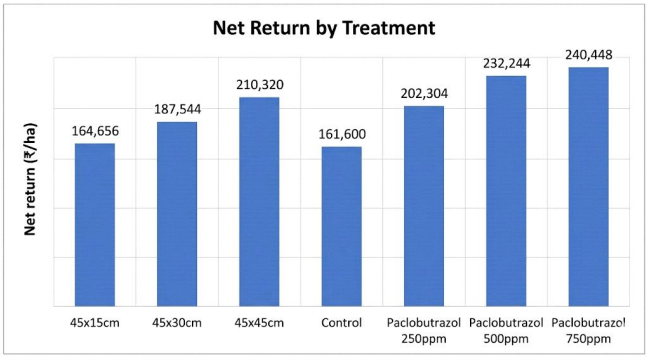


Fig. 3 : Effect of paclobutrazol and planting density on net return (Rs).

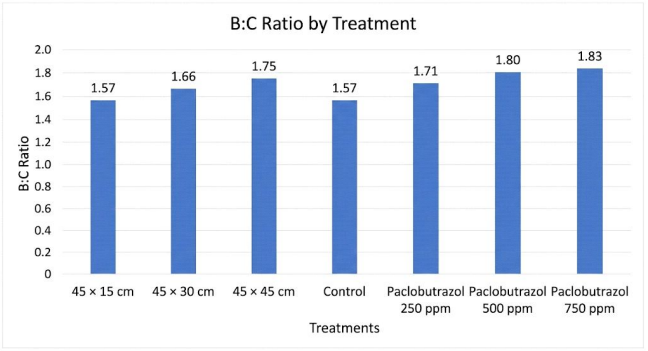


Fig. 4 : Effect of paclobutrazol and planting density on B:C ratio.

Table 3 : Effect of paclobutrazol and planting density on economics of seeds production in onion.

Treatments	Seed yield (kg/ha)	Cost of cultivation (` /ha)	Gross return (` /ha)	Net return (` /ha)	B:C ratio
45 × 15 cm	568.32	290,000	454,656	164,656	1.57
45 × 30 cm	590.68	285,000	472,544	187,544	1.66
45 × 45 cm	612.90	280,000	490,320	210,320	1.75
Control	558.25	285,000	446,600	161,600	1.57
Paclobutrazol 250 ppm	611.63	287,000	489,304	202,304	1.71
Paclobutrazol 500 ppm	650.93	288,500	520,744	232,244	1.80
Paclobutrazol 750 ppm	663.06	290,000	530,448	240,448	1.83

Conclusion

The findings of the present study demonstrate that planting geometry and paclobutrazol application play a crucial role in regulating growth, seed yield, seed quality, and economic returns of onion. Wider spacing (45 × 45 cm) proved superior in promoting vegetative growth, improving reproductive characteristics and enhancing seed yield due to reduced competition and better resource utilization. Paclobutrazol effectively regulated plant growth and increased reproductive efficiency, with the 750-ppm

treatment producing the highest yield and economic benefits. The interaction between wider spacing and higher paclobutrazol concentration showed a synergistic effect, resulting in improved seed weight, delayed bolting, and greater profitability. Based on these results, planting onion at 45 × 45 cm combined with paclobutrazol application at 750 ppm can be recommended as an efficient and economically viable practice for onion seed production under semi-arid agro-climatic conditions. These findings provide a scientific basis for developing integrated agronomic strategies aimed at improving productivity and farm income.

References

Agsure (2025). Onion Market Trends and Key Insights 2025. https://www.agsure.in/blog/our-blog-1/onion-market-insights-27

APEDA (2024). Fresh onions: Export statistics and major producing states. https://apeda.gov.in/FreshOnions

Ashrafuzzaman, M., Millat M.N., Ismail M.R. and Shahidullah S.M. (2025). Influence of paclobutrazol and bulb sizes on seed yield and yield attributing traits of onion (*Allium cepa* L.) cv Taherpuri. *Arch. Agron. Soil Sci.*, **55(6)**, 601-610. https://doi.org/10.1080/03650340902855326

CEIC (2025). Production: Horticulture crops: Vegetables: Onion: Rajasthan. https://www.ceicdata.com/en/india/production-of-horticulture-crops-in-major-states-vegetables-onion/production-horticulture-crops-vegetables-onion-rajasthan

Dantas, M.P., de Oliveira C.R.S., Ueda Yamaguchi N., da Silva Júnior A.H., Peralta R.M., Bracht A. and Corrêa R.C.G. (2025). Pathways in Agro-Industrial Waste Upcycling: A Review of Sustainable Textile Innovations and Economic Perspectives. *Plants*, **14(23)**, 3574. https://doi.org/10.3390/plants14233574

Dataful (2025). *Year and state wise area and production of onion*. https://dataful.in/datasets/21304/

Thombare, R.A., Chavan R.V., More S.S., Bharti S.V., Munde T.B. and Patharikar D.T. (2026). Growth performance and instability analysis of area, production and productivity of onion in India using non-linear model. *Int. J. Agricult. Ext. Soc. Develop.*, **9(1)**, 159-166. https://www.doi.org/10.33545/26180723.2026.v9.i1c.2903

Gelaye, Y., Nakachew K. and Ali S. (2024). A review of the prospective effects of spacing and varieties on onion yield and yield components (*Allium cepa* L.) in Ethiopia. *Scientific Reports*, **14**, 10234. https://doi.org/10.1155/2024/2795747

Illo, A.I., Fingillah A.S., Muhammad H.A., Usman H. and Aminu M.B. (2025). Economic analysis and resource use efficiency of onion production in Aliero Local Government Area of Kebbi State, Nigeria. *J. Res. Agricult. Anim. Sci.*, **12(3)**, 27-35. https://doi.org/10.35629/9459-12032735

Jamkar, N.S. (2018). Effect of spacing and fertilizer levels on onion production under drip fertigation. Department of Irrigation and Drainage Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. M. Tech. 2018. Print. xiv, 106p. (Unpublished). https://krishikosh.egranth.ac.in/items/0b5d19f8-9007-445f-8135-104f44569849

Kamboj, N.K. (2016). Effect of planting time and paclobutrazol on growth and seed yield of onion. *CABI Digital Library*. https://doi.org/10.5555/20163353673

Miyazaki, Y., Hirama S., Kiuchi R. and Ikeda H. (2025). Bulb division and morphological variations in onions (*Allium cepa* L.) in response to exogenous gibberellin treatments. *Scientia Horticulturae*, **350**, 114350. https://doi.org/10.1016/j.scienta.2025.114350

Mudhalifah, W., Pribadi D.U. and Sukendah (2025). Increasing red onions (*Allium ascalonicum* L.) growth and yield through the application of goat urine liquid organic fertilizer and paclobutrazol. *Juatika Jurnal Agronomi Tanaman Tropika*, **7(3)**. https://doi.org/10.31219/osf.io/4593

Nissa, K., Sharma R., Bharat N.K. and Mehta D.K. (2026). Paclobutrazol and its impact on growth and physiology in various crops: A review. *Plant Archives*, **26(1)**, 112-125. https://www.researchgate.net/publication/399858331

Park, H.H., Kim Y.O. and Kuk Y.I. (2025). Assessment of the agricultural effectiveness of biodegradable mulch film in onion cultivation. *Plants*, **14(15)**, 2286. https://doi.org/10.3390/plants14152286

PIB (2024). 2.60 lakh tons of onion exported in 2024-25, till 31st July, 2024. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2042765

Singh, A.K., Bishnoi S., Vishwakarma S.K., Pandey S.K., Priya N.K., Singh G., Kumar A. and Tripathi S. (2025). Role of PM Kisan Samman Nidhi in enhancing farmers knowledge and adaptation of modern onion production technologies: A Review. *J. Exp. Agricult. Int.*, **47(7)**, 1-13. https://www.researchgate.net/publication/393436043

Sureshrao, J.N. (2018). Effect of spacing and fertilizer levels on onion production under drip fertigation. [*Thesis*, Krishikosh]. https://krishikosh.egranth.ac.in/handle/1/5810000000