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A Preliminary Study on the Allelopathic Impact of Vigna radiata on Wheat Growth

Vigna radiata'nın Allelopatik Etkisinin Buğday Gelişimi Üzerine Ön Çalışma

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Abstract

Allelopathy is a natural mechanism that offers an environmentally friendly alternative to agrochemicals. While the allelopathic potential of mung bean (*Vigna radiata* L.) on wheat production is recognized, its effect under field conditions has not been fully investigated. The primary objective of this preliminary study was to observe the allelopathic impact of *Vigna radiata* in different treatment forms on wheat growth and weed dynamics. The study was conducted in a small-scale, non-replicated experimental field over two years, utilizing two separate allelopathic sources. In the first year, fermented extract from *Vigna radiata* seeds was applied, and in the second year, fermented extract from pod husk was used. Wheat growth, yield, and weed emergence parameters were subsequently observed until the harvest period. Observations revealed that *Vigna radiata* treatments notably suppressed weed emergence. Regarding wheat yield, both treatments did not cause a negative effect compared to the control groups; in fact, the results for the 1000 grain weight parameter were superior to the control group. These findings indicate that allelochemicals from *Vigna radiata* possess potential for effective weed control. Despite the limitations of being a small scale, non-replicated study, the findings provide a crucial hypothetical foundation, demonstrating that *Vigna radiata* has a beneficial allelopathic potential for both weed management and yield quality. These preliminary observations provide a strong justification for future comprehensive, replicated, and controlled field trials necessary for low-input agricultural systems.

Öz

Allelopati, tarım kimyasallarına çevre dostu bir alternatif sunan doğal bir mekanizmadır. Maş fasulyesinin (*Vigna radiata* L.) buğday üretimi üzerindeki allelopatik potansiyeli bilinmesine rağmen, tarla koşulları altındaki etkisi tam olarak araştırılmamıştır. Bu ön araştırma çalışmasının temel amacı, farklı uygulama formlarındaki *Vigna radiata*'nın buğday büyümesi ve yabancı ot dinamikleri üzerindeki allelopatik etkisini gözlemlemektir. Çalışma, iki yıl boyunca küçük ölçekli, tekrarlanmamış bir deneme alanında, iki ayrı allelopatik kaynak kullanılarak yürütülmüştür. Denemenin birinci yılında *Vigna radiata* tohumlarından, ikinci yılında ise bakla kabuğundan elde edilen fermente ekstraktlar uygulanmıştır. Buğday büyüme, verim ve yabancı ot çıkış parametreleri hasat dönemine kadar gözlemlenmiştir. Gözlemler, *Vigna radiata* uygulamalarının yabancı ot çıkışını önemli ölçüde baskıladığını ortaya koymuştur. Buğday verimi açısından *Vigna radiata* uygulamaları, kontrol gruplarına kıyasla olumsuz bir etki oluşturmamış; aksine, 1000 tane ağırlığı parametresinde kontrol grubundan daha üstün sonuçlar elde edilmiştir. Bu bulgular, *Vigna radiata*'dan elde edilen allelokimyasalların yabancı ot kontrolünde etkili olduğunu göstermektedir. Küçük ölçekli ve tekrarlanmamış bir çalışma olmasının getirdiği sınırlamalara rağmen, bulgular *Vigna radiata*'nın hem yabancı ot yönetimi hem de verim kalitesi açısından faydalı bir allelopatik potansiyele sahip olduğunu gösteren önemli bir hipotez temeli sunmaktadır. Bu ön araştırma gözlemleri, düşük girdili tarım sistemleri için gerekli olan kapsamlı, tekrarlanmış ve kontrollü tarla denemeleri için güçlü bir gerekçe oluşturmaktadır.

INTRODUCTION

Wheat *(Triticum spp*.), which holds strategic importance in global food security, is the fundamental food source for millions of people worldwide (Ulukan, 2024; Sharma & Sharma, 2025). However, modern wheat production faces significant challenges, particularly those related to weed control and the resulting environmental impacts from the increased use of synthetic herbicides (Nakka et al., 2019; Ofosu et al., 2023). In this context, allelopathy emerges as a natural biological mechanism defined as the positive or negative influence on the growth of surrounding plants through secondary metabolites (allelochemicals) secreted by a plant (Cheng & Cheng, 2015; Latif et al., 2017).

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Allelopathy has been characterized as a phenomenon where one plant exerts a direct or indirect, either beneficial or detrimental, influence on another through the release of chemical compounds (allelochemicals or phytotoxins) into the surrounding environment (Rice, 1984). These compounds are introduced into the system via various mechanisms in both natural and agricultural settings, including root exudation, leaching, volatilization, stem flow, and the decomposition of plant residues (Birkett et al., 2001; Aslam et al., 2017). Allelopathy offers an environmentally friendly alternative for sustainable and low-input agricultural systems by harboring potential in both weed control and plant growth promotion (Narwal, 2006; Mushtaq et al., 2020; Scavo & Mauromicale, 2021).

The nature of allelopathic interactions varies significantly depending on the type of allelochemicals secreted and the physiological response of the target plant. Extensive studies have documented the weed-suppressing capabilities of cereal crops; for instance, rye (*Secale cereale* L.) and wheat (*Triticum aestivum* L.) have been reported to significantly inhibit the germination of subsequent weeds through the release of phenolic acids and benzoxazinoids (Putnam & DeFrank, 1983; Macías et al., 2007). Furthermore, the herbicidal activity of aqueous extracts from plants such as sorghum, rice, maize, sunflower, and eucalyptus, as well as various medicinal species, has been extensively demonstrated as an effective strategy for weed control across diverse environmental conditions (Subramanyam et al., 2013). Similarly, the compound "sorgoleone," exuded from the roots of sorghum (*Sorghum bicolor* L.), exhibits potent natural herbicidal activity by disrupting the photosynthetic electron transport system even at very low concentrations (Dayan, 2006). Beyond inhibitory effects, it has been observed that certain plant extracts at low dosages can act as growth regulators by stimulating cell division and nutrient uptake in target species (Farooq et al., 2011). These findings reinforce the role of allelochemicals as strategic tools in reducing reliance on synthetic herbicides and maintaining ecological balance.

Vigna radiata, which belongs to the Fabaceae family, is a valuable crop in agricultural systems due to its rapid growth, nitrogen-fixing ability, and short vegetation period (Mehandi et al., 2019). Findings in the literature indicate that various parts of, including plant residues and root exudates, possess allelopathic potential (Lertmongkol et al., 2011; Aslam et al., 2017). This potential, mostly investigated in controlled laboratory or petri dish studies, is primarily known to inhibit the germination of weed seeds (Azirak & Karaman, 2008; Möhler et al., 2018; Li et al., 2021). However, a significant knowledge gap persists regarding how these effects would manifest under real field conditions interacting with soil, climate, and other plant dynamics throughout the entire developmental period of wheat. Furthermore, the efficacy of fermented extract forms, which could be easily applied by local farmers, is yet to be fully explored.

Considering this knowledge deficit, it became imperative to investigate the allelopathic potential of *Vigna radiata* under actual field conditions. A critical component of this research is the assessment of allelopathic applications derived from two distinct sources (fermented seed and pod husk extracts) for their capacity to suppress the natural emergence of weeds, in addition to their potential influence on wheat yield. Accordingly, the current study is designed as an initial, small scale, non-replicated observational study aiming to characterize the existence and nature of the allelopathic effect prior to any large-scale field applications.

The primary aim of this preliminary study is to observe the effect of the fermented *Vigna radiata* extracts, applied over two distinct years, on wheat growth, yield parameters, and weed emergence dynamics. The findings are expected to present preliminary data demonstrating the allelopathic efficacy of *Vigna radiata* and its potential to contribute to weed control without negatively impacting yield quality.

MATERIALS AND METHODS

Study Area and Experimental Design

The study was conducted at University of Dicle, Faculty of Agriculture Department of Field crops, Diyarbakır, Türkiye, under semi-controlled conditions during 2020 and 2025.

The plant materials consisted of a mung bean variety (*Vigna radiata* L.), the NM54 (Pakistan origin), a local chickpea (*Cicer arietinum* L.) variety, and two durum wheat (*Triticum turgidum* L. var. durum) varieties (Sena and local).

The mean monthly temperatures (°C) 2022-2023 and 2024-2025 growing seasons were presented in Table 1. The long-term mean temperature for the entire duration was 17.16 °C.

Table 1. Monthly mean temperatures (°C) recorded at Dicle University between 2019 and 2025

Months	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024	2024-2025
October	19.19	20.13	18.63	19.21	18.37	17.49
November	9.71	10.44	11.48	10.77	11.57	9.14
December	6.81	4.75	3.97	6.71	6.42	3.91
January	3.71	4.12	2.11	3.17	5.4	3.94
February	3.68	7.08	7.1	3.14	6.54	2.98
March	10.56	8.46	5.7	11.51	8.91	11.66
April	13.6	15.97	16.82	13.74	17.27	14.48
May	19.29	23.9	18.41	18.66	19.37	21.82
June	26.07	27.94	27.64	26.72	29.83	28.23
July	31.27	32.48	31.82	31.43	31.77	32.77
August	30.45	31.1	31.38	32.06	31.64	31.88
September	27.74	25.46	26.62	26.49	25.39	25.45
Mean	**16.84**	**17.65**	**16.81**	**16.97**	**17.71**	**16.98**

The experiment was designed as preliminary field studies. Two plots, each 4 square meters, were arranged for the trial.

The trial soil was prepared from the soil where wheat and mung bean were grown as pre crops during the previous summer and winter growing season. However, the soils of mung bean and wheat were not mixed. Crop rotation and applications for the plots were given in Table 2.

Table 2. Crop rotation cycles on the plots

Growing season	Plot-1	Sowing Date	Plot-2	Sowing Date
2015-2016	Chickpea	November 2015	Fallow	-
2016-2017	Chickpea	February 2016	Fallow	-
2017-2018	Wheat	December 2017	Fallow	-
2018-2019	Chickpea	February 2019	Fallow	-
2019-2020	Wheat	December 2019	Mung bean	April 2020
2020-2021	Wheat	1 Jan, 9 Feb, 14 March	Wheat	1 Jan, 9 Feb, 14 March
2021	Chickpea	21 April Spring	Chickpea	21 April 2021
2021-2022	Fallow	-	Fallow	-
2022	Mung bean	April Spring	Chickpea	March Spring
2022-2023	Wheat	December 2022	Wheat	December 2022
2023-2024	Fallow	-	Fallow	-
2024	Chickpea	14 March 2024 Spring	Mung bean	22 April 2024 Spring
2024-2025	Wheat	1 December 2024	Wheat	1 December 2024

Methods

Preparation fermented seed extract: mung bean seed extract was prepared from 1000 g dry mung bean (cv. NM54) seeds. The seeds were placed in a 10 liter container with tap water, and fermented for a period of one month.

Fermented pod husk extract: mung bean pod husk extract was prepared from 1000 g dry mung bean pod husks. The residue was placed in a 20 liter container with tap water, and fermented for a period of one month.

To ensure a controlled fermentation process and prevent photodegradation of potential allelochemicals, the incubation was maintained at a temperature of 20±5 °C under strictly dark conditions. Following the fermentation period, the resulting extract was filtered and stored for further experimental use.

Wheat seeds were sown on three different dates of 2021 (1 January, 9 February, 14 March), chickpea seed was sown 21 March and plants were harvested in June, and wheat and chickpeas were planted and harvested in each trial year. Plots were fallow until 2022, and weed emergence was recorded. Crop rotation was wheat and mung bean for Plot 1. Crop rotation was mung bean and wheat for Plot 2.

Wheat was sown with seeding rate 450 seeds m^2 in both plots on 17 December 2022. Pre-sowing fertilization was supplied 60 kg ha^{-1} as DAP (18-46-0), then top dressing was applied at a rate of 150 kg ha^{-1} urea (%46 N). Chickpea was sown in 7 row plots of 4 m length with between-and within row spacing of 0.50 m and 0.10 m, respectively in June 2021 and 11 row between-and within row spacing of 0.35 m and 0.10 m in 21 March 2022. Mung bean was sown 11 row between-and within row spacing of 0.35 m and 0.10 m in 21 April 2022

Fermented Seed Extract Treatment, in 2022–2023 growing season, following wheat emergence, the fermented mung bean seed extract was applied to Plot 2 with irrigation water. Plot 1 was irrigated but non treated as extract.

Fermented Pod Husk Extract Treatment, 2024–2025 Growing Season, wheat was sown in both plot1 and plot2. Wheat planting procedures from the previous year were applied. Following wheat emergence, the fermented extract from mung bean pod husks was applied to Plot 1 with irrigation water, but Plot 2 was control.

Pre-ear emergence, weeds were harvested, dried, and weighed to determine their dry weight. This parameter was used as a key indicator to evaluate the allelopathic suppression potential of the mung bean.

During the tillering stage (Zadoks scale 20–29, 106 days after sowing), plant samples were collected from an area of 400 cm^2 (20 x 20 cm quadrat) in both plots (Figure 1).



Figure 1. Wheat and weed development during the 2022-2023 season

Observations were taken on plant height (cm), spike length (cm), number of spikes per square meter (count), spikes per square meter (g), grain number per square meter (count) and 1000 grain weight (g). Observational data regarding weed emergence and wheat growth were analyzed through descriptive statistics, with results expressed as mean values for each parameter.

RESULTS

The initial results focus on characterizing the allelopathic influence of *Vigna radiata* extracts on early-stage growth, weed dry weight, and key wheat yield parameters compared to the control plots.

Observations across both application years indicate that *Vigna radiata* treatments were effective in suppressing weed biomass compared to the control plots (Table 3).

Table 3. Effects of fermented mung bean seed extract (2023) and pod husk extract (2025) on weed dry weight

	2023			2025		
Treatment	Control	Treated	Suppression vs Control (%)	Control	Treated	Suppression vs Control (%)
Fermented extract of mung bean	92.74	54.52	41.2	126.5	9.2	92.7

For fermented seed extract treatment, dry weight for weed treated with fermented seed extract treatment was lower than control in the 2023 season.

For fermented pod husk extract treatment, a highly pronounced suppression was observed, with the weed dry weight in the treated plot being remarkably low compared to the control, indicating a reduction in the 2025 season.

Early-stage plant developmental parameters, measured at the tillering stage (Zadoks scale 20–29, 106 days after sowing) in the 2023 season, indicated that the allelopathic treatment had a minimal impact on wheat growth, although the control group generally exhibited higher biomass (Table 4).

Table 4. Growth parameters of wheat plants at the tillering stage (Zadoks 20–29)

	Plant height (cm)	Root length (cm)	Stem Fresh Weight (g)	Root Fresh Weight (g)	Stem Dry Weight (g)	Root Dry Weight (g)
Control	42.15	21	95.22	43.69	17.26	8.98
Treated	33.6	19	32.14	25.57	6.62	5.05

Yield and yield components were presented in Table 5.

Table 5. Yield and yield components of wheat in treated and control plots during 2022–2023 and 2024–2025 seasons

	2022-2023		2024-2025	
	Control	**Treated**	**Control**	**Treated**
Plant height (cm)	87.25	77.9	133.6	131.8
Spike length (cm)	6.7	6.1	9.7	12
Number of spikes per square meter	595	475	528	575
Spike weight per square meter (g)	1085	705	490	709
Seed weight per square meter (g)	830	516	358	450.6
1000 Seed weight (g)	43.33	45.62	31	36.2

The control group was high for seed weight per square meter in 2023, but the samples treated with extract were high in 2025. 1000-seed weight-a key quality indicator in both years (2023 and 2025) (Yildirim et al., 2018) and 1000 seed weight was higher in the treated with extract plots than control (Figure 2).



Figure 2. Differences in plant height, spike length, spike number, spike weight, and 1000-grain weight of wheat between extract treated and control plots during the 2023 and 2025 growing seasons

The observations presented in Figures 3-9 detail the temporal changes in the emergence and development of wheat, chickpea/mung bean, and weed populations across the entire rotation period (2021-2025), documenting the progression of crop-weed competitive dynamics.



Figure 3. Emergence of wheat and weeds in the 2020–2021 growing season

Wheat seedling emergence after mung bean was weaker and less dense. Weed emergence was high in continuous wheat planting areas, i.e., monoculture wheat rotation, but less in mung bean planting rotation (Figure 3). In spring 2021, a large difference in chickpea emergence was observed between the two plots. Almost no chickpea emerged in the plot previously planted with mung bean, while normal emergence occurred in the plot where wheat had been grown before (Figure 4). The lack of emergence in the mung bean plot was likely caused by allelopathic substances remaining in the soil, which suppressed the emergence of wheat, chickpea, and weeds.



Figure 4. Emergence of chickpea and weeds during spring 2021

After the chickpea emergence observations in spring 2021, both plots were left fallow until spring 2022. Weed emergence (eg. *Sonchus oleraceus* L., *Sinapis arvensis* L., *Malva sylvestris* L., *Echinochola crus-galli* L.) was higher in the plot where chickpea did not emerge and the soil remained unused for a longer period (Figure 5). This was likely due to the prolonged fallow period allowing weed seeds to remain viable without disturbance.

The fallow period observations in Figure 5 mapped the natural inter-seasonal shifts and intensity of weed populations independent of allelopathic interventions, providing a foundation for analyzing competitive pressure within the rotation. Research has demonstrated a significant influence of soil properties such as texture, organic matter, pH, and nutrient content on the spatial distribution of weed populations (Pätzold et al., 2020).



Figure 5. Weed emergence during the 2021–2022 fallow period

In autumn 2022, the plots were left fallow. In spring 2023, mung bean and chickpea were planted after wheat as part of the legume rotation (Figure 6). Both species showed full and healthy emergence.



Figure 6. Mung bean and chickpea rotation following the 2021–2022 fallow period

The central finding of the study clearly shows that, compared to the 2022–2023 season when fermented seed extract was applied (Figures 7), the fermented pod husk extract treatment utilized in the 2024–2025 wheat season (Figure 9) provided a distinctly higher and more effective suppression of weed emergence and development.



Figure 7. Wheat and weed emergence in 2022–2023 under control and fermented seed extract

In autumn 2023, the plots were left fallow. In spring 2024, mung bean and chickpea were planted after wheat as part of the legume rotation (Figure 8). Both species showed full and healthy emergence.



Figure 8. Mung bean and chickpea rotation after the 2023–2024 fallow period

In 2024, fermented extract was prepared using mung bean pod husks and applied with irrigation after wheat emergence. Weed and wheat emergence were monitored. Weed emergence was strongly suppressed (92.7%) in the treated plot compared to the control (Figure 9).

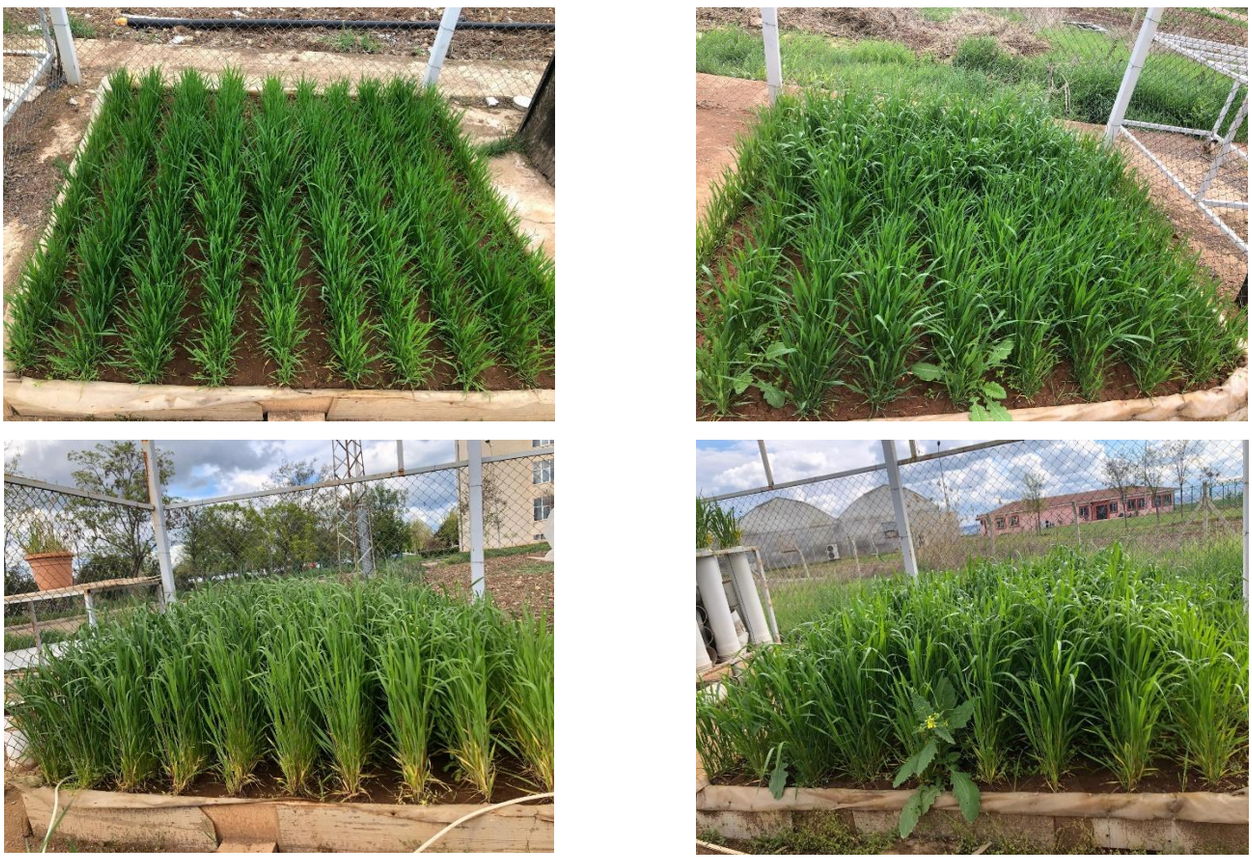


Figure 9. Wheat and weed emergence in 2024–2025 following fermented pod husk extract application

DISCUSSION

The primary objective of this small-scale preliminary study was to investigate the allelopathic potential of extracts, applied in two different forms over two consecutive wheat growing seasons, on weed dynamics and yield parameters under field conditions. The results from this observation provide compelling initial evidence supporting the use of derived allelochemicals as a sustainable weed management tool in wheat cultivation.

Efficacy in Weed Suppression

The main finding was the pronounced suppression of weed biomass observed in the treated plots across both treatment years (Table 3). The reduction in weed dry weight, particularly the dramatic reduction recorded in the second year (when fermented pod husk extract was used), strongly suggests that the allelochemicals present in the extracts effectively inhibited the natural emergence and/or growth of competing weeds. This observation aligned with previous controlled studies which established the herbicidal potential of mung bean residues, often attributed to the presence of specific secondary metabolites like phenols and alkaloids (Lertmongkol et al., 2011). Similarly, Gerami et al. (2012) reported that the superior weed suppression observed with mung bean and cowpea green manures aligns with findings indicating that mung bean, particularly when combined with 150 kg N ha^{-1}, provides the most effective inhibition of weed density and dry matter in subsequent wheat crops.

Impact on Wheat Performance

The allelopathic treatments did not impose a negative impact on the final wheat yield parameters (Table 5), an outcome highly desired for sustainable solutions. While some early-stage growth parameters (Table 4) showed lower fresh and dry weights compared to the control -likely due to the high concentration of applied extracts- the final yield demonstrated resilience. Furthermore, the consistently higher 1000 seed weight recorded in the treatment plots in both years (vs. in 2023; vs. in 2025) indicates that the effective weed suppression mitigated competitive stress, allowing the remaining wheat plants to allocate resources more efficiently to grain filling, thereby improving grain quality. The observed resilience of final wheat yield alongside the improved 1000 seed weight strongly supports the premise that effective allelopathic weed suppression successfully mitigates competitive stress, a mechanism that has been widely documented as crucial for optimizing resource allocation to grain filling and enhancing final crop quality in sustainable systems (Cheema et al., 2012; Naeem et al., 2018). The achievement of effective weed control without any negative imposition on final yield parameters aligns with the growing global need for sustainable solutions (Savić et al., 2025), positioning allelopathy as a promising, eco-friendly strategy to manage competition and enhance crop performance in wheat cultivation, thereby reducing reliance on synthetic herbicides (Jabran et al., 2015).

Comparison of Allelopathic Sources (Year 1 vs. Year 2)

The study utilized two distinct allelopathic sources: a fermented seed extract (Plot 1) and a fermented pod husk extract (Plot 2). The variation in the outcomes, especially regarding weed suppression, suggests differences in the quantity and type of allelochemicals present in these leachates.

The greater weed suppression (~92.7%) observed in the second year (pod husk extract) compared to the first year (~41.2% reduction) is noteworthy. This divergence suggests that the decomposition of *Vigna radiata* plant residues likely released a higher concentration or a broader spectrum of potent allelochemicals into the solution than the fermented seed extract. Similarly, Waller et al., (1995) reported that when stem extracts were partitioned using water and organic solvents, water extracts exhibited the strongest inhibitory effects on mung bean and lettuce growth. Moreover, soil bioassays after mung bean harvest also indicated residual allelopathic activity. Residues from previous crops are known to release compounds over a sustained period, enhancing the bio-efficacy of the extract. The selection of pod husk as a primary allelopathic source was specifically driven by their unique biochemical profile and their role as a significant agro-industrial byproduct that remains underutilized despite its high bio-activity. Researchers have identified black and green gram husk as protein-rich feed ingredients with optimal calcium-to-phosphorus ratios; furthermore, these husks exhibit significant antioxidant activity due to their high concentrations of polyphenols, flavonoids, tannins, carotenoids, and chlorophyll (Arulnathan et al., 2013; Basha & Rao, 2017; Krishnappa et al., 2017). This observation highlights the potential

superiority of fermented residue extract as a readily available, on-farm bio-herbicide resource for local farmers. This finding aligns with broader allelopathy research, where plant residues are often recognized as superior sources due to the decomposition process releasing a higher concentration and a wider array of bio-active compounds into the soil compared to simple aqueous extracts of seeds (Jabran et al., 2015; Naeem et al., 2018; Motalebnejad et al., 2023). Over-reliance on herbicides and indiscriminate spraying drive up farm input costs. This practice simultaneously leads to negative environmental impacts.

Limitations of the Study and Future Directions

These initial data successfully fill a critical gap in the literature by demonstrating the practical allelopathic potential of *Vigna radiata* in a field setting, moving beyond prior controlled laboratory studies. The critical need for field-scale validation is further reinforced by the work of Savić et al. (2025), who emphasize that a comprehensive understanding of plant competitive interactions, including the mechanisms of allelopathy, is essential for designing resilient, high-performing agroecosystems in changing environmental conditions.

CONCLUSION

This preliminary, two-year field study successfully investigated the allelopathic potential of extracts, derived from both seeds and pod husk residues, as a biologically-based weed management tool in wheat production. The principal finding confirms that the treatment of extracts significantly suppresses the emergence and biomass of naturally occurring weed species (eg. *Sinapis arvensis* L., *Avena sterilis* L., *Stellaria media* L.) in the field. Notably, the fermented pod husk extract demonstrated exceptional efficacy, achieving a substantial reduction in weed dry weight in the second year. These allelopathic treatments demonstrated no detrimental effect on wheat performance. Instead, the observed weed control likely mitigated interspecific competition, leading to a consistently higher 1000 seed weight (a key quality parameter) in the treated plots across both seasons compared to the control.

The observed allelopathic suppression of weed biomass by *Vigna radiata* extracts suggests a complex interaction involving natural phytotoxins that disrupt the physiological development of resident weed species without compromising wheat vigor. This selective inhibitory effect is particularly significant in the context of increasing global herbicide resistance, as it highlights the potential for botanical derivatives to serve as effective bio-herbicides. Furthermore, the enhancement of wheat quality parameters, such as the 1000 seed weight, indicates that the reduction in weed crop competition directly translates into improved resource use efficiency (RUE) for the primary crop. By integrating such allelopathic interventions, farmers can potentially reduce their reliance on synthetic inputs, thereby promoting soil health and biodiversity within the agroecosystem. These findings align with the principles of integrated weed management (IWM) and underscore the need for further metabolomic profiling to identify the specific allelochemicals responsible for these inhibitory effects.

These preliminary observations offer compelling pioneering data that strongly support the hypothesis that *Vigna radiata* possesses beneficial allelopathic properties suitable for integration into sustainable and low-input agricultural systems. This work provides the necessary scientific foundation to justify larger, statistically replicated field trials, which are essential for developing and validating effective, environmentally friendly weed control strategies for global wheat production. This pioneering field study suggests that *Vigna radiata* derivatives hold substantial promise for integration into sustainable, low input weed management strategies in wheat production.

REFERENCES

Arulnathan, N., Murugan, M., & Balakrishnan, V. (2013). Proximate principles, Fibre fraction and Mineral content of Black gram husk (*Vigna mungo*). *International Journal of Livestock Research*, 3(3), 24-30. https://www.researchgate.net/profile/N-Arulnathan-2/publication/346521108

Aslam, F., Khaliq, A., Matloob, A., Tanveer, A., Hussain, S., & Zahir, Z.A. (2017). Allelopathy in agro-ecosystems: a critical review of wheat allelopathy-concepts and implications. *Chemoecology*, 27(1), 1-24. https://doi.org/10.1007/s00049-016-0225-x

Azirak, S., & Karaman, S. (2008). Allelopathic effect of some essential oils and components on germination of weed species. *Acta Agriculturae Scandinavica Section B-Soil and Plant Science*, 58(1), 88-92. https://doi.org/10.1080/09064710701228353

Basha, S.A., & Rao, U.P. (2017). Bioactivities of fractions obtained from green gram (*Vigna radiata*) milled by-products. *Food Bioscience*, 19, 134-141. https://doi.org/10.1016/j.fbio.2017.07.004

Birkett, M.A., Chamberlain, K., Hooper, A.M., & Pickett, J.A. (2001). Does allelopathy offer real promise for practical weed management and for explaining rhizosphere interactions involving higher plants?. *Plant and Soil*, 232(1), 31-39. https://doi.org/10.1023/A:1010325801256

Cheema, Z.A., Farooq, M., Khaliq, A., & Haider, G. (2012). Allelopathy for weed management in wheat. *Pakistan Journal of Weed Science Research*, 2012, 18(Special Issue), 741-747.

Cheng, F., & Cheng, Z. (2015). Research progress on the use of plant allelopathy in agriculture and the physiological and ecological mechanisms of allelopathy. *Frontiers in Plant Science*, 6, 1020. https://doi.org/10.3389/fpls.2015.01020

Dayan, F.E. (2006). Factors modulating the levels of the allelochemical sorgoleone in *Sorghum bicolor*. *Planta*, 224(2), 339-346. https://doi.org/10.1007/s00425-005-0217-5

Farooq, M., Jabran, K., Cheema, Z.A., Wahid, A., & Siddique, K.H.M. (2011). The role of allelopathy in agricultural pest management. *Pest Management Science*, 67(5), 493-506. https://doi.org/10.1002/ps.2091

Gerami, F., Aynehband, A., & Fateh, E. (2012). Weed suppression in wheat (*Triticum aestivum* L.) by legume and non-legume green manures along with different N fertilizer levels. *International Journal of Agriculture and Crop Sciences*, 4(9), 556-560.

Jabran, K., Mahajan, G., Sardana, V., & Chauhan, B.S. (2015). Allelopathy for weed control in agricultural systems. *Crop Protection*, 72, 57-65. https://doi.org/10.1016/j.cropro.2015.03.004

Krishnappa, N.P., Basha, S.A., Negi, P.S., & Prasada Rao, U.J. (2017). Phenolic acid composition, antioxidant and antimicrobial activities of green gram (*Vigna radiata*) exudate, husk, and germinated seed of different stages. *Journal of Food Processing And Preservation*, 41(6), e13273. https://doi.org/10.1111/jfpp.13273

Latif, S., Chiapusio, G., & Weston, L.A. (2017). Allelopathy and the role of allelochemicals in plant defence. *In Advances in Botanical Research*, 82, 19-54. Academic Press. https://doi.org/10.1016/bs.abr.2016.12.001

Lertmongkol, S., Sarobol, E., & Premasthira, C.U. (2011). Allelopathic effects of mungbean (*Vigna radiata*) on subsequent crops. *Agriculture and Natural Resources*, 45(5), 773-779.

Li, J., Chen, L., Chen, Q., Miao, Y., Peng, Z., Huang, B., & Du, H. (2021). Allelopathic effect of *Artemisia argyi* on the germination and growth of various weeds. *Scientific Reports*, 11(1), 4303. https://doi.org/10.1038/s41598-021-83752-6

Macías, F.A., Molinillo, J.M., Varela, R.M., & Galindo, J.C. (2007). Allelopathy-a natural alternative for weed control. *Pest Management Science: Formerly Pesticide Science*, 63(4), 327-348. https://doi.org/10.1002/ps.1342

Mehandi, S., Quatadah, S.M., Mishra, S.P., Singh, I.P., Praveen, N., & Dwivedi, N. (2019). Mungbean (*Vigna radiata* L. wilczek): retrospect and prospects. In Legume crops-characterization and breeding for improved food security. *IntechOpen*.https://doi.org/10.5772/intechopen.85657

Motalebnejad, M., Karimmojeni, H., Majidi, M.M., & Mastinu, A. (2023). Allelopathic effect of aqueous extracts of grass genotypes on *Eruca sativa* L. *Plants*, 12(19), 3358. https://doi.org/10.3390/plants12193358

Möhler, H., Diekötter, T., Herrmann, J.D., & Donath, T.W. (2018). Allelopathic vs. autotoxic potential of a grassland weed-evidence from a seed germination experiment. *Plant Ecology & Diversity,* 11(4), 539-549. https://doi.org/10.1080/17550874.2018.1541487

Mushtaq, W., Siddiqui, M.B., & Hakeem, K.R. (2020). Allelopathy. *Springer International Publishing*. https://doi.org/10.1007/978-3-030-40807-7

Naeem, M., Cheema, Z.A., Ihsan, M.Z., Hussain, Y., Mazari, A., & Abbas, H.T. (2018). Allelopathic effects of different plant water extracts on yield and weeds of wheat. *Planta Daninha*, 36, e018177840.https://doi.org/10.1590/S0100835820183601000094

Nakka, S., Jugulam, M., Peterson, D., & Asif, M. (2019). Herbicide resistance: Development of wheat production systems and current status of resistant weeds in wheat cropping systems. *The Crop Journal*, 7(6), 750-760. https://doi.org/10.1016/j.cj.2019.09.004

Narwal, S.S. (2006). Allelopathy in ecological sustainable agriculture. In: Reigosa, M., Pedrol, N., González, L. (eds). In Allelopathy: a physiological process with ecological implications Dordrecht: *Springer Netherlands*. 537-564. https://doi.org/10.1007/1-4020-4280-9_24

Ofosu, R., Agyemang, E.D., Márton, A., Pásztor, G., Taller, J., & Kazinczi, G. (2023). Herbicide resistance: managing weeds in a changing world. *Agronomy*, 13(6), 1595. https://doi.org/10.3390/agronomy13061595

Pätzold, S., Hbirkou, C., Dicke, D., Gerhards, R., & Welp, G. (2020). Linking weed patterns with soil properties: a long-term case study. *Precision Agriculture*, 21(3), 569-588. https://doi.org/10.1007/s11119-019-09682-6

Putnam, A.R., & DeFrank, J. (1983). Use of phytotoxic plant residues for selective weed control. *Crop Protection*, 2 (2), 173-181. https://doi.org/10.1016/0261-2194(83)90042-X

Rice, E.L. (1984). *Allelopathy*. Academic Press, Inc. (London) Ltd. ISBN: 0-12-587055-8.

Scavo, A., & Mauromicale, G. (2021). Crop allelopathy for sustainable weed management in agroecosystems: knowing the present with a view to the future. *Agronomy*, 11 (11), 2104. https://doi.org/10.3390/agronomy11112104

Sharma, K., & Sharma, P.K. (2025). Wheat as a nutritional powerhouse: Shaping global food security. In *Triticum*-the pillar of global food security. *IntechOpen*, 215. https://doi.org/10.5772/intechopen.1009499

Savić, A., Popović, A., Đurović, S., Pisinov, B., Ugrinović, M., & Todorović, M.J. (2025). A framework for understanding crop–weed competition in agroecosystems. *Agronomy*, 15 (10), 2366. https://doi.org/10.3390/agronomy15102366

Subramanyam, D., Srinivasulu, D., Sumathi, V., & Sajitha, K. (2013). Plant origin herbicides: chemistry, mode of action and weed management. *International Journal of Agricultural Sciences*, 9(1), 413-422.

Ulukan, H. (2024). Wheat production trends and research priorities: A global perspective. In advances in wheat breeding: towards climate resilience and nutrient security. Singapore: *Springer Nature Singapore*. 1-22. https://doi.org/10.1007/978-981-99-9478-6_1

Waller, G.R., Cheng, C.S., Chou, C.H., Kim, D., Yang, C.F., Huang, S.C., & Lin, Y.F. (1995). Allelopathic activity of naturally occurring compounds from mung beans (*Vigna radiata*) and their surrounding soil. Allelopathy. *American Chemical Society*. 242-257. https://doi.org/10.1021/bk-1995-0582.ch018

Yildirim, M., Barutcular, C., Koc, M., Dizlek, H., Hossain, A., Islam, M.S., & Sabagh, A.E. (2018). Assessment of the grain quality of wheat genotypes grown under multiple environments using GGE biplot analysis. *Fresenius Environmental Bulletin*, 27(7), 4830-4837.