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IDENTIFICATION OF PRE AND POST EMERGENT SELECTIVE WEEDICIDE FOR EFFECTIVE CONTROL OF WEEDS IN FENUGREEK

Original Article

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ABSTRACT

Background: Fenugreek (*Trigonella foenum-graecum* L.) is a valuable forage legume known for its nutritional and medicinal uses, particularly in semi-arid regions. However, its productivity is often compromised by weed competition due to limited availability of selective herbicides. Effective weed control is crucial to optimize yield without compromising plant health. This study aimed to assess the comparative efficacy and phytotoxic effects of selected pre- and post-emergent herbicides on fenugreek growth, yield, and weed suppression under changing climatic conditions.

Objective: To evaluate the effect of selective herbicides and weed infestation on the growth, development, and forage yield of fenugreek.

Methods: The experiment was conducted during 2022–2023 at the Vegetable Research Institute, Faisalabad, using a randomized complete block design with six treatments replicated thrice. Treatments included two pre-emergent herbicides (Pendimethelene at 1000 mL/acre, Dual Gold at 800 mL/acre), two post-emergent herbicides (Cardinal at 2 g/acre, Quazilofop at 400 mL/acre), a weed-free control, and an untreated control. Data on plant height, leaf yield, and weed infestation were recorded. Environmental data were monitored to assess climatic influence.

Results: Days to first (78 days) and second cutting (32 days after) remained constant. Controlled plots recorded maximum plant height (90.2 cm) and leaf yield (29.69 T/Ha) with 100% weed control. Uncontrolled plots had 90% infestation, lowest height (40.1 cm), and yield (3.89 T/Ha). Cardinal achieved 70% weed control with 75.1 cm height and 26.6 T/Ha yield. Pendimethelene and Dual Gold achieved 80% and 90% weed control but showed stunted growth (65.2 cm, 23.75 T/Ha and 55.1 cm, 19.9 T/Ha respectively). Quazilofop caused leaf burning, resulting in the lowest herbicide-treated yield (18.09 T/Ha).

Conclusion: Cardinal offered the best balance between weed control and crop safety. Manual weeding remained the most effective. Integrated weed management is recommended to enhance productivity while minimizing herbicide-induced stress.

Keywords: Crop yield, Fenugreek, Herbicide toxicity, Plant height, Selective weed control, Trigonella foenum-graecum, Weeds.

INTRODUCTION

Fenugreek (*Trigonella foenum-graecum* L.), a diploid species (2n = 16) of the Fabaceae family, has long been valued for its medicinal, culinary, and agricultural utility. Originating from the Mediterranean region, it has been cultivated since ancient times, with archaeological evidence confirming its use in Mesopotamia and Egypt as early as 4000 BCE. Ancient civilizations employed its seeds for embalming, animal fodder, and as a traditional remedy, and it later gained prominence across India, North Africa, and the Middle East (1,2). The term "foenum-graecum," meaning “Greek hay,” reflects its historical use as livestock feed in Greco-Roman agriculture (1). The plant is characterized by trifoliate leaves, slender stems, pale yellowish flowers, and pods containing hard brown seeds that are both nutritionally dense and pharmacologically active (2,3). Today, fenugreek is cultivated globally, particularly in semi-arid regions such as India, Pakistan, Iran, Ethiopia, and parts of the Mediterranean, where it serves dual roles as a food and forage crop. In India, major production occurs in Rajasthan, Gujarat, Madhya Pradesh, and Uttar Pradesh, while in Ethiopia, it holds agronomic significance for smallholder farmers (3,4). Its agricultural appeal stems from its adaptability to dryland conditions, high biomass production, nitrogen-fixing ability, and notable protein content—ranging from 20% to 25%—making it an excellent forage component for mixed-livestock systems (5).

Despite its agronomic value, fenugreek cultivation is significantly hindered by weed infestation, especially during early growth stages. Due to its relatively slow initial growth, fenugreek is particularly vulnerable to competition from aggressive weed species such as *Chenopodium album*, *Amaranthus* spp., and *Cyperus rotundus*. These weeds compete for essential resources—light, water, nutrients, and space—leading to considerable yield losses if not controlled efficiently. Reports indicate that unchecked weed growth can cause biomass reductions of 30% to over 60%, depending on the density and species of weeds present (6,7). The critical period for weed competition typically occurs within the first 25–30 days after sowing, when fenugreek seedlings are unable to compete effectively (5,6). The lack of registered, crop-specific herbicides for fenugreek in countries like Pakistan presents a major constraint for optimizing yields. Being a minor crop in comparison to cereals or major legumes, fenugreek has received limited attention in herbicide development and registration. Most available herbicides are either broad-spectrum and damaging to the crop itself or have not been validated under local agronomic conditions (8). Consequently, farmers often rely on manual or mechanical weeding, which is both labor-intensive and cost-prohibitive, particularly in resource-limited and rain-fed settings. The absence of effective chemical weed control options represents a substantial gap in the management practices for fenugreek cultivation and highlights the need for targeted interventions to improve productivity and sustainability (9,10). In light of these challenges, the current study was designed to identify effective pre- and post-emergent weedicides for the control of weeds in fenugreek (*Trigonella foenum-graecum* L.), with the objective of enhancing forage yield, maintaining crop health, and reducing the labor burden associated with traditional weed management practices.

METHODS

The field trial was conducted at the Vegetable Research Institute, Faisalabad, during the 2022–2023 cropping season to evaluate the efficacy of selected herbicides on weed suppression and agronomic performance in *Trigonella foenum-graecum* L. (fenugreek). The experimental site is located in a subtropical agro-climatic zone at 31.4504°N latitude and 73.1350°E longitude, with an elevation of approximately 189 meters above sea level. The trial was laid out using a randomized complete block design (RCBD) consisting of five treatments, replicated three times, with each plot measuring 7.5 × 0.75 meters. The fenugreek variety "Methi Qasoori" was selected as the test cultivar for its regional adaptation and commonly cultivated status. A total of nine fenugreek genotypes were evaluated under the assigned treatments. Herbicide treatments included two pre-emergent and two post-emergent agents, with a fifth treatment representing a weed-free control (manual hoeing) and a sixth treatment left as the weedy check (no weeding conducted). The pre-emergent herbicides used were Pendimethalin at 1000 mL/acre and S-metolachlor (marketed as Dual Gold) at 800 mL/acre, both applied immediately after sowing. Post-emergent treatments included Flumetsulam (Cardinal) at 2 g/acre and Quazalofop at 400 mL/acre, administered 35 days after sowing when the crop had reached an adequate vegetative stage for selective spraying (11,12). The sowing was performed using the traditional "kera" method, and all agronomic inputs were standardized across treatments. A basal dose of one bag each of DAP and SOP per acre was applied at sowing, followed by an additional application of one bag of urea 20 days post-sowing to ensure optimal nutrient availability. Manual weeding by hoeing was restricted to the weed-free control plot, while no mechanical or chemical intervention was made in the weedy check plots, allowing for natural weed infestation and competition. The variables observed included plant height, fresh leaf yield, and weed incidence per unit area. Weather data covering temperature, rainfall, and humidity across the two growing seasons (October to April) were recorded through the Department of Agricultural Meteorology in Faisalabad for

contextual analysis of climatic influences on herbicide efficacy and plant performance. All data were recorded using standard field evaluation protocols.

Table : Comparative Evaluation of Pre- and Post-Emergent Herbicides on Growth, Yield, and Weed Suppression in Fenugreek (*Trigonella foenum-graecum* L.)

Sr.No	Herbicides	Mode	Dose
1	Pendimethelene	Pre-emergence	1000ml/acre
2	(Dual Gold) S-metolachlor	Pre-emergence	800ml/acre
3	Cardinal (Flumetsulam)	post-emergent	2g/acre
4	Quazilofop	post-emergent	400ml/acre

RESULTS

The application of different herbicide treatments had significant effects on the growth and yield parameters of *Trigonella foenum-graecum* L., as well as on weed suppression efficacy. Across all treatments, the days to first cutting remained consistent at 78 days, with the second cutting occurring uniformly 32 days later. This uniformity suggested that herbicide treatments did not alter the crop's cutting phenology directly; however, substantial variation was observed in plant height, leaf yield, and weed infestation. The manually controlled treatment exhibited the highest plant height of 90.2 cm and the highest leaf yield of 29.69 T/Ha, with zero weed infestation. In contrast, the un-controlled treatment, which received no weed management, resulted in the shortest plant height of 40.1 cm and the lowest yield of 3.89 T/Ha. This stark contrast highlighted the detrimental impact of unchecked weed competition on crop productivity. Among the herbicide treatments, Cardinal (flumetsulam) showed the most favorable results, with plant height reaching 75.1 cm and a leaf yield of 26.6 T/Ha. Pendimethelene also performed moderately well, with a plant height of 65.2 cm and a yield of 23.75 T/Ha. Dual Gold resulted in a plant height of 55.1 cm and a yield of 19.9 T/Ha, while Quazilofop recorded the lowest among the chemical treatments at 52.2 cm plant height and 18.09 T/Ha yield.

Weed infestation varied significantly across treatments. The un-controlled plot showed the highest infestation at 90%, followed by Quazilofop (70%) and Cardinal (60%). Pendimethelene and Dual Gold exhibited relatively lower weed presence at 40% and 30%, respectively. The weed species observed across plots included *Chenopodium murale*, *Chenopodium album*, and *Convolvulus arvensis*. Weed control effectiveness was highest in the manually weeded plot (100%), followed by Dual Gold (90%), Pendimethelene (80%), and both Cardinal and Quazilofop (70%). The treatments also differed in their phytotoxic impacts. Pendimethelene and Dual Gold were associated with stunted growth, potentially due to their interference with root development and hormonal signaling. Cardinal caused a general slowdown in plant growth without severe toxicity, while Quazilofop was associated with visible leaf burning, indicating chemical injury. Notably, all treatments shared the same cutting schedule, but biomass accumulation and growth characteristics varied, indicating that weed pressure and herbicide-induced stress influenced overall productivity. Although Dual Gold achieved superior weed control, it did not translate to the highest biomass, possibly due to residual phytotoxicity. Conversely, Cardinal balanced acceptable weed suppression with lower toxicity, resulting in a comparatively higher yield.

Table 1: Monthly Weather data during crop season October 2024 to April 2025

Month	Air Temp (oC)		Differ 1&2	Rel. Humidity %		Pan Evaporation (mm)		Rain fall (mm)	Wind velocity (km hour-1& days)		Dew	Cloudy		Soil Temp (100 cm depth)	Sun Shine Hours		Fog
	Max	Min		8:00 am	5:00 pm	8:00 am	5:00 pm		8:00 am	5:00 pm		Days	Nights		H	M	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
October	34.8	21.4	13.4	80.3	48.1	1.2	2.3	-	1.2/7	2.0/16	31	-	-	30.3	9	1	15
November	27.0	14.8	12.2	88.8	60.9	0.5	1.1	0.2	0.4/3	0.4/3	29	-	1	26.4	4	51	28
December	21.1	6.1	14.9	87.6	53.5	0.6	1.0	TR	1.0/6	1.6/12	31	-	-	20.9	5	56	6
January	21.5	5.5	16.0	88.0	51.5	0.6	1.2	TR	0.5/2	2.4/18	30	1	1	17.9	6	10	7
February	24.7	10.0	14.8	85.7	46.6	0.8	1.4	35.7	0.3/2	4.1/21	22	1	6	19.0	7	00	1
March	29.6	14.2	15.4	73.7	39.4	1.7	2.7	7.3	2.6/16	4.1/26	27	-	4	21.9	9	38	-
April	38.9	21.9	17.0	54.2	32.1	2.8	3.8	5.0	1.6/11	4.4/29	29	-	-	27.4	10	20	38.9

Table 2: Effect of Pre and post emergent herbicides on Fenugreek and weed control

Sr. No	Variety	Days to 1st cutting	Days to 2nd cutting	Plant height (cm)	Leaf yield (T/Ha)	Weeds infestation	Weeds	Weeds Control	Effect on plants
1	Pendimethelene	78	32	65.2	23.75	40%	Chenopodium murale, Chenopodium album, Convolvulus arvensis	80%	Stunted growth
2	Dual Gold	78	32	55.1	19.9	30%	Chenopodium murale, Chenopodium album, Convolvulus arvensis	90%	Stunted growth
3	Cardinal	78	32	75.1	26.6	60%	Chenopodium murale, Chenopodium album, Convolvulus arvensis	70%	Slow down plant growth
4	Quazilofop	78	32	52.2	18.09	70%	Chenopodium murale, Chenopodium album, Convolvulus arvensis	70%	Burning of leaves
5	Controlled	78	32	90.2	29.69	0%	Chenopodium murale, Chenopodium album, Convolvulus arvensis	100%	Un-effected
6	Un-Controlled	78	32	40.1	3.89	90%	Chenopodium murale, Chenopodium album, Convolvulus arvensis	0%	Slow growth

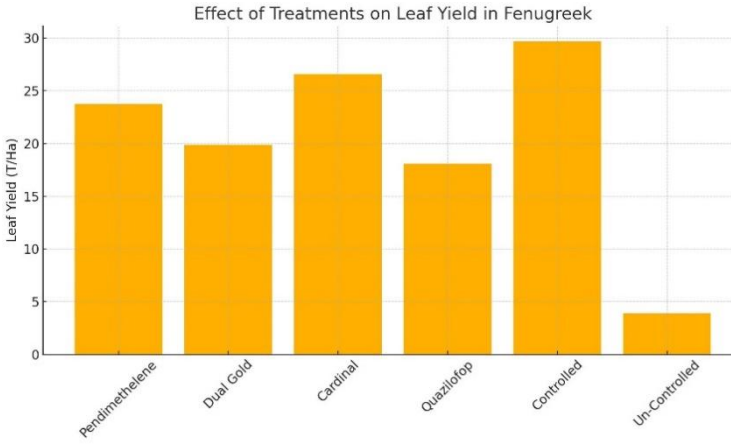

Figure 1 Effect of Treatments on Leaf Yield in Fenugreek

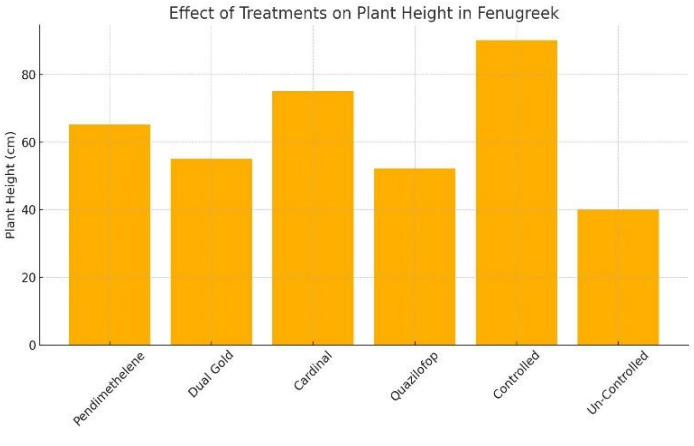

Figure 2 Effect of Treatments on Plant Height in Fenugreek

DISCUSSION

The findings of the present study provided clear evidence that effective weed control plays a pivotal role in enhancing vegetative growth and leaf yield of fenugreek under semi-arid climatic conditions. The manually weeded treatment consistently outperformed all herbicide-treated and unweeded plots in terms of plant height, leaf biomass, and overall weed suppression. This result confirms earlier reports that manual or integrated weed control strategies ensure optimal crop performance by minimizing competitive stress during critical early growth stages (12,13). The stable phenological timings for first and second cutting across all treatments, despite significant differences in biomass accumulation, reinforce the interpretation that environmental and genetic factors may play a more dominant role in phenological development, while weed control practices largely influence quantitative growth metrics. Among the herbicidal treatments, flumetsulam (Cardinal) demonstrated comparatively superior efficacy with respect to biomass yield and plant height, supporting its classification as a translocated herbicide with systemic action that effectively manages broadleaf weeds under favorable climatic conditions such as adequate sunlight and moisture (14,15). Nonetheless, moderate weed infestation persisted in Cardinal-treated plots, indicating that complete suppression was not achieved. This residual competition, alongside the herbicide's partial impact on metabolic pathways, likely contributed to delayed vegetative development, albeit without the severe stunting observed in other treatments. These results align with previous findings indicating that systemic herbicides with moderate selectivity often balance efficacy with lower crop phytotoxicity (16,17).

Pendimethelene and Dual Gold, both pre-emergent herbicides, resulted in noticeably stunted growth, which may be attributed to their respective mechanisms of action. Pendimethelene, known for its interference with microtubule assembly, and S-metolachlor (Dual Gold), which impairs fatty acid synthesis, likely induced phytotoxic effects at root zones, reducing nutrient uptake and subsequently limiting shoot development (18,19). Although these treatments showed better weed suppression than post-emergent options, the resulting plant stress underscores the importance of precise application timing and dosage. Stunting was particularly evident despite relatively lower weed infestation, suggesting a trade-off between chemical efficacy and crop tolerance. This reinforces the need to consider crop-specific sensitivity when recommending herbicides for minor crops like fenugreek (20). Quazilofop, a post-emergent grass-specific herbicide, demonstrated the least favorable outcome in terms of both biomass yield and plant health, with observable symptoms of phytotoxicity including leaf scorching and growth suppression. The relatively high weed infestation in Quazilofop-treated plots further highlighted its limited spectrum of control against broadleaf weeds such as *Chenopodium murale*, *Chenopodium album*, and *Convolvulus arvensis*, which were dominant across the site (21,22). These findings indicate that narrow-spectrum herbicides, even when effective against specific weed types, may be inadequate in mixed weed populations commonly found in field conditions. The interaction between climatic variability and herbicide performance was another significant observation. Reduced sunlight hours and high relative humidity due to smog and fog from October to December likely delayed photosynthesis and slowed herbicide breakdown, thereby influencing both crop and weed physiology (23). Fluctuating temperatures and diurnal shifts also impacted soil temperature and evaporation rates, which are known to modulate herbicide volatilization and root uptake dynamics. These environmental factors must be integrated into future weed management protocols to ensure consistent herbicidal performance under changing climatic scenarios.

A major strength of this study was its comprehensive environmental monitoring, which allowed for contextual interpretation of herbicide efficacy. The inclusion of both pre- and post-emergent herbicides provided a broader understanding of management options. However, limitations included the absence of detailed statistical validation (e.g., ANOVA or LSD testing), which restricts the ability to confirm the significance of observed differences. Furthermore, no residue analysis was performed to determine the persistence of herbicides in soil or crop tissue, a critical component for food safety assessments. The evaluation also did not consider economic parameters such as cost-benefit ratios, labor input, or herbicide application feasibility, which are essential for recommending practical weed control strategies to resource-limited farmers. Future studies should incorporate biochemical and physiological assessments to better understand the mechanisms underlying herbicide-induced phytotoxicity. Evaluations under varied sowing dates and across multiple agro-ecological zones would enhance generalizability. Additionally, integrating mechanical or cultural methods with chemical control in an integrated weed management (IWM) framework may optimize both crop safety and weed suppression. The findings of this research reinforce the necessity of crop-specific herbicide development and underscore the need for climate-resilient weed control solutions tailored to emerging agricultural challenges in semi-arid regions.

CONCLUSION

The study demonstrated that effective weed management significantly enhances the growth and yield of fenugreek under semi-arid conditions. Manual weed control proved most efficient, but among chemical options, flumetsulam (Cardinal) offered the best balance of efficacy and crop safety. In contrast, Pendimethelene and Dual Gold caused stunted growth, while Quazilofop led to phytotoxic effects. These findings underscore the importance of selecting herbicides with minimal crop impact and support the integration of selective herbicides into sustainable weed management practices for optimizing fenugreek production.

AUTHOR CONTRIBUTION

Author	**Contribution**
Kashif Rashid*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Waseem Abbas	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Muhammad Sajjad Saeed	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Ghazanfar Hammad	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Muhammad Amin	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Atif Ali	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Sajid Ali	Contributed to study concept and Data collection Has given Final Approval of the version to be published
Etlas Amin	Writing - Review & Editing, Assistance with Data Curation

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Osama Haris	Writing - Review & Editing, Assistance with Data Curation
Sajid Hussain	Writing - Review & Editing, Assistance with Data Curation

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