Journal of Medicinal and industrial plants (2024) 2 (4):72 –83.
DOI: https://doi.org/10.32894/MEDIP.24.4.8
ISSN: (2959 – 121X)

Journal of Medicinal and Industrial Plants
(MEDIP)
http://medip.uokirkuk.edu.iq/index.php/medip

The Effect of Intercropping and Soil Cover Types on the Production Indicators of Sunflower and Cowpea Crops

Bokan Samad Fatah* **Sami Muhammadamin Maaroof****

Department of Field Crops and Medicinal Plants, College of Agricultural Engineering Sciences, Salahaddin Universit , Erbil,Iraq

Corresponding author: E-Mail: bokan.fatah@su.edu.krd , sami.maaroof@su.edu.krd

KEY WORDS:
Qushtappa, Ankawa, Cowpea, Sunflower, Intercropping, Growth, Seed yield

Received:
23/12/2024
Accepted:
08/01/2025
Available online:
10/01/2025

ABSTRACT

In two stages (30–45 DAS and 45–60 DAS), the study assessed the growth of cowpeas and sunflowers in Qushtappa and Ankawa under various intercropping ratios (4SF:1CP, 4SF:2CP, 4SF:3CP, and 4SF:4CP) and cover types (exposed or mulched). The results indicated that locations, cover types, and intercropping ratios had a substantial impact. With more main stem nodes and faster rates of leaf growth, mulched plots fared better overall, particularly in later growth stages. Early growth stages were dominated by exposed plots, however later growth stages saw higher yields from mulched plots. Different cover types and intercropping ratios resulted in different cowpea leaf growth rates and seed yields. Although sunflower seed weight increased in all scenarios, mulched plots frequently had better seed yields and counts per head, especially in higher cowpea fractions. In general, location, ratio of intercropping, and early growth stages were dominated by exposed plots, however later growth stages saw higher yields from mulched plots. Different cover types and intercropping ratios resulted in different cowpea leaf growth rates and seed yields. Although sunflower seed weight increased in all scenarios, mulched plots frequently had better seed yields and counts per head, especially in higher cowpea fractions. All things considered, growth and yield results were highly impacted by location, intercropping ratio, and cover type.

تاثير الزراعة المتداخلة ونوع غطاء التربة في مؤشرات الانتاج لمحصولي زهرة الشمس واللوبياء

بوكان صمد فتاح **سامي محمدأمين معروف**

قسم المحاصيل الحقلية والنباتات الطبية كلية علوم الهندسة الزراعية/ جامعة صلاح الدين/ اربيل/ العراق

الخلاصة

قيّمت الدراسة نمو نباتي اللوبيا وعباد الشمس في موقعين (قوشتبة وعنكاوا) عبر مرحلتين من النمو (٣٠-٤٥ يومًا بعد البذار و٤٥-٦٠ يومًا بعد البذار) تحت نسب مختلفة من الزراعة البينية بين عباد الشمس (SF) واللوبيا .(CP) تضمنت النسب SF:1CP٤، SF:2CP٤، SF:3CP٤، وSF:4CP٤، بالإضافة إلى نوع الغطاء (التربة المكشوفة أو المغطاة بالمواد العضوية).

أظهرت النتائج أن نسب الزراعة البينية، وأنظمة النمو، والموقع كان لها تأثير كبير على النمو. عمومًا، أظهرت التغطية العضوية قيم نمو أعلى، خصوصًا في المراحل المتأخرة من النمو، وبرزت اختلافات ملحوظة في بعض تركيبات الزراعة البينية. زاد عدد العقد الرئيسية على الساق مع التغطية العضوية، خاصة في المراحل المتأخرة من النمو وبعض تركيبات الزراعة البينية، ولكن النمو اختلف عبر نسب الزراعة البينية وأنواع الغطاء. أثرت نسبة الزراعة البينية بشكل كبير على النمو. خلال المرحلة المبكرة من النمو، أظهرت القطع غير المغطاة قيم تفرع أعلى بشكل متكرر، بينما أظهرت القطع المغطاة أداءً أفضل في المراحل المتأخرة، خاصة في تركيبات زراعية معينة. كما أثرت نسب الزراعة البينية وأنواع الغطاء على معدلات نمو أوراق اللوبيا؛ حيث أظهرت القطع المكشوفة أداءً أفضل في المراحل المبكرة، بينما حققت القطع المغطاة غالبًا معدلات نمو أعلى في المراحل اللاحقة. اختلف أداء محصول اللوبيا باختلاف الموقع ونوع الغطاء ونسبة الزراعة البينية. في المراحل المبكرة من النمو، أظهرت القطع المكشوفة عدد بذور أكثر لكل نبات، ولكن القطع المغطاة أظهرت أداءً أفضل من حيث وزن البذور والإنتاجية، خاصة عند تطبيق تركيبات زراعية معينة. تأثرت إنتاجية عباد الشمس بالموقع ونوع الغطاء ونسب الزراعة البينية. بينما تحسن وزن البذور باستمرار تحت الظروف المكشوفة والمغطاة، كان عدد البذور لكل رأس والعائد الكلي للبذور أعلى في الغالب في القطع المغطاة، خاصة مع ارتفاع نسب اللوبيا.

كلمات مفتاحية : قوش تبة، عينكاوه، اللوبيا، زهرة الشمس، الزراعة المتداخلة,, النمو، حاصل الحبوب.

1. INTRODUCTION

Intercropping, the agricultural practice of cultivating two or more crops on the same piece of land within a single growing season, is a sustainable method for enhancing agricultural productivity and resource use efficiency. By optimizing natural resource utilization, such as sunlight, water, and soil nutrients, intercropping systems often yield higher outputs compared to monocropping. This approach reduces resource competition by leveraging the complementary growth habits of different crops, allowing them to coexist harmoniously (Zhang et al., 2023). Additionally, intercropping has shown resilience against environmental stresses like drought and pests, making it a key component of sustainable farming (Li et al., 2017). Mulching, the process of covering soil surfaces with organic or inorganic materials, complements intercropping by conserving moisture, reducing weed growth, and preventing erosion. It enhances soil structure and maintains optimal temperatures, fostering root development and nutrient uptake (Patel & Singh, 2020). In regions facing water scarcity, mulching minimizes evaporation and reduces irrigation needs, offering a practical solution to sustain productivity (Gupta et al., 2022). As climate change alters rainfall patterns, mulching and intercropping together can mitigate water shortages. Projections indicate drier winters and concentrated spring rains in regions like Erbil, Iraq, where erratic precipitation threatens agriculture. Mulching helps retain soil moisture during dry spells, ensuring water availability for intercropped plants. This synergy between mulching and intercropping promotes resilient farming systems adaptable to changing climates (Raza et al., 2020). Sunflower (Helianthus annuus L.) and cowpea (Vigna unguiculata L.) are ideal candidates for intercropping under covered and non-covered conditions due to their contrasting growth traits. Sunflowers, with their deep roots, access nutrients from lower soil layers, while cowpeas enrich the soil with nitrogen through shallow roots. Mulching enhances these interactions by preserving soil moisture and reducing competition for water (Singh, 2023). Historically, intercropping has been integral to traditional farming in Asia, Africa, and Latin America, where farmers combined it with mulching to optimize land use and sustain yields. These practices ensured soil fertility and food security in areas with limited modern inputs (Vandermeer, 1992). Today, they are being revisited to address challenges like climate change, soil degradation, and water scarcity (Willey, 1979). The additive intercropping model, where sunflower is planted at full density and cowpea at varying densities, has been extensively studied for maximizing resource efficiency. Mulching further supports this system by preserving nutrients and moisture, allowing both crops to thrive without excessive competition (Li et al., 2017). This study investigates the combined effects of intercropping and mulching on sunflower and cowpea growth in the Erbil region. It examines different intercropping ratios under covered and non-covered conditions, aiming to provide practical insights for sustainable agriculture. The results will contribute to strategies for

improving productivity and resilience in water-scarce and climate-affected regions (Singh et al., 2023). By exploring mulching and intercropping synergies, this research seeks to optimize resource use, enhance yields, and promote sustainable farming practices. The findings will guide the adoption of resilient agricultural systems tailored to arid and semi-arid conditions. This research aims to determine the optimal planting ratio for sunflower-cowpea intercropping in arid and semi-arid regions.

2. MATERIALS AND METHODS

The experiment was carried out at two locations, Qushtappa and Ankawa, to assess the growth, yield, and performance of sunflower (*Helianthus annuus* L.) and cowpea (*Vigna unguiculata* L.) intercropped under various ratios and soil cover conditions. These sites reflect different soil fertility and environmental conditions as depicted in tables 1 and 2 including soil analysis and some meteorological aspects of the locations Ankawa has a somewhat suitable microclimate and slightly higher fertility than Qushtappa which is semi-arid. Two development stages—30–45 days after sowing (DAS) and 45–60 DAS—were used for the study.

Three replications of a split-plot design were used. The subplots had several intercrop ratios of sunflower to cowpea, including pure stand (cowpea), pure stand (sunflower), and other combinations such 4SF:1CP, 4SF:2CP, 4SF:3CP, and 4SF:4CP. 4SF: nCP indicates rows of sunflower to rows of cowpea. Means with the same letter are not significantly different**,** the main plots featured bare and covered soil conditions. After plowing, harrowing, and leveling the plot, seeds were manually sown at the suggested intervals for each intercrop ratio. All plots received the same level of irrigation, weeding, and pest control, and mulching was done with organic materials from wheat hay. All the plot area was covered completely to one-inch thick. Growth traits like biomass accumulation, leaf area index, and plant height were among the data gathered, as were crop-specific yield characteristics. The weight of 100 seeds, the number of seeds per plant, and the seed production per hectare were all measured for cowpea. Characteristics such as seed yield per hectare, weight of 100 seeds, and quantity of seeds per head were noted for sunflower. ANOVA was used for statistical analysis, and the Least Significant Difference (LSD) test was used for mean comparisons at a significance level of 5%. To guarantee thorough results, pooled analysis was performed across the two locations and developmental stages. The same-letter means were regarded as not being substantially different. Both crops were grown together on 14th July and harvested differently in the same year, cowpea on 15/9 while sunflower on 15/10/2024, The mulched plot surfaces were executed by one inch wheat hay from the wheat that was cultivated previously on winter season

Since Cowpea plants do not grow perpendicular to the ground, the length of the plant, measured from the soil surface to the plant`s end tip, was used in place of the height of the plant. Image computer application was used to measure the leaf area, following the researchers Ferreira and Rasband 2012" whom explained how to compute the leaf area index by dividing the leaf area by the ground area. After the plants were dried for 48 hours at 75°C in a special oven, their dry weights were calculated. Then, using the Watson formula cited from Dizayee and Maaroof, 2020 (formula, relative growth rates were computed by dividing the growth difference across two time periods by the time gap between them. The difference in trait values throughout each time period was also used to compute additional growth rates by the formula;

Growth rate = $(W_2-W_1)/(T_2-T_1)$, W and T referring two trait scale (as weight in g) and elapsed times respectively. and results were statistically evaluated using ANOVA at a 5% significance level utilizing OPSTAT is a user-friendly statistical analysis software

The weight of five sunflower discs per treatment was measured individually, and the average was calculated. A random sample of 1000 dried seeds were weighed with a high-precision scale to determine seed density and quality. Seed yield was calculated by combining the seed weight from the net plot and five sample plants, then converting it to kilograms per hectare. Sunflower heads were harvested at maturity, when the outer brackets browned. Seeds were extracted, dried to 10% moisture content, and stored for analysis.

Table 1: Soil test analysis of both locations

location	Ankawa	Qushtappa
EC:Ds/m	0.4	0.6
pH	7.78	7.92
N%	0.011	0.08
P (ppm)	47.5	25.5
K (ppm)	188	120
O.M %	0.93	0.81
Sand %	16.3	33.8
Silt %	49.3	36.8
Clay %	34.4	29.4
Soil Texture	Silty Clay Loam	Clay Loam

Table2: Agrometeorology parameters at Ankawa and Qushtappa locations 2023-2024

Scale / Month	Air Temperature C°				Relative humidity %	
	Maximum		Minimum			
	Qushtappa	Ankawa	Qushtappa	Ankawa	Qushtappa	Ankawa
November	21	21.4	11.4	12.6	64.3	70.4
December	17.1	17.5	7.9	7.9	69.4	85.3
January	14.1	14.6	6.5	6.3	73.1	87
February	14.9	15.2	6	5.1	67.3	87.6
March	18.9	18.5	8.2	8.1	61.2	86
April	28.6	28.8	15	15.4	44.7	84.8
May	30.4	30.6	18.2	19.4	36.2	71.6
June	41.4	42.6	26.7	28.3	13.8	56.3
July	42.2	44.6	27.6	30.4	16.1	58
August	42.4	44.8	27.1	28.8	16.1	57
September	36.8	38.9	23.3	24	23	57.1
October	29.1	30.4	15.7	16.5	22.2	64
Total rainfall from the previous season in mm per winter season mm					370	445

3. RESULTS AND DISCUSSION

First: Cowpea

a-Growth in Plant Length (cm day-1);

Table 3 shows data on cowpea growth in plant length in cm intercropped with sunflower under cover types (Exposed and Covered) and ratios (4 SF:1 CP, 4 SF:2 CP, 4 SF:3 CP, 4 SF:4 CP) were collected from Qushtappa and Ankawa at two growth periods: 30–45 DAS and 45–60 DAS. From 30–45 DAS: Qushtappa: In bared cover, 4 SF:3 CP had the lowest mean 3.420 cm d-1 and Pure Stand the highest 4.447 cm d-1. In covered treatment, 4 SF:1 CP had the highest mean of 4.153 cm d-1 and 4 SF:3 CP the lowest 3.310. 4 SF:3 CP performed consistently worse across both cover types. Ankawa: In Exposed cover, mean values ranged from 3.737 cm d-1 to 4.023 cm d-1, while in covered treatment, they ranged from 3.710 cm d-1 to 3.977 cm d-1, showing little variation across treatments. Adebayo, A.K et al (2024) found similar results.

According to pooled ANOVA analysis, 4 SF:1 CP had the highest mean 4.208 cm d-1 and 4 SF:3 CP the lowest 3.365 cm d-1 under exposed settings. 4 SF:1 CP had the greatest mean 4.000 cm d-1 and 4 SF:3 CP the lowest 3.767 cm d-1 under covered conditions. In both covers, 4 SF:3 CP continuously did poorly. Between 45 and 60 DAS: Qushtappa: Pure Stand had the lowest mean 1.310 cm d-1 and 4 SF:4 CP the highest (2.090) in exposed cover. The highest mean in covered treatment was 4 SF:4 CP 3.200 cm d-1, while the lowest was 4 SF:1 CP (2.177). Ankawa: Means varied between 1.890 and 2.400 in exposed cover. The range of values in mulched cover was 2.070 cm d-1 to 2.553 cm d-1. Pooled ANOVA: Pure Stand had the lowest mean 1.743 cm d-1 and 4 SF:4 CP the

highest 2.645 cm d-1 in exposed cover.

Table 3: Growth rate mean values of Cowpeas (plant length cm trait) intercropped additionally to sunflower in exposed and covered plots at the locations of Qushtappa and Ankawa at two age stages in days after sowing

Growth Period	Location	Coverage with wheat hay	Sole and Intercrop row ratios, Sunflower (SF): Cowpea (CP)					Mean
			Sole cropping (Cowpea)	4 SF: 1 CP	4 SF:2 CP	4 SF: 3 CP	4 SF:4 CP	
From 30 to 45 days after sowing	Qushtappa	Exposed	4.447a	4.263a	4.133a	3.420b	4.180a	4.089a
		Covered	3.933ab	4.153a	4.113a	3.310b	4.047a	3.911a
		Mean	4.190a	4.208a	4.123a	3.365b	4.113a	
	Ankawa	Exposed	3.957a	4.023a	4.000a	3.823a	3.737a	3.908a
		Covered	3.843a	3.977a	3.777a	3.710a	3.843a	3.830a
		Mean	3.900a	4.000a	3.888a	3.767a	3.790a	
	Pooled ANOVA	Exposed	4.190a	4.208a	4.123a	3.365b	4.113a	3.998a
		Covered	3.900a	4.000a	3.888a	3.767a	3.790a	3.871a
		Mean	4.045a	4.104a	4.006a	3.566a	3.952a	
From 45 to 60 days after sowing	Qushtappa	Exposed	1.310a	1.333a	1.710a	1.890a	2.090a	1.667b
		Covered	2.177b	2.400b	1.843b	1.890b	3.200a	2.302a
		Mean	1.743b	1.867b	1.777b	1.890b	2.645a	
	Ankawa	Exposed	2.090a	2.177a	2.400a	1.890a	2.023a	2.116a
		Covered	2.287a	2.200a	2.087a	2.070a	2.553a	2.239a
		Mean	2.188a	2.188a	2.243a	1.980a	2.288a	
	Pooled ANOVA	Exposed	1.743b	1.867b	1.777b	1.890b	2.645a	1.891a
		Covered	2.188a	2.188a	2.243a	1.980a	2.288a	2.271a
		Mean	1.966a	2.028a	2.010a	1.935a	2.467a	

* 4SF : n Vu , indicates rows of sunflower : rows of Cowpea**Means with the same letter are not significantly different

b-Growth in Nodes per Plant (nodes day^{-1}**)**

During two growth periods—30–45 DAS and 45–60 DAS—data on cowpea growth performance as main stem nodes per plant (Table 4) interplanted with sunflower under cover types (Exposed and Covered) and ratios (4 SF:1 CP, 4 SF:2 CP, 4 SF:3 CP, and 4 SF:4 CP) were gathered from Qushtappa and Ankawa. Between 30 and 45 DAS: Qushtappa: The mean for exposed cover was highest for 4 SF:2 CP was 0.490 nodes d^{-1} and lowest for 4 SF:3 CP was 0.313 nods d^{-1}. The greatest CP in mulched cover was 4 SF:2 0.470 nodes d^{-1}, while the lowest CP was 4 SF:3 0.290 nodes d^{-1}. Ankawa: While mulched settings demonstrated constant performance mean values under exposed settings varied from 0.400 nodes d^{-1} to 0.513 nodes d^{-1}.

Pooled ANOVA: The mean for exposed cover was the lowest for 4 SF:3 CP 0.302 nodes $d^{-1}$and the highest for 4 SF:2 CP 0.480 nodes d^{-1}.Similar studies executed by Sadiq (2023). From 45–60 DAS: Qushtappa: In exposed cover, and 4 SF:1 CP had the lowest mean 0.200 nodes d^{-1}, while 4 SF:4 CP had the highest (0.313). In mulched cover, 4 SF:4 CP had the highest mean 0.513 nodes d^{-1} and 4 SF:2 CP the lowest 0.200nodes d^{-1} Ankawa: Mean values in exposed conditions ranged from 0.400 nodes d^{-1} to 0.513 nodes d^{-1}, and in mulched conditions from 0.423 nodes d^{-1} to 0.490 nodes d^{-1}. Pooled ANOVA: In exposed cover, 4 SF:4 CP had the highest mean (0.413) and 4 SF:1 CP and 4 SF:2 CP the lowest 0.233 nodes d^{-1}. In mulched cover, 4 SF:4 CP had the highest mean 0.357 nodes $d^{-1}$and 4 SF:3 CP the lowest 0.300 nodes d^{-1}.

C- Growth of Branches per Plant

At two locations (Qushtappa and Ankawa), were table (5) assesses some growth traits under various intercropping ratios (4 SF:1 CP, 4 SF:2 CP, etc.) and plot cover types (Exposed and Mulched). Each plot type's data is shown first, then location-wise means and a summary of the pooled ANOVA.

At two growth periods—30–45 DAS and 45–60 DAS—data on cowpea growth performance (leaves per plant) interplanted with sunflower under cover types (Exposed and Mulched) and ratios (4 SF:1 CP, 4 SF:2 CP, 4 SF:3 CP, and 4 SF:4 CP) were gathered from Qushtappa and Ankawa.

Broad Remarks: In both growth phases, exposed plots typically had more branches per plant than mulched plots. Throughout 30 to 45 DAS, Qushtappa continuously had somewhat more branches than Ankawa, suggesting a location-based impact. Competitive effects were suggested at increasing densities, as lower densities (4 SF:1 CP, 4 SF:2 CP) produced more branches, whereas higher densities (4 SF:4 CP) produced fewer branches. In Qushtappa (30–45 DAS), in particular, mulched plots had less branches. However, during 45–60 DAS, branch counts in mulched plots improved in some ratios (e.g., 4 SF:4 CP). Statistical Significance: In exposed plots, variations were primarily non-significant between 30 and 45 DAS, but in some treatments, particularly at higher cowpea densities, they were significant between 45 and 60 DAS. Across sites, cover types, and growth phases, branch counts generally declined as cowpea density rose. Tahir et al. (2024) worked on similar issue.

D- Number of Leaves per Plant (leaves er day = L d^{-1})

Qushtappa: In exposed cover, the mean for 4 SF:1 CP and 4 SF:3 CP was the lowest at 1.200 L d^{-1} between 30 and 45 DAS, while the highest value was 1.687 L d^{-1} for 4 SF:4 CP. In mulched cover, 4 SF:2 CP had the greatest mean at 1.510 L d^{-1}, whereas Pure Stand had the lowest at 1.00 L d^{-1}. Overall, performance differed slightly between treatments. In Ankawa, 4 SF:1 CP had the highest mean in exposed cover (1.067 L d^{-1}), whereas Pure Stand had the lowest (0.553 L d^{-1}). Under mulched cover, the mean values, which varied from 0.470 L d^{-1} to 0.580 L d^{-1}, stayed the same.

The exposed cover mean was the highest using pooled ANOVA, 4 SF:2 CP had the largest exposed cover mean (1.445 L d^{-1}), whereas 4 SF:3 CP had the lowest (1.110 L d^{-1}). Pure Stand had the lowest mean (0.522 L d^{-1}) and 4 SF:1 CP had the highest (0.823 L d^{-1}) in mulched cover.

Table 5: Growth rate mean values of Cowpeas (Branches plant^{-1} trait) intercropped additionally to sunflower in exposed and mulched plots at the locations of Qushtappa and Ankawa at two age stages in days after sowing.

Growth Period	Location	Coverage with wheat hay	Intercrop row ratios, Sunflower (SF): Cowpea (CP)					Mean
			Sole cropping (Cowpea)	4 SF: 1 CP	4 SF:2 CP	4 SF: 3 CP	4 SF:4 CP	
From 30 to 45 days after sowing	Qushtappa	Exposed	0.353a	0.333a	0.377a	0.267a	0.290a	0.324a
		Covered	0.267a	0.270a	0.247a	0.177a	0.133a	0.219a
		Mean	0.310a	0.302ab	0.312a	0.222ab	0.212b	
	Ankawa	Exposed	0.333a	0.310a	0.247a	0.290a	0.223a	0.281a
		Covered	0.247a	0.223a	0.200a	0.200a	0.157a	0.205a
		Mean	0.290a	0.267ab	0.223ab	0.245ab	0.190b	
	Pooled ANOVA	Exposed	0.310a	0.302a	0.312a	0.222a	0.212a	0.302a
		Covered	0.290a	0.267a	0.223a	0.245a	0.190a	0.212a
		Mean	0.300a	0.284ab	0.268ab	0.233ab	0.201b	
From 45 to 60 days after sowing	Qushtappa	Exposed	0.067a	0.110a	0.110a	0.133a	0.180a	0.120a
		Covered	0.177ab	0.157ab	0.113b	0.067b	0.333a	0.169a
		Mean	0.122b	0.133ab	0.112b	0.100b	0.257a	
	Ankawa	Exposed	0.133a	0.177a	0.180a	0.133a	0.113a	0.147a

		Covered	0.110a	0.200a	0.110a	0.133a	0.200a	0.151a
		Mean	0.122a	0.188a	0.145a	0.133a	0.157a	
	Pooled ANOVA	**Exposed**	0.122b	0.133ab	0.112b	0.100b	0.257a	0.134a
		Covered	0.122a	0.188a	0.145a	0.133a	0.157a	0.160a
		Mean	0.067a	0.110a	0.110a	0.133a	0.180a	0.120a

* 4SF : n Vu , indicates rows of sunflower : rows of Cowpea

**Means with the same letter are not significantly different

Qushtappa: Between 45 and 60 DAS, the mean for exposed cover was the highest for 4 SF:4 CP (0.467 L d^{-1}) and the lowest for Pure Stand (0.330 L d^{-1}). The highest mean in mulched cover was 0.977 L d^{-1} for 4 SF:4 CP while the lowest was 0.113 L d^{-1} for 4 SF:2 CP. 4 SF:2 CP and 4 SF:3 CP had the highest mean (0.467 L d^{-1}) in Ankawa exposed cover, whereas 4 SF:4 CP had the lowest (0.200 L d^{-1}). The mean in mulched cover was 0.887 L d^{-1} for 4 SF:4 CP and 0.443 L d^{-1} for 4 SF:1 CP.

Pooled ANOVA: The mean for exposed cover was 0.722 L d^{-1} for 4 SF:4 CP and 0.257 L d^{-1} for 4 SF:2 CP. The highest mean in mulched cover was 0.543 L d^{-1} for 4 SF:4 CP while the lowest was 0.388 L d^{-1} for 4 SF:3 CP. Not all differences are statistically significant.

Table 6 : Growth rate mean values of Cowpeas (leaves plant^{-1} trait) intercropped additionally to sunflower in exposed and mulched plots at the locations of Qushtappa and Ankawa at two age stages in days after sowing .

Growth Period	**Location**	**Covered with organic materials**	**Intercrop row ratios, Sunflower (SF): Cowpea (CP)**					**Mean**
			Sole croping (Cowpea)	**4 SF: 1 CP**	**4 SF:2 CP**	**4 SF: 3 CP**	**4 SF:4 CP**	
From 30 to 45 days after sowing	**Qushtappa**	**Exposed**	1.443a	1.200a	1.380a	1.200a	1.687a	1.382a
		Covered	1.000a	1.423a	1.510a	1.020a	1.087a	1.208a
		Mean	1.222a	1.312a	1.445a	1.110a	1.387a	
	Ankawa	**Exposed**	0.553b	1.067a	0.823ab	0.847ab	0.820ab	0.822a
		Covered	0.490a	0.580a	0.470a	0.557a	0.557a	0.531a
		Mean	0.522a	0.823a	0.647a	0.702a	0.688a	
	Pooled ANOVA	**Exposed**	1.222a	1.312a	1.445a	1.110a	1.387a	1.102a
		Covered	0.522a	0.823a	0.647a	0.702a	0.688a	0.869a
		Mean	0.872a	1.068a	1.046a	0.906a	1.038a	
From 45 to 60 days after sowing	**Qushtappa**	**Exposed**	0.330a	0.600a	0.400a	0.423a	0.467a	0.444a
		Covered	0.643ab	0.357ab	0.113b	0.620ab	0.977a	0.542a
		Mean	0.487a	0.478a	0.257a	0.522a	0.722a	
	Ankawa	**Exposed**	0.447a	0.423a	0.467a	0.310a	0.200a	0.369b
		Covered	0.733a	0.443a	0.533a	0.467a	0.887a	0.613a
		Mean	0.590a	0.433a	0.500a	0.388a	0.543a	
	Pooled ANOVA	**Exposed**	0.487a	0.478a	0.257a	0.522a	0.722a	0.407b
		Covered	0.590a	0.433a	0.500a	0.388a	0.543a	0.577a
		Mean	0.538a	0.456a	0.378a	0.455a	0.633a	

* 4SF : n Vu , indicates rows of sunflower : rows of Cowpea**Means with the same letter are not significantly different

E- Yield and Yield Components of cowpea

Effect of Intercropping on Seed Number depicted in table 7, Pure Stand had the lowest seed number (183.8) and 4 SF:1 CP had the greatest (220.7) in Qushtappa (Exposed). Other treatments showed no discernible trend. The average number of seeds in mulched plots was slightly lower than in exposed plots, ranging from 176.1 to 204.4. There was little fluctuation in the seed numbers in Ankawa, which ranged from 177.8 to 211.3 under both exposed and mulched circumstances. Effect of Cover:

Bare plots in Qushtappa often yielded more seeds than mulched plots. There was no discernible difference in Ankawa. Comparing locations, Ankawa performed consistently throughout treatments, but Qushtappa responded more strongly to intercropping

Table 7: Yield performance of cowpea under addition intercrop type between cowpea and sunflower in exposed and mulched plots at the locations of Qushtappa and Ankawa .

Trait	Plot location and cover type		Intercrop row ratios, Sunflower (SF): Cowpea (CP)					
			Sole Cowpea	4 SF: 1 CP	4SF:2 CP	4 SF: 3 CP	4 SF:4 CP	Mean
No. of seeds per plant	Qushtappa	Exposed	183.8b	220.7a	212.8ab	198.1ab	206.4ab	204.3a
		Mulched	176.1a	204.413a	177.727a	189.760a	195.900a	188.8b
		Mean	179.9b	212.5a	195.3ab	193.9ab	201.1ab	
	Ankawa	Exposed	177.8a	203.1a	211.3a	199.9a	190.2a	196.5a
		Mulched	184.1a	198.3a	188.9a	201.2a	200.3a	194.6a
		Mean	180.9a	200.7a	200.1a	200.5a	195.3a	
	Pooled ANOVA	Exposed	179.9b	212.5a	195.3ab	193.9ab	201.2ab	200.4a
		Mulched	180.9a	200.7a	200.1a	200.5a	195.3a	191.7a
		Mean	180.4a	206.6a	197.7a	197.2a	198.2a	
Weight of 100 seeds g	Qushtappa	Exposed	21.171a	21.977a	21.682a	21.940a	21.937a	22.180a
		Mulched	21.722b	22.706a	22.647a	23.133a	22.583ab	22.120a
		Mean	21.446b	22.341a	22.164a	22.537a	22.260a	
	Ankawa	Exposed	21.343b	22.567a	22.603a	23.060a	22.833a	22.481a
		Mulched	22.100b	22.845ab	22.690ab	23.207a	22.333b	22.635a
		Mean	21.722b	22.706a	22.647a	23.133a	22.583a	
	Pooled ANOVA	Exposed	21.211a	22.067a	22.011a	21.997a	22.107a	21.878a
		Mulched	21.130a	21.887a	21.353a	21.883a	21.767a	21.604a
		Mean	21.171a	21.977a	21.682a	21.940a	21.937a	
Seed yield t ha^{-1}	Qushtappa	Exposed	1.209a	1.633a	1.361a	1.223a	1.375a	1.360a
		Mulched	1.086a	1.411a	1.128a	1.344a	1.461a	1.286a
		Mean	1.148b	1.522a	1.245ab	1.283ab	1.418ab	
	Ankawa	Exposed	1.206a	1.571a	1.602a	1.483a	1.217a	1.416a
		Mulched	1.269ab	1.514ab	1.095b	1.509ab	1.747a	1.427a
		Mean	1.238a	1.543a	1.349a	1.496a	1.482a	
	d A N	Exposed	1.148a	1.522a	1.245a	1.283a	1.418a	1.388a

		Mulched	**1.238a**	**1.543a**	**1.349a**	**1.496a**	**1.482a**	**1.356a**
		Mean	**1.193a**	**1.532a**	**1.297a**	**1.390a**	**1.450a**	

* 4SF : n Vu , indicates rows of sunflower : rows of Cowpea**Means with the same letter are not significantly different

treatments. The maximum mean number of seeds (206.6) was found in the pooled ANOVA: 4 SF:1 CP. The averages of mulched plots were somewhat lower significant in terms of statistics.

The effects of mulching differed according on the area; in Qushtappa, there was a modest suppression, but in Ankawa, there was no discernible pattern. Plot cover, location, and intercropping ratio correlations may become clearer with additional statistical research.

Weight of 100 Seeds (g): Qushtappa Seed weights in exposed plots varied little, ranging from 21.171g to 21.977g. Weights in mulched plots varied from 21.722g to 23.133g, indicating a minor benefit

There were not many differences between exposed and mulched areas. Key Takeaways for Seed Yield: In both sites, intercropping continuously performed better than pure stands. The best results were observed in 4 SF:1 CP and 4 SF:4 CP, when mulched plots marginally boosted seed output. Compared to Qushtappa, yields in Ankawa were often more reliable. Zhao, et al (2024) found that straw determined growth , yield and quality of sunflower.

Second: Yield and Yield components of Sunflower

Yield and Yield Components of Sunflower

The number of seeds at Ankawa varied slightly depending on the intercrop ratio. The 4 SF:4 CP ratio under mulched conditions had the highest value of 427.1 seeds plant^{-1}, while the 4 SF:3 CP ratio in exposed plots had the lowest value 390.0 seeds plant^{-1}. Seed output was positively impacted by mulching, although there was only a slight variance between intercrop types. In both locations, mulched plots performed better than exposed plots, according to the pooled ANOVA results. Under mulched conditions, the 4 SF:4 CP ratio produced the greatest mean of 422.0 seeds plant^{-1}, indicating a notable benefit in this cropping method. In conclusion, mulching improves sunflower yield performance across all intercrop kinds. Depending on location-specific conditions, various intercrop ratios exhibit superior productivity. The relationship among cover type, location. The yield performance of sunflowers under various cowpea intercrop types in both bare and mulched plots at two locations—Qushtappa and Ankawa—is shown in the table. The weight of 100 seeds (g) and the quantity of seeds per head are among the characteristics that are measured. Regarding the quantity of seeds per head: In comparison to exposed plots, mulched plots at Qushtappa consistently produced more seeds at all intercrop ratios. The pure sunflower stand under exposed conditions had the lowest mean value (332.3), whereas the 4 SF:1 CP ratio under mulched conditions had the highest mean value (396.6). In terms of seed yield, mulched plots did better than exposed ones overall. The amount of seeds at Ankawa varied slightly depending on the intercrop ratio. The 4 SF:4 CP ratio under mulched conditions had the highest value (427.1), while the 4 SF:3 CP ratio in exposed plots had the lowest value (390.0). Seed output was positively impacted by mulching, although there was only a slight variance between intercrop types.

Table 8 : Yield performance of Sunflower under addition intercrop type between cowpea and sunflower in exposed and mulched plots at the locations of Qushtappa and Ankawa

Trait	**Plot location and cover type**		**Intercrop row ratios, Sunflower (SF): Cowpea (CP)**					
			Sole Sunflower	**4 SF: 1 CP**	**4SF:2 CP**	**4 SF: 3 CP**	**4 SF:4 CP**	**Mean**
	Qushtappa	**Exposed**	332.3b	389.8a	361.7ab	384.2a	381.8ab	369.9a
		Mulched	366.5a	396.6a	392.9a	381.4a	376.5a	382.8a
		Mean	349.4b	393.2a	377.3ab	382.8ab	379.2ab	

Seed yield No. of seeds plant^{-1}	**Ankawa**	**Exposed**	406.1ab	406.8ab	405.5ab	390.0b	416.9a	405.1a
		Mulched	394.3b	394.4b	396.1b	412.6ab	427.1a	404.9a
		Mean	400.2b	400.6b	400.8b	401.3b	422.0a	
	Pooled ANOVA	**Exposed**	349.4b	393.2a	377.3ab	382.8a	379.2ab	387.5a
		Mulched	400.2a	400.6a	400.8a	401.3a	422.0a	393.8a
		Mean	374.8b	396.9b	389.1b	392.1b	400.6a	
Weight of 100 seeds (g)	**Qushtappa**	**Exposed**	11.550a	11.773a	12.767a	12.523a	12.550a	12.233a
		Mulched	11.850b	12.563ab	13.520a	13.070ab	13.347ab	12.870a
		Mean	11.700b	12.168ab	13.143a	12.797a	12.948a	
	Ankawa	**Exposed**	11.107b	13.227a	12.883a	13.063a	13.480a	12.752a
		Mulched	11.937b	13.510a	12.750ab	13.097a	13.537a	12.966a
		Mean	11.522b	13.368a	12.817a	13.080a	13.508a	
	Pooled ANOVA	**Exposed**	11.700b	12.168ab	13.143a	12.797ab	12.948a	12.492a
		Mulched	11.522b	13.368a	12.817a	13.080a	13.508a	12.918a
		Mean	11.611b	12.768a	12.980a	12.938a	13.228a	
Seed yield t ha^{-1}	**Qushtappa**	**Exposed**	1.745b	2.100ab	2.119a	2.205a	2.281a	2.090a
		Mulched	1.887a	2.202a	2.190a	1.985a	2.092a	2.071a
		Mean	1.816b	2.151a	2.155a	2.095a	2.187a	
	Ankawa	**Exposed**	2.167b	2.298b	2.397ab	2.199b	2.575a	2.327b
		Mulched	2.121b	2.537a	2.365ab	2.509a	2.512a	2.409a
		Mean	2.144c	2.417ab	2.381ab	2.354b	2.544a	
	Pooled ANOVA	**Exposed**	1.816b	2.151a	2.155a	2.095a	2.187a	2.209b
		Mulched	2.144b	2.417a	2.381ab	2.354ab	2.544a	2.240a
		Mean						

* 4SF : n Vu , indicates rows of sunflower : rows of Cowpea**Means with the same letter are not significantly different

In both locations, mulched plots performed better than exposed plots, according to the pooled ANOVA results. Under mulched conditions, the 4 SF:4 CP ratio produced the greatest mean yield (422.0), indicating a notable benefit in this cropping method. Regarding 100 seeds' weight (g): When comparing mulched and exposed plots in Qushtappa, the weight of 100 seeds was often higher in the former. The greatest average weight. Mulched plots at Ankawa also displayed increased seed weight. The 4 SF:4 CP ratio under mulched conditions had the highest value (13.537 g), while the pure stand under exposed conditions had the lowest value (11.107 g). Across all intercrop ratios, mulching reliably increased the weight of 100 seeds, according to the pooled ANOVA results. The 4 SF:4 CP ratio under mulched settings had the highest pooled mean (13.508 g), indicating a notable improvement brought about by mulching.

The yield performance of sunflowers under various cowpea intercrop types in both bare and mulched plots at two locations—Qushtappa and Ankawa—is shown in the table. Among the characteristics that are measured are the quantity of seeds per head ,the weight of 100 seeds (g), and seed yield (t ha^{-1}). Regarding the quantity of seeds per head, at Qushtappa, mulched plots continuously yielded more seeds than exposed plots in every intercrop ratio. The pure sunflower stand under exposed conditions had the lowest mean value (332.3), whereas the 4 SF:1 CP ratio under mulched conditions had the highest mean value (396.6). In terms of seed yield, mulched plots

did better than exposed ones overall. The amount of seeds at Ankawa varied slightly depending on the intercrop ratio. The 4 SF:4 CP ratio under mulched conditions had the highest value (427.1), while the 4 SF:3 CP ratio in exposed plots had the lowest value (390.0). Seed output was positively impacted by mulching, although there was only a slight variance between intercrop types.

In both locations, mulched plots performed better than exposed plots, according to the pooled ANOVA results. Under mulched conditions, the 4 SF:4 CP ratio produced the greatest mean yield (422.0), indicating a notable benefit in this cropping method. Regarding 100 seeds' weight (g): When comparing mulched and exposed plots in Qushtappa, the weight of 100 seeds was often higher in the former. The pure sunflower stand under exposed conditions had the lowest mean weight (11.550 g), whereas the 4 SF:2 CP ratio under mulched conditions had the highest mean weight (13.520 g). Mulched plots at Ankawa also displayed increased seed weight. Under mulched conditions, the 4 SF:4 CP ratio had the maximum value (13.537 g) , Across all intercrop ratios, mulching reliably increased the weight of 100 seeds, according to the pooled ANOVA results. The 4 SF:4 CP ratio under mulched settings had the highest pooled mean (13.508 g), indicating a notable improvement brought about by mulching. Regarding the seed yield (t ha^{-1}): In general, mulched plots at Qushtappa produced more seeds than exposed plots. Under exposed circumstances, the 4 SF:4 CP ratio produced the maximum yield (2.281 t ha^{-1}), whereas mulched plots produced yields that were comparatively constant across all ratios. Similar trends were seen in seed yield at Ankawa, where mulched plots outperformed exposed plots. Under exposed circumstances, the 4 SF:4 CP ratio produced the maximum yield (2.575 t ha^{-1}), whereas mulched conditions also consistently produced high yields. These results reinforce the conclusion that mulching enhances sunflower yield components and productivity across different intercrop configurations, further supporting sustainable agricultural practices as described by Mousavi and Eskandari (2011).

4. Conclusion

Although productivity varies by location, cover type, and intercrop ratio, mulching increases sunflower production throughout intercrop systems. The optimal ratio is 4 SF:4 CP, particularly during the later growth stages (45–60 days). Additionally, mulching enhances the development of cowpea leaves, surpassing bare circumstances and guaranteeing the best possible crop production.

Recommendations

Intercropping sunflower (SF) with cowpea (CP) increases seed weight and yield, particularly at 4 SF:1 CP and 4 SF:4 CP ratios, and it works well everywhere. Mulching retains soil moisture, which improves results. Environmental variables influencing the variability between Qushtappa and Ankawa should be the focus of future research.

5. Reference

Adebayo, A.K., Anjorin, F.B., Olanipekun, S.O., Aluko, O.A. and Adewumi, A.D., 2024. Performances of Maize Grown as Intercrop with Cowpea under Different Planting Patterns. *Journal of Applied Sciences and Environmental Management*, *28*(7), pp.2033-2040.

Dizayee, A.S. and Maaroof, S.M.A., 2020. Growth, Yield and Yield Components of Wheat (Triticum Aestivum L.), Chickpea and Wild Mustard as Influenced by Intercropping in Different Row Proportions. Zanco Journal of Pure and Applied Sciences, 32(1), pp.115-126.

Ferreira, T. and Rasband, W., 2012. ImageJ User Guide: IJ 1.42 r. National Institute of Health.

Gupta, Meena, K.A., J.K., Dular, R.K., Bhinchhar, B.K., Meena, R.K., Meena, M.D. and Meena, R.K., 2022. Impact of Cluster Front Line Demonstrations on the Yield and Economics of Chickpea under National Food Security Mission in Bharatpur District of Rajasthan, India. *Legume Research-An International Journal*, *45*(9), pp.1161-1166.

Li, Zhang, W.P., Liu, G.C., J.H., Fornara, D., Zhang, L.Z., Zhang, F.F. and Sun,L., 2017. Temporal Dynamics of Nutrient Uptake by Neighbouring Plant Species: Evidence from Intercropping. Functional Ecology, 31(2), pp.469-479.

Mousavi, S.R. and Eskandari, H. (2011) Intercropping as a Means of Sustainable Agriculture', Journal of Applied Environmental and Biological Sciences, 1(9), pp. 1581–1588.

Patel, Singh, 2020. *Intercropping and Relay Cropping to Increase Productivity, Resilience, and Long-term Sustainability of Corn and Soybean Cropping Systems in Lowa* (Doctoral Dissertation, Lowa State University).

Raza, M.A., Feng, L.Y., Van Der Werf, W., Iqbal, N., Khan, I., Khan, A., Din, A.M.U., Naeem, M., Meraj, T.A., Hassan, M.J. and Khan, A., (2020). Optimum Strip Width Increases Dry Matter, Nutrient Accumulation, and Seed Yield of Intercrops under the Relay Intercropping System. *Food and Energy Security*, *9*(2), p.e199.

Sadiq, W.O., 2023. *Studies on Growth, Yield and Efficiency in Cowpea/Sesame Intercropping as Influenced by Spatial Arrangement and Population* Density (Master's thesis, Kwara State University (Nigeria)).

Singh, P., et al. (2023) Understanding Soil Carbon and Phosphorus Dynamics under Grass-legume Intercropping in a Semi-arid Region. Agronomy, 13(7), p.1692

Tahir, S.M., Sa'adu, M., Ibrahim, N.M. and Dalhatu, A.S., 2024. Effect of Inter and Intra Row Spacing on Performance of Cowpea (Vigna Unguiculata (L.) Walp.) During Cropping Season in Randagi Birnin Gwari Kaduna State, Nigeria. *IOASD J Med Pharm Sci*, *1*(1), pp.38-44.

Vandermeer, J. (1992) The Ecology of Intercropping. Cambridge University Press.

Willey, R.W. (1979) Intercropping—Its Importance and Research Needs. Part 1: Competition and Yield Advantages', Field Crops Abstracts, 32(1), pp. 1–10.

Zhang, X., Li, T., and Makowski, D. (2023) The productive Performance of Intercropping. Proceedings of the National Academy of Sciences, 120(2), p.e2201886120

Zhao, N., Bai, L., Han, D., Yao, Z., Liu, X., Hao, Y., Chen, Z., Zhang, X., Zhang, D., Jin, X. and Wang, Z., 2024. Combined Application of Leguminous Green Manure and Straw Determined Grain Yield and Nutrient Use Efficiency in Wheat–Maize–Sunflower Rotations System in Northwest China. *Plants*, *13*(10), p.1358.