

Profitability and Yield Stability of Sweet Corn (*Zea mays* L.) Under Diverse Legume Intercropping Arrangements

Abstract

The present study assessed the agronomic performance and economic efficiency of sweet corn intercropped with cowpea and black gram under varied spatial arrangements. The comparison of sole sweet corn against six intercropping configurations with varied row ratios- 1:1, 1:2, and 2:2- was made through a randomized complete block design with three replications to assess their varying effects on yield enhancement, biological complementarities, and system profitability. The sweet corn productivity increased significantly in all the intercropping treatments. The 2:2 sweet corn + cowpea system (T₆) recorded the maximum cob yield of 12.25 t/ha and stover yield of 21.50 t/ha, which was 64.4% over the mono-crop control. Black gram intercrops also recorded increased yield, and T₇ (2:2) resulted in a 47.3% increase in cob yield. The performance of intercrops also showed similar advantages: cowpea recorded its maximum pod yield of 32.20 q/ha in T₆, while the maximum seed yield of black gram was recorded as 15.63 q/ha in T₇. This benefit is an indication of increased nitrogen fixation, efficient canopy stratification, and better partitioning of resources in the intercropping systems.

The economic evaluation revealed that intercropping was significantly superior over mono-cropping in profitability. T₆ recorded the maximum gross return (Rs 3,14,903/ha) and net return (Rs 2,25,964/ha) along with the maximum benefit–cost ratio of 3.51, which is significantly higher over the control. Cowpea-based systems were invariably superior in economic performance compared to black gram-based systems due to their better compatibility and contribution to system-level efficiency. On the whole, the findings suggest that sweet corn–cowpea intercropping, especially the 2:2 arrangement, has an added advantage due to a better yield increase, biological efficiency, and economic return. This might thus place cereal–legume intercropping in a favourable position as a productive, economically viable, and sustainable alternative to monoculture sweet corn cultivation.

Keywords: Intercropping efficiency; system profitability; legume integration; yield enhancement; sustainable cropping systems.

1. Introduction

Intercropping, especially the strategic pairing of cereals and legumes relationship between cereals and legumes, represents one of the most intellectually stimulating and ecologically intriguing paradigms in contemporary agronomic science. Indeed, it epitomizes a

harmonious coming together of biological complementarities where species of divergent functional traits come together to create cropping systems that are not only productive but also resilient, resource-efficient, and ecologically enriched. Sweet corn (*Zea mays* L.), being a crop of immense nutritional, commercial, and industrial importance, is inherently exacting upon the soil and often suffers from yield instability under monocultural regimes as a consequence of progressive nutrient depletion and structural degradation. In this backdrop, the inclusion of short-duration, biologically dynamic legumes like cowpea (*Vigna unguiculata* L.) and black gram (*Vigna mungo* L.) represents an agronomic intervention of great import in terms of fortifying yield stability and concurrently enriching the soil milieu (Peoples *et al.*, 2009).

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Legumes are considered ecological engineers in intercropping systems, primarily through symbiotic nitrogen fixation and their ability to modulate complex rhizosphere biochemical pathways. Accordingly, the presence of legumes increases organic matter turnover in the soil, enhances microbial consortia activity, and improves the structure of the soil, all leading to an inherently more favourable nutrient environment for cereal growth (Brooker *et al.*, 2015). Beyond their subterranean ecological contributions, legumes also complement sweet corn through their more subtle patterns of canopy development, root foraging depth, and phenological timing. These traits orchestrate a delicate equilibrium between competing species, allowing resource acquisition such as light, water, and nutrients to be synergistically optimized (Lithourgidis *et al.*, 2011). This biological harmony has consistently promoted cob yield, bolstered stover biomass, and augmented overall system productivity in maize–cowpea and maize–black gram combinations (Jaswal *et al.*, 2023).

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From an economic perspective, cereal–legume intercropping is invariably touted as being capable of cushioning farming operations against market instability and environmental unpredictability. These systems ensure greater profitability, increased gross and net returns, and higher benefit–cost ratios due to varied outputs and improved internal nutrient cycling compared to mono-crop sweet corn (Tripathi *et al.*, 2021). Of the different legumes, cowpea is particularly exemplary because of its high nitrogen-fixing ability, rapid vegetative spread, and excellent compatibility with sweet corn, which often makes it superior in improving systems performance (Uzoh *et al.*, 2019). With these multifaceted agronomic, ecological, and economic merits, sweet corn deserves rigorous profitability and yield stability evaluation under diverse legume intercropping arrangements. The present study sets out to investigate the behavior of cowpea and black gram across varied spatial configurations with the aim of unravelling the intricate plant–plant interactions, resource-sharing dynamics, and economic gains that collectively shape the sustainability and productivity of sweet corn–legume

intercropping systems.

2. Material and methods

The field experiment was undertaken to evaluate the profitability, productivity, and yield stability of sweet corn (*Zea mays* L.) under diverse legume intercropping arrangements. The study employed a randomized block design (RBD) with three replications, wherein sweet corn functioned as the principal crop and cowpea (*Vigna unguiculata* L.) and black gram (*Vigna mungo* L.) were incorporated as intercrops across systematically varied spatial row proportions. The treatment structure comprised: **T₁ – sole sweet corn (control); T₂ – sweet corn + cowpea (1:1); T₃ – sweet corn + black gram (1:1); T₄ – sweet corn + cowpea (1:2); T₅ – sweet corn + black gram (1:2); T₆ – sweet corn + cowpea (2:2); T₇ – sweet corn + black gram (2:2).** All plots were meticulously maintained under weed-free conditions to ensure uniform crop performance and minimize confounding competitive effects. The treatment specifications are detailed in **Table 1**. The design made it possible to carry out a thorough evaluation of the different arrangements of cowpea and black gram in terms of their influence on interspecific complementarity, resource-sharing efficiency, system productivity and the economic viability of sweet corn-based intercropping systems. The whole process ended up with a clearer grasp of yield stability and profitability outcomes in the case of the tested arrangements.

Sweet corn was harvested at 80 DAS during the morning hours, 20 days after silk emergence. The harvest was completed in two pickings and the total yield was determined by summing the yield from each picking. Cob weight was measured from five plants per plot, and the overall yield was expressed in t/ha. Fresh stover weight was also recorded from each plot and similarly calculated in t/ha. Black gram was harvested at 75 DAS, along with the stover which was followed by threshing and sun-drying the seed. Cowpea was harvested at 55, 62, and 70 DAS with three pickings performed as the pods matured for vegetable purposes. The yield from each plot was recorded and later computed.

The economics of production for different systems were calculated on the basis of prevailing market price for the cost of the inputs and value of the produce. Gross and net returns and benefit: cost ratio was calculated.

3. Results and discussion

3.1 Effect of legumes as intercrop in sweet corn (*Zea mays* L.) on yield and economics

3.1.1 Cob and stover yield of main crop (sweet corn)

The cob and stover yield in different intercropping treatments significantly outperformed (Table 2) the sole sweet corn treatment. Cob yield for sole sweet corn (T1) was 7.45 t/ha, while the highest yield was recorded in T6 (sweet corn + cowpea in a 2:2 ratio), representing a 64.4% increase over the sole crop (T1). T7 (sweet corn + black gram in a 2:2 ratio) also showed a notable increase of 47.3% in cob yield compared to the control. Among 1:1 and 1:2 intercropping ratios, T4 (sweet corn + cowpea in a 1:2 ratio) exhibited a 39.2% yield, while T5 (sweet corn + black gram in a 1:2 ratio) produced a 29.2% more cob yield compared to T1 (control), whereas T2 and T3 produced 15.43% and 8.85% more yield compared to T1. A same trend was observed in the stover yield where T6 produced 21.5 t/ha, which is significantly high when compared to rest treatments.

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3.1.2 Pod/Seed and Stover yield of intercrop (Cowpea and Black gram)

The Table 3 compares Yield of cowpea pod and black gram seed yield, along with stover yield across different sweet corn-legume intercropping treatments are presented in Table 3. T6 (sweet corn + cowpea 2:2) achieved the highest cowpea pod yield of 32.20 q/ha, marking a 44.3% increase over T2 and a 2.9% increase over T4. T7 (sweet corn + black gram 2:2) yielded 15.63 q/ha black gram seed, showing an 88% increase over T3 and 51.0% over T5. Stover yield for cowpea in T6 increased by 25.4% over T2, while black gram in T7 exhibited a 21.9% increase over T3 and 5.8% over T5.

3.2 Effect of legumes as intercrop in sweet corn (*Zea mays L.*) on economics

Effect of Legume Intercropping in sweet corn (*Zea mays L.*) on economic returns

3.2.1 Cost of Cultivation

The cost of cultivation varied significantly among treatments. Sole sweet corn (T1) had the lowest cultivation cost (Rs 59,533/ha). Intercropping with cowpea increased the cost of cultivation, which ranged from Rs 81,208/ha to Rs 88,938/ha. Intercropping with black gram followed a similar trend, which ranged from Rs 71,125/ha to Rs 75,494/ha (Table 4).

3.2.2 Gross Return

Intercropping treatments generated higher gross returns compared to sole sweet corn (T1), which had a return of Rs 1,33,581/ha. The highest gross return was observed in the 2:2 cowpea intercropping treatment (T6), which was Rs 3,14,903/ha, followed by T4 (1:2 cowpea)

at Rs 2,68,158/ha, where the black gram intercropping system also produced a notable return of Rs 2,61,024/ha in the 2:2 ratio (T7) and Rs 2,19,258/ha in the 1:2 ratio (T5) (Table 4)..

3.2.3 Net Return

There was a substantial increase in net return across all legume-sweet corn intercropping treatments compared to sole sweet corn (T1). There was a significant increment of net return, especially in sweet corn + cowpea (T6) intercropping (Rs 2,25,964/ha), while the sole sweet corn treatment (T1) had the lowest (Rs 74,048/ha). Among black gram intercropping treatments, the 2:2 row ratio (T7) achieved Rs 1,86,230/ha, which is significantly higher than the control. Both 1:2 intercropping systems of cowpea and black gram (T4 and T5) also exhibited high net returns of Rs 1,81,630/ha and Rs 1,47,147/ha, respectively. (Table 4).

3.2.4 Benefit-Cost Ratio(B:C)

The B: C ratio highlighted the superiority of legumes as an intercrop in the sweet corn intercropping system. Significantly high B: C ratio was observed in the cowpea intercropping (2:2 row ratio) T6 at 3.51. In contrast, sole sweet corn (T1) had the lowest B:C ratio of 2.21. All intercropping systems demonstrated enhanced economic efficiency compared to the sole crop (correct the font size)(Table 4)..

3.3 System yield and economics 4. Discussion:

Intercropping sweet corn with legumes significantly enhanced enhances both cob and stover yields compared to the sole sweet corn cultivation treatment (T1). Specifically, T6 (sweet corn + cowpea in a 2:2 row ratio) achieved a significantly cob yield representing a remarkable 64.4% increase over T1(sole sweet corn). This substantial increase may be attributed due to the synergistic effect of intercropping where cowpea likely contributes to improved soil fertility through nitrogen fixation and enhanced nutrient availability similar observation was notated by Dingha *et al.* (2021). A similar trend was observed in stover production of sweet corn where T6 produced comparatively had better stover yield compared to than the control (T1). The consistent superiority of cowpea-based intercropping systems over black gram in terms of both cob and stover yields highlighting-highlights the importance of selection selecting appropriate legume species to maximize the benefits of intercropping was reported by Yu *et al.*, (2023). The cost-benefit analysis of legume intercropping systems in sweet corn revealed that cowpea-based intercropping especially in a 2:2 ratio (T6) offered the high gross and net return with a significantly high B:C ratio of 3.51. These economic advantages may be due as intercropping of legumes enhancing enhances resource use efficiency such as nitrogen fixation and improving crop productivity through complementary

plant interactions. This scientific advantage is supported by **Tripathi et al. (2021)** and also ~~is also supported~~ by **Uzoh et al. (2019)**, who emphasized the productivity and efficiency of legume-cereal intercropping. Such systems not only enhance economic returns but also improve agronomic parameters and nitrogen savings, proving sustainable potential of intercropping over mono-cropping. The cost of cultivation was lowest in sole sweet corn T1 (Rs 59,533/ha) while intercropping with cowpea and black gram increased the cost of cultivation. **Consequently**, intercropping system generated higher gross (Rs 3,14,903/ha) and net return especially in sweet corn + cowpea (T6) gross return and net return (Rs 2,25,964/ha). B:C of T6 is highest (3.51) compared to sole sweet corn had the lowest (2.21).

The present study investigated the agronomic performance and economic efficiency of sweet corn intercropped with cowpea and black gram under varied spatial arrangements, demonstrating significant enhancements in yield, biological complementarities, and system profitability compared to monoculture sweet corn. Specifically, the 2:2 sweet corn + cowpea system (T₆) emerged as the most advantageous, recording the maximum cob yield of 12.25 t/ha, a 64.4% increase over the mono-crop control, and a stover yield of 21.50 t/ha. This system also achieved the highest gross return, net return, and a benefit–cost ratio of 3.51. Black gram intercropping also showed positive results, with a 47.3% increase in cob yield in the T₇ system. These findings underscore the potential of cereal–legume intercropping as a productive, economically viable, and sustainable alternative to monoculture sweet corn cultivation.

The yield improvement in the intercropping systems as observed can be explained by well-documented synergies between cereals and legumes, especially **through** enhanced resource-use efficiency (**Bouray et al., 2023**). Via symbiotic fixation of nitrogen, legumes lead to the increase in the soil fertility, which is **a** the key nutrient needed to grow cereals (**Mogale et al., 2023; Namatsheve et al., 2021**). This is also in line with the external studies which suggest intercropping enhances the uptake of phosphorus (P) and lowers the need of P fertilizers (**Tang et al., 2020**). Legumes lead to greater microbial activity and organic matter cycling thus producing a more favourable nutrient environment within the primary crop (**Akchaya et al., 2025**). The high performance of the cowpea-based systems compared to black gram in terms of cob and stover yields and economic returns has always been high and therefore speciation of species is very crucial when it comes to improving intercropping. The strong capacity of cowpea to fix nitrogen, its rapid vegetative expansion, and its tremendous compatibility with sweet corn are some of the attributes that could have had strong impact on its **strong obtained** benefits.

Beyond subterranean contributions, legumes complement sweet corn through optimised resource acquisition, such as light, water, and nutrients, due to their distinct canopy development, root foraging depths, and phenological timing (Bouras et al., 2023). This biological harmony has been shown to promote cob yield and augment overall system productivity in various maize-legume combinations (Sahoo et al., 2023). The current study's results, showing a remarkable 64.4% increase in cob yield in the T₆ system, resonate with other studies that have found significant yield advantages (ranging from 15.6% to 49.9%) in integrated farming systems incorporating intercropping (Chai et al., 2021).

Economically, our results strongly support the idea that cereal-legume intercropping would help in insulating farming against market fluctuations and environmental uncertainty (Tripathi et al., 2021). The gross returns, net returns, and benefit-cost ratios of intercropped plots are significantly greater (especially cowpea), which proves the importance of intercropping in terms of ensuring higher profitability than mono-crop sweet corn (Tripathi et al., 2021). This economic benefit is based on diversified outputs and enhanced internal nutrient cycling, thus, minimizing the use of external inputs (Akchaya et al., 2025). Although the intercropping systems had higher cost of cultivation than the sole sweet corn system, the gross and net returns had significantly increased to cover the extra costs and hence the high economic efficiency.

Conclusion

In conclusion, this study highlights the diverse agronomic, ecological, and economic benefits of sweet corn–legume intercropping, especially with cowpea in a 2:2 spatial layout. The results support the broader use of such systems as a sustainable farming method that not only boosts productivity and profitability but also improves soil health and resource efficiency. thereby moving towards more resilient food production systems (Ray et al., 2025; Yu et al., 2024). Future research could explore the long-term effects of these intercropping systems on soil health parameters and the genetic basis for the observed complementarities between sweet corn and different legume species.

Competing Interests

Authors have declared that no competing interests exist.

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Table 1: Treatment Details

T1	Sole sweet corn (control)
T2	Sweet corn + Cowpea (1:1)
T3	Sweet corn + Black gram (1:1)
T4	Sweet corn + Cowpea (1:2)
T5	Sweet corn + Black gram (1:2)
T6	Sweet corn + Cowpea (2:2)
T7	Sweet corn + Black gram (2:2)

Table 2: Cob and stover yield of main crop (sweet corn)

	Treatment	Cob Yield (t/ha)	Stover Yield (t/ha)
T1	Sole Sweet corn (control)	7.45 ^d	13.38 ^b
T2	Sweet corn + Cowpea (1:1)	8.60 ^{bcd}	14.72 ^b
T3	Sweet corn + Black gram (1:1)	8.11 ^{ed}	13.55 ^b

T4	Sweet corn + Cowpea (1:2)	10.37 ^{abc}	16.77 ^{ab}
T5	Sweet corn + Black gram (1:2)	9.63 ^{bcd}	15.30 ^b
T6	Sweet corn + Cowpea (2:2)	12.25 ^a	21.50 ^a
T7	Sweet corn + Black gram (2:2)	10.97 ^{ab}	18.06 ^{ab}
SEm (±)		0.48	1.0
CD (0.05)		1.49	3.08

Table 3: Pod/Seed and Stover yield of intercrop (Cowpea and Black gram)

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Table 4: Economics of Sweet Corn (*Zea mays* L.) under Legume Intercropping

Table 4: Effect of legumes as intercrop in sweet corn (*Zea mays* L.) on economics

Treatment		Cowpea pod (q/ha)	Black gram seed yield (q/h)	Stover yield of cowpea(q/ha)	Stover yield of black gram (q/ha)
T1	Sole Sweet corn (control)	-	-	-	-
T2	Sweet corn + Cowpea (1:1)	22.33	-	65.34	-
T3	Sweet corn + Black gram (1:1)	-	8.20	-	28.02
T4	Sweet corn + Cowpea (1:2)	31.21	-	82.01	-
T5	Sweet corn + Black gram (1:2)	-	10.35	-	32.3
T6	Sweet corn + Cowpea (2:2)	32.20	-	81.9	-
T7	Sweet corn + Black gram (2:2)	-	15.63	-	34.17
SEm (±)		0.76		0.81	
CD (0.05)		2.35		2.51	

Treatment		Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
T1	Sole Sweet corn (control)	59533	133581	74048	2.21
T2	Sweet corn + Cowpea (1:1)	81208	217240	136032	2.65
T3	Sweet corn + Black gram (1:1)	71125	184060	112935	2.56
T4	Sweet corn + Cowpea (1:2)	86527	268158	181630	3.08
T5	Sweet corn + Black gram (1:2)	72111	219258	147147	3.00
T6	Sweet corn + Cowpea (2:2)	88938	314903	225964	3.51
T7	Sweet corn + Black gram (2:2)	75494	261024	186230	3.45