International Journal of Plant & Soil Science

Volume 37, Issue 9, Page 243-248, 2025; Article no.IJPSS.142506
ISSN: 2320-7035

Smart Timing and Low Tunnel Covering: Enhancing Off-Season Cowpea Yield and Profitability in the Bara Tract of South Gujarat, India

Ankitkumar Gadhiya [a*], D. R. Bhanderi [b], Y. N. Tandel [c], P. M. Sankhla [d], Priyanka Patel [e] and Bhakti Panchal [f]

[a] Agricultural Research Station, NAU, Tanchha, India.
[b] Department of Vegetable Science, ASPEE College of Horticulture, NAU, Navsari, India.
[c] Department of Fruit Science, ASPEE College of Horticulture, NAU, Navsari, India.
[d] Department of Horticulture, College of Agriculture, NAU, Bharuch, India.
[e] Polytechnic in Horticulture, NAU, Navsari, India.
[f] Krushi Vigyan Kendra, NAU, Surat, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijpss/2025/v37i95703

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://pr.sdiarticle5.com/review-history/142506

Short Research Article

Received: 13/06/2025
Accepted: 23/08/2025
Published: 27/08/2025

ABSTRACT

A field experiment was conducted during the spring (*rabi*) seasons of 2022–23 and 2023–24 at the Agricultural Research Station, Navsari Agricultural University, Tanchha, in a Split Plot Design with three replications, comprising two glazing (covering) materials *i.e.* UV-stabilized plastic film (50 µ), biodegradable plastic and with an open field (control) in the main plots and five sowing times from

---

**Corresponding author: E-mail: gadhiyaankit@nau.in;*

Cite as: *Ankitkumar Gadhiya, D. R. Bhanderi, Y. N. Tandel, P. M. Sankhla, Priyanka Patel, and Bhakti Panchal. 2025. "Smart Timing and Low Tunnel Covering: Enhancing Off-Season Cowpea Yield and Profitability in the Bara Tract of South Gujarat, India". International Journal of Plant & Soil Science 37 (9):243–248. https://doi.org/10.9734/ijpss/2025/v37i95703.*

the third week of November to the third week of December in sub plots, using the cowpea variety AVCP-1. Results indicated that both glazing material and sowing time significantly influenced yield, while their interaction effects were have had non-significant effects. Biodegradable plastic low tunnels recorded the highest pooled (collective) yield (2.80 kg plot^{-1}), whereas the open field condition produced the lowest (1.85 kg plot^{-1}). Among sowing times, the fourth week of November resulted in the highest pooled (collective) yield (2.87 kg plot^{-1}) compared to the third week of December (1.99 kg plot^{-1}). Economic analysis revealed that the combination of biodegradable plastic low tunnel and sowing in the fourth week of November achieved the highest net income (₹ 2,94,501 ha^{-1}), while the lowest was recorded under the open field with the third week of December sowing (₹ 66,505 ha^{-1}). Hence, the strategic integration of microclimate modifying structures with optimally timed sowing is a proven approach to enhancing yield stability and profitability across diverse agro-climatic zones.

Keywords: Biodegradable plastic; cowpea; tunnel; UV-stabilized.

1. INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp.) is an important legume crop valued for its high protein content (23–25%), essential amino acids and micronutrients, making it a vital component of food and nutritional security in tropical and subtropical regions (Singh *et al*., 2002). It exhibits remarkable adaptability to diverse agro-climatic conditions and contributes to soil fertility through symbiotic nitrogen fixation, often adding 60–70 kg N ha^{-1} to the soil (Ehlers and Hall, 1997). In India, cowpea is cultivated extensively in arid and semi-arid regions, with Gujarat holding a significant share in national production (Agarwal *et al*., 2024).

Off-season cultivation of cowpea offers lucrative market opportunities due to higher price premiums during lean supply periods (Sindhu and Chatterjee, 2020). However, it faces climatic constraints such as suboptimal winter temperatures, fluctuating humidity and pest pressure, which adversely affect germination, flowering and yield (Ayisha, 2022). Low tunnel technology, particularly with suitable glazing (covering) materials, has been reported to modify the crop microclimate by increasing ambient temperature, conserving soil moisture and shielding plants from biotic and abiotic stress (Faivor, *2014*; Kumar *et al*., 2017).

Sowing time is another critical factor influencing phenology, photosynthetic efficiency and ultimately yield and market returns (Aliyu *et al*., 2023). Synchronizing the sowing period with favorable climatic windows ensures adequate thermal time for vegetative and reproductive growth, thereby improving yield and profitability (Basu *et al*., 2025). The integration of optimal glazing (covering) material with timely sowing has shown synergistic benefits in protected cultivation systems, yet there is limited location specific research on its impact on off-season cowpea in Gujarat. Therefore, the present study was undertaken to assess the combined influence of glazing materials and sowing times on yield performance and economic returns of off-season cowpea under low tunnel conditions, with the goal of developing practical recommendations for farmers in South Gujarat and similar agro-climatic zones.

2. MATERIALS AND METHODS

The present study was conducted at the Agricultural Research Station, Navsari Agricultural University, Tanchha, Ta. Amod, Dist. Bharuch during the spring (*rabi)* seasons of (2022–23 and 2023–24). The site is situated at 21.91° N latitude, 72.90° E longitude, with an average elevation of 19.0 m above mean sea level. The experiment was laid out in a Split Plot Design with three replications. The main plot treatments consisted of two glazing (covering) materials for low tunnels: UV stabilized plastic film (50 μ), biodegradable plastic and/with an open field (control). The sub plot treatments comprised five sowing times: 3rd week of November, 4th week of November, 1st week of December, 2nd week of December and 3rd week of December.

The cowpea variety used was AVCP-1, sown at a spacing of 45 cm × 15 cm. Low tunnels were removed 35 days after sowing. In each plot, five healthy and uniform plants were randomly selected, tagged and sequentially numbered for recording observations at different growth stages, depending on the trait under study. The mean values of these plants were used for statistical analysis. Final yield data were computed from the net plot and expressed in kg ha⁻¹. The objective of the study was to determine the effect of glazing materials and sowing times on the yield and economics of off-season cowpea under low tunnel conditions.

3. RESULTS AND DISCUSSION

The yield per plot of cowpea, as influenced by different glazing (covering) materials, sowing times and their interactions, was assessed for the spring seasons of two consecutive years (2022–23 and 2023–24) and through pooled (collective) analysis. The recorded values clearly indicate that both glazing (covering) material and sowing time exerted a significant influence on yield performance, whereas their interaction effects were statistically non-significant.

3.1 Effect of Glazing (covering) Material on Yield

As the (Table 1) set, across both experimental years and in the pooled (collective) analysis, the use of biodegradable plastic low tunnels (P_2) consistently produced the highest yield per plot, with values of (2.55 kg in 2022–23, 3.06 kg in 2023–24 and 2.80 kg in the pooled (collective) mean). The superior performance of P_2 can be attributed to its capacity to create a favorable microclimate by moderating temperature fluctuations, conserving soil moisture and reducing biotic and abiotic stresses during the early growth period.

These benefits likely enhanced physiological processes such as photosynthesis assimilate partitioning and reproductive development, culminating in higher pod yield. The open field condition (P_3), on the other hand, produced the lowest yields in all observations (1.61 kg, 2.08 kg, and 1.85 kg, respectively), possibly due to exposure to suboptimal winter temperatures, greater evapotranspiration losses and higher pest and disease incidence, plus the weeds probable negative existence. The results are consistent with the findings of Abdelrahman *et al*. (2016) in cowpea, Jat *et al*. (2017) in French bean and Mukherjee *et al*. (2013) in vegetable pea, who reported substantial yield advantages under protected cultivation as compared to open field conditions.

Table 1. Effect of glazing (covering) material of low tunnel and sowing time on green pod yield (kg plot $^{-1}$) of cowpea

Treatments	Green pod yield (kg plot^{-1})		
	2022-23	2023-24	Pooled
Glazing (covering) material of low tunnel (P)			
P_1 : UV Stabilized plastic film glazed low tunnel (50 μ)	2.32	2.85	2.59
P_2 : Biodegradable plastic low tunnel	2.55	3.06	2.80
P_3 : Open field (control)	1.61	2.08	1.85
SEm (±)	0.05	0.08	0.05
CD at 5%	0.20	0.30	0.16
CV (%)	9.14	11.16	10.86
Sowing time (S)			
S_1 : 3rd week of November	2.09	2.54	2.32
S_2 : 4th week of November	2.61	3.13	2.87
S_3 : 1st week of December	2.18	2.69	2.43
S_4 : 2nd week of December	2.13	2.78	2.45
S_5 : 3rd week of December	1.80	2.19	1.99
SEm (±)	0.09	0.12	0.08
CD at 5%	0.27	0.35	0.22
Interaction effect (P × S)			
SEm (±)	0.16	0.21	0.13
CD at 5%	NS	NS	NS
CV %	12.89	13.42	13.28
Pooled interaction			
Source	Y×P	Y×S	Y×P×S
SEm (±)	0.07	0.11	0.19
CD at 5%	NS	NS	NS

3.2 Effect of Sowing Time on Yield

Also as the (Table 1) set, sowing time significantly influenced yield performance in both years and in the pooled (collective) analysis. The fourth week of November (S_2) recorded the maximum yields per plot of (2.61 kg in 2022–23, 3.13 kg in 2023–24, and 2.87 kg in the pooled mean). This sowing window appears to have coincided with optimal climatic conditions for germination, vegetative growth and flowering, ensuring adequate thermal time and light interception for photosynthetic activity. In contrast, sowing in the third week of December (S_5) resulted in the lowest yields (1.80 kg, 2.19 kg, and 1.99 kg, respectively).

Delayed sowing time beyond the optimum period likely exposed the crop to suboptimal growing degree days and shorter effective growing periods, thereby reducing biomass accumulation and pod development. Similar patterns have been observed in earlier studies, where delayed sowing time was associated with reduced pod set and smaller pod size due to temperature and photoperiod constraints (Jezla, 2022).

3.3 Interaction Effects

The interaction between glazing (covering) material and sowing time (P × S) did not exert a statistically significant effect on yield in either experimental year or in the pooled (collective) analysis. Furthermore, the pooled interaction effects of year × glazing (covering) material (Y × P), year × sowing time (Y × S), and year × glazing material × sowing time (Y × P × S) were also non-significant. This suggests that the beneficial effects of glazing (covering) material and sowing time are largely improver rather than synergistic. The absence of significant interaction effects may be due to the fact that both factors independently contribute to modifying the crop microenvironment and phenological development without substantial overlap in their functional impacts.

3.4 Economic Implications

As the (Table 2) set, the cost of production of the cowpea variety AVCP-1 was also influenced by glazing (covering) material and sowing time. Economic analysis, computed based on prevailing market prices, included total cost, gross income and net income. The treatment combination of biodegradable plastic low tunnel with sowing in the fourth week of November (P_2S_2) achieved the highest net income of ₹2,94,501 per hectare, reflecting the combined benefits of higher yield and marketable quality.

In contrast, the lowest net income (₹66,505 per hectare) was obtained under the open field condition with sowing in the third week of December (P_3S_5), a combination associated with both reduced yield and lower economic returns.

Table 2. Economics of cowpea production as influenced by different treatment combination

Treatments	Yield (kg ha^{-1})	Fixed cost (₹)	Variable cost (₹)	Total Cost (₹)	Gross return (₹)	Net return (₹)
1	**2**	**3**	**4**	**5**	**6**	**7**
P_1S_1	12013	129,940	43,862	173802	360399	186597
P_1S_2	14637	129,940	43,862	173802	439121	265319
P_1S_3	11964	129,940	43,862	173802	358926	185124
P_1S_4	11296	129,940	43,862	173802	338889	165087
P_1S_5	9961	129,940	43,862	173802	298843	125041
P_2S_1	12315	129,940	42,196	172136	369444	197308
P_2S_2	15555	129,940	42,196	172136	466637	294501
P_2S_3	12631	129,940	42,196	172136	378935	206799
P_2S_4	13237	129,940	42,196	172136	397101	224965
P_2S_5	11188	129,940	42,196	172136	335648	163512
P_3S_1	7835	129,940	0	129940	235064	105124
P_3S_2	9693	129,940	0	129940	290784	160844
P_3S_3	9177	129,940	0	129940	275298	145358
P_3S_4	9545	129,940	0	129940	286335	156395
P_3S_5	6548	129,940	0	129940	196445	66505

These findings underscore the economic viability of adopting biodegradable plastic low tunnels and timely sowing in the fourth week of November for maximizing productivity and profitability in cowpea cultivation.

Overall, the results demonstrate that optimizing both the production environment through appropriate glazing materials and the crop calendar through timely sowing can significantly enhance cowpea yields and economic returns under low tunnel conditions. The findings not only validate the role of protected cultivation in mitigating adverse climatic effects but also provide a practical recommendation for farmers aiming to achieve higher productivity in off-season cowpea production.

4. CONCLUSION

Biodegradable plastic low tunnels (P_2) produced the highest pooled yield of cowpea (2.80 kg plot^{-1}) compared to the open field control (P_3) with 1.85 kg plot^{-1}. Sowing in the fourth week of November (S_2) yielded (2.87 kg plot^{-1}), outperforming the third week of December (S_5) with (1.99 kg plot^{-1}). The combination P_2S_2 recorded the maximum net income (₹ 2,94,501 ha^{-1}), whereas P_3S_5 gave the lowest (₹ 66,505 ha^{-1}).

These results confirm that biodegradable plastic low tunnels combined with timely sowing in late November can substantially enhance both yield and profitability of off-season cowpea under low tunnel conditions. Therefore, the strategic integration of microclimate modifying structures with optimally timed sowing is a proven approach to enhancing yield stability and profitability across diverse agro-climatic zones.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Abdelrahman, N. A., Abdalla, E. A., Ibrahim, E. A., & El Naim, A. M. (2016). The effect of plastic mulch on growth and yield of rain-fed cowpea and watermelon in North Kordofan State of Sudan. *World, 4*(5), 139–142.

Agarwal, D., Devra, S. J., & Raj, S. R. (2024). Pulses in India: Comprehensive analysis of production, challenges, and strategic vision for 2030. *Journal of Experimental Agriculture International, 46*(11), 293–304.

Aliyu, I., Dugje, I. Y., & Kamai, N. (2023). Effects of cowpea (*Vigna unguiculata* (L.) Walp.) varieties and sowing dates on performance of cowpea in sesame and cowpea intercropped in Sudan savanna, Nigeria. *Journal of Agricultural Economics, Environment and Social Sciences, 9*(2), 47–59.

Basu, S., Mondal, S., Dhakre, D. S., & Pramanik, K. (2025). Effect of sowing time on phenology, growth and yield across lentil varieties in Lower Gangetic Plains of India. *Legume Research – An International Journal, 1*, 8.

Ehlers, J. D., & Hall, A. E. (1997). Cowpea (*Vigna unguiculata* L. Walp.). *Field Crops Research, 53*(1–3), 187–204.

Faivor, R. M. S. (2014). *Low tunnel strategies for microclimate modification and early vegetable production*. Michigan State University.

Jat, R. A., Patel, R. B., & Patel, D. B. (2017). Effect of protected cultivation on growth and yield of French bean (*Phaseolus vulgaris* L.) under South Gujarat conditions. *International Journal of Agricultural Sciences, 9*(5), 3920–3923.

Jezla, P. A. (2022). *Crop establishment methods and weed management on productivity of cowpea [Vigna unguiculata (L.) Walp.]* (Doctoral dissertation, Department of Agronomy, College of Agriculture, Vellanikkara).

Kumar, S., Kumar, A., Singh, S. S., & Bala, S. (2017). Influence of microclimate condition of under low tunnel on productive responses in bitter gourd (*Momordica charantia*). *Bulletin of Environment, Pharmacology and Life Sciences, 6*(3), 46–50.

Mukherjee, D., Sharma, B. R., & Mani, J. K. (2013). Influence of different sowing dates and cultivars on growth, yield and disease incidence in garden pea (*Pisum sativum*) under mid hill situation. *Indian Journal of Agricultural Sciences, 83*(9), 918–923.

Sindhu, V., & Chatterjee, R. (2020). Off-season vegetable cultivation under protected structures: A promising technology for doubling farmer's income. *International Archives of Applied Sciences and Technology, 11*, 208–214.

Singh, B. B., Mohan Raj, D. R., Dashiell, K. E., & Jackai, L. E. N. (2002). *Advances in cowpea research*. Ibadan, Nigeria: International Institute of Tropical Agriculture (IITA) and Japan International Research Center for Agricultural Sciences (JIRCAS).

Peer-review history:
The peer review history for this paper can be accessed here:
https://pr.sdiarticle5.com/review-history/142506