Journal of Food Legumes
37(1): 72-79, 2024
DOI: 10.59797/jfl.v37.i1.178

Research Paper

Influence of herbicide-based integrated weed management strategies on growth and yield of fenugreek (*Trigonella foenum-graecum* L.) it Indo-gangetic plains

Isha Ahlawat[1*], Todarmal[1], SS Punia[1], Garima Dahiya[2], Sumit Bhardwaj[1] and Abhishek[1]

[1]*Department of Agronomy,* [2]*Department of Soil Science, CCS Haryana Agricultural University, Hisar-125004, Haryana*[1]

[*]***Corresponding author e-mail:*** *isha3214@gmail.com*

Received: *29 January 2024*
Accepted: *22 March 2024*

Handling Editor:
Dr. C.P. Nath, ICAR-Indian Institute of Pulses Research, Kanpur, India

ABSTRACT

In the present study, a field experiment was conducted over two years to evaluate the efficacy and economic performance of imidazolinones. The combined application of imidazolinones with pendimethalin exhibited enhanced effectiveness in controlling the weed populations compared to their individual application. PRE application of pendimethalin + imazethapyr (Ready mix) at 1500 g ha^{-1}, followed by one hoeing at 3-4 leaf stage, proved highly effective in suppressing the dominant weed flora and recorded higher growth parameters and significantly increased the seed yield of fenugreek. Moreover, it emerged as a profitable alternative to the current recommendation of weed control in fenugreek, which involves two hoeing sessions at 25 and 45 days after sowing (DAS).

Key words**:** Fenugreek, Hoeing, Imidazolinones, Integrated, Pendimethalin, Weed.

INTRODUCTION

Fenugreek (*Trigonella foenum-graecum* L.) is a multipurpose seed spice crop native to India's arid and semi-arid regions. It has a unique place for adding taste, flavor, and aroma to food, throughout the world. India is the largest producer of fenugreek in the world, occupying 169 thousand ha area with an annual output of 252 thousand MT and average productivity of 1.7 MT ha^{-1} (Ahlawat *et al.* 2023b). Madhya Pradesh, Rajasthan, Uttarakhand, Punjab, Maharashtra, Haryana, UP and Gujarat are predominant fenugreek-growing states that contribute to maximum production in the country. In Haryana, it is grown on an area of 2.7 thousand ha with a production of 7.5 thousand MT and productivity of 2.7 MT ha^{-1}. The average yield of fenugreek needs to be increased, which will increase the productivity of the country as well. Growing superior cultivars and implementing innovative production technologies can boost fenugreek crop productivity.

Weeds are undesired plants that obstruct the use of land and hence harm crop output. The crop weed competition is more prevalent in the early stage of legume growth and therefore, the initial 50-60 days after sowing is very critical (Padmaja *et al.* 2013, Hedayetullah and Kumar 2023). The ever-changing nature of weed issues necessitates the constant development of new weed management technologies, which can be mechanical/physical, chemical, cultural/agronomic, biological, or combined (Clements *et al.* 2014). Chemical weed control treatments are more widely accepted among producers because of their ease of use, low cost, timeliness, and efficiency. However, a sharp increase in weed herbicide resistance and growing concerns about environmental contamination as a result of indiscriminate herbicide usage has required a shift and/or concentration on alternative control strategies and integrated weed management (Chauhan *et al.* 2017, Ahlawat *et al.* 2023a).

Weeds offer maximum competition to fenugreek at its initial 25 days of growth and cause severe yield reductions in the crop ranging from 14.2 to 69.0% depending upon their density and duration of competition (Kumar *et al.* 2005). The goal of integrated weed management is to keep weed densities under control while giving crops a competitive advantage over weeds (Zimdahl 2017). For the establishment of a sound framework for combating weed problems, a thorough understanding of relationships between crops and accompanying weeds is required. Weeds have high photosynthetic rates and relative growth rates, as well as the ability to make rapid phenotypic changes in response to stress (Radosevich *et al*. 1997). One of the major developments in Indian farming systems has been a greater dependence on herbicidal weed control. Herbicide resistance causes a loss of herbicide resources, and since new herbicide modes of action are improbable, non-chemical cultural weed management techniques must be used. Other management strategies such as zero tillage (Malik *et al*. 2000, 2002), the use of weed-competitive varieties (Chauhan *et al*. 2001a, b), early sowing, crop rotation, herbicide mixtures and sequences (Yadav *et al*. 2016), herbicide rotation (Yadav and Malik 2005), and proper spray techniques must be combined with herbicides (Miller and Bellinder 2001). Weed management measures can give the crop a competitive edge early in the season by facilitating early crop canopy formation and maximizing the crop's resource use to lower weed density, biomass, and seed bank additions (Kumar *et al.* 2023). These crop competition characteristics can be employed as part of the best management strategies for reducing herbicide use and minimizing herbicide selection impact on herbicide-resistant weed populations in farm areas. The development of integrated weed management that is economically viable as well as ecologically safe is of immense importance to control weeds effectively. Hence, for effective weed management in fenugreek, it is of utmost importance to ascertain the most suitable weed control technique. In cognizance of the above details, the present experiment was conducted to study the effect of different herbicide-based IWM strategies on the growth and yield of fenugreek (*Trigonella foenum-graecum* L.) in Indo-Gangetic Plains.

MATERIALS AND METHODS

Description of field sites and experimental design

The present study was conducted over two years (2018 and 2019) at the Agronomy Research Farm of CCS Haryana Agricultural University, Hisar, Haryana (29°10´N, 75°46´E) to observe the growth and yield parameters of *Trigonella foenum-graecum* L. Soil of experimental field was sandy loam in texture, low in available N (181 kg ha^{-1}), medium in available P (17 kg ha^{-1}) and high in available K (285 kg ha^{-1}) with slightly alkaline in reaction (pH 7.8). The experiment's goal was to assess the effectiveness of several herbicides and their ready-mix combinations against various weeds in fenugreek. The experiment was grown in a randomized block design, comprising fifteen treatments with three replications. The different weed control treatments *viz.,* PRE imazethapyr at 80 g ha^{-1}, PRE imazethapyr + imazamox [Ready Mix (RM)] at 70 g ha^{-1}, PRE pendimethalin at 1000 g ha^{-1}, PRE pendimethalin + imazethapyr (RM) at 1000 g ha^{-1}, PRE pendimethalin + imazethapyr (RM) at 1250 g ha^{-1}, PRE pendimethalin + imazethapyr (RM) at 1500 g ha^{-1}, POE imazethapyr at 80 g ha^{-1} at 3-4 leaf stage, POE imazethapyr + imazamox (RM) at 70 g ha^{-1} at 3-4 leaf stage, PRE imazethapyr at 80 g ha^{-1} + one hoeing at 3-4 leaf stage, PRE imazethapyr + imazamox (RM) at 70 g ha^{-1} + one hoeing at 3-4 leaf stage, PRE pendimethalin at 1000 g ha^{-1} + one hoeing at 3-4 leaf stage, PRE pendimethalin + imazethapyr (RM) at 1500 g ha^{-1} + one hoeing at 3-4 leaf stage and two hoeing at 30 and 60 DAS were compared with weedy check and weed free (Table 1). The experiment aimed to assess the performance of various imidazolinones and their ready-mix combinations alone as well as with one hoeing employed at 3-4 leaf stage against predominant weeds in fenugreek. The size of each plot was 6.0 m × 6.0 m. The fenugreek variety used for sowing in the experiment was HM-51 during 2018-19 and MH-54 during 2019-20. As both varieties perform better under Haryana conditions and the efficacy of herbicides was tested in both varieties and also for studying the varietal sensitivity. Sowing of experiments in both years was done in November to observe the growth and yield parameters of *Trigonella foenum-graecum* L. The recommended dose of fertilizers (20 kg N and 40 kg P ha^{-1} through DAP) was applied as a basal dose at sowing and need-based irrigation was given to the crop through flooding. A knapsack sprayer fitted with a flat fan nozzle was used to apply pre-emergent herbicides immediately after sowing in moist soil, and other post-emergence herbicides were sprayed at 46 DAS using a spray volume of 500 L ha^{-1}. The crop was managed using the state university's recommended agronomic approaches.

Weed sampling

Parameters on growth studies, yield attributes and yield, and economics of fenugreek were recorded. Observations on crop biomass from two random spots were recorded at 45, 75 DAS, and harvesting stages by placing a quadrate of 0.5 m × 0.5 m size. The samples were oven-dried at 60 ℃ until constant weights were achieved. Then dried crop samples were weighed and the weight taken was expressed in terms of g m^{-2} before subjecting to statistical analysis. Visual crop injury to fenugreek in terms of chlorosis, stunting, leaf burning,

Table 1. Details of treatments used in field experiment (2018-19 and 2019-20)

Treatment	Dose (g ha^{-1})	Time of application
Imazethapyr	80	PRE
Imazethapyr + one hoeing	80	PRE and 3-4 leaf stage
Imazethapyr	80	3-4 leaf stage
Imazethapyr + imazamox (RM)	70	PRE
Imazethapyr + imazamox (RM)	70	3-4 leaf stage
Imazethapyr + imazamox (RM) + one hoeing	70	PRE and 3-4 leaf stage
Pendimethalin	1000	PRE
Pendimethalin + one hoeing	1000	PRE and 3-4 leaf stage
Pendimethalin + imazethapyr (RM)	1000	PRE
Pendimethalin + imazethapyr (RM)	1250	PRE
Pendimethalin + imazethapyr (RM)	1500	PRE
Pendimethalin + imazethapyr (RM) + one hoeing	1500	PRE and 3-4 leaf stage
Weedy free	-	-
Weedy check	-	-

scorching, hyponasty, and epinasty due to different herbicides and rates was quantified visually at 7, 15, and 30 DAT (days after treatment) on a 0-100 scale, where 0 = no effect and 100 = complete mortality. To determine the economic viability of the various treatments, the benefit-cost ratio (B:C ratio) was determined (gross return ÷ cost of cultivation).

Statistical Analysis

The data obtained on various parameters were tabulated and subjected to statistical analysis by using the techniques of the analysis of variance (ANOVA) as suggested by Panse and Sukhatme (1989). Analysis was performed in 'R software (version 0.1.0)'. Analysis of variance was performed on the data, and the significance of differences between treatments was evaluated by calculating CD at a 5% level of significance differences evaluated by using one-way ANOVA. Before statistical analysis, square root transformation was applied to the density of weeds. After testing for variance homogeneity and normal distribution, phytotoxicity values were altered by angular transformation to fulfill the requirements for carrying out ANOVA. For the other parameters, original data were used.

RESULTS AND DISCUSSION

Weed interference

The experimental field was infested with six dicotyledon, and one monocotyledon grassy weed. The total weed density was lower in the first year than in the second year. Dicotyledon/ broad-leaved weeds with 84.3 and 88.1% relative density were more dominant than monocotyledon grassy/ sedge weeds having 13.7 and 11.9% relative density in the first and second year, respectively. Major weed species that appeared in the experimental field were gathered and identified. *Anagallis arvensis* was the most dominant weed, followed by *Medicago denticulate, Rumex dentatus, Lathyrus aphaca*, *Phalaris minor*, *Melilotus indica* and *Coronopus didymus* during both years.

Crop growth parameters

The interaction of a plant's genetic characteristics with its environment determines how morphological crop growth occurs. The genetic makeup of a plant, which is essentially constant, determines its ability to grow and produce as much as possible under specific environmental conditions. It is the environmental conditions, which can be controlled up to some extent to obtain higher yield. Crop growth attributes *viz.* plant height (cm), dry matter accumulation (g m^{-2}), and number of branches plant^{-1} were strongly impacted by several weed control methods. Plant height and crop biomass are crucial parameters related to the growth and development of the crop. They indicate the vigor, strength, and adaptability of the plant to the existing environmental conditions. There was a substantial difference in fenugreek plant height and crop biomass as a result of the impact of various weed control treatments (Tables 2 and 3). Among herbicidal treatments, PRE pendimethalin + imazethapyr (RM) at 1500 g ha^{-1} + one hoeing at the 3-4 leaf stage was the most effective treatment concerning the plant height of the crop. The results of this study are validated by Kamboj *et al.* (2005) and Chovatia *et al*. (2010). Higher weed populations remove more nutrients from the soil and absorb the nutrients faster than crops. Therefore, assuring greater nutrient availability to the crop during its initial period of growth due to suppression of weeds by suitable herbicide and hand hoeing resulted in increasing the growth of fenugreek. The maximum number of branches of plant^{-1} (7.4 and 7.0) were recorded under the weed-free treatment (Table 2). In the case of herbicides, maximum branches were obtained with PRE pendimethalin + imazethapyr (RM) at 1500 g ha^{-1} + one hoeing at 3-4 leaf stage which produced 66.7 and 73.7% higher number of branches plant^{-1} over weedy check treatment during 2018-19 and 2019-20, respectively. The results are in concordance with the findings of Verma *et al.* (2017).

Yield attributes and yield

Unchecked weed development in weedy control effectively competed with the crop throughout the growing season, which had a negative impact on fenugreek's yield and yield characteristics. Maximum pods/plant were recorded with weed-free treatment and it was significantly (74.9 and 80.9%) higher as compared to weedy check during both years 2018-19 and 2019-20, respectively. Statistically similar results were recorded with PRE pendimethalin + imazethapyr (RM) at 1500 g ha^{-1} + one hoeing, PRE imazethapyr + imazamox (RM) at 70 g ha^{-1} + one hoeing, PRE imazethapyr at 80 g ha^{-1} + one hoeing and PRE pendimethalin at 1000 g ha^{-1} + one hoeing, but, significantly higher over rest of the treatments. The number of seeds/pod (18.3 and 15.2) was highest with a ready mix of pendimethalin + imazethapyr @ 1500 g ha^{-1} + one hoeing during 2018-19 and 2019-20 (Table 2). The positive response of yield attributes to different weed control treatments could be ascribed to the overall increment in crop growth recorded at different growth stages especially dry matter production of fenugreek. Integration of pre-emergence herbicides with one-hand hoeing performed at the 3-4 leaf stage provided higher yield as compared to the sole application of pre-emergence herbicides (Table 3). This was possibly because not all weed cohorts were eliminated by PRE and POE herbicides alone. As a result, some weeds continued to grow alongside crop plants, competing with them for limited natural resources, which inhibited crop growth as evidenced by lower dry weight, fewer effective tillers, fewer grains per spike, and fewer bold grains, leading to lower grain yields. The maximum yield and yield parameters were documented with PRE application of pendimethalin + imazethapyr (RM) at 1500 g ha^{-1} + one hoeing at the 3-4 leaf stage. These results are also verified by the findings of Kumar *et al.* (2015), Sangwan *et al.* (2016), Singh *et al.* (2017) and Meena

Table 2. Effect of herbicidal treatments on yield attributes of fenugreek (2018-19 and 2019-20)

Treatment	No. of branches plant^{-1}		No. of pods plant^{-1}		Pod length (cm)		No. of seeds pod^{-1}		Test weight (g)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Imazethapyr	5.2efg	4.9de	72.6fg	67.8fg	11.8ef	10.1gh	16.0d	13.0de	11.1bcde	10.0bcde
Imazethapyr + one hoeing	6.8ab	6.3ab	99.5ab	94.7ab	14.1abcd	12.4abcde	17.6abcd	14.7abcde	11.9abc	10.7abc
Imazethapyr	5.0fg	4.7e	70.6fg	65.9fg	11.7ef	9.9gh	16.6cd	13.6bcde	10.9def	9.9bcde
Imazethapyr + imazamox (RM)	5.6def	5.3cde	78.9def	74.1def	12.1ef	10.4fgh	16.4bcd	13.3cde	11.3abcde	10.1
Imazethapyr + imazamox (RM)	5.4defg	5de	74.2efg	69.7efg	12.0ef	10.2gh	16.2d	13.1cde	10.9cdef	9.8cde
Imazethapyr + imazamox (RM) + one hoeing	6.9ab	6.5ab	99.9ab	95.1ab	14.7abc	12.9abcd	18.1abc	15.0abcd	11.9abc	10.8abc
Pendimethalin	4.9gh	4.6ef	69.3g	64.5g	11.5ef	9.6gh	15.9d	12.8e	10.8ef	9.6de
Pendimethalin + one hoeing	6.6bc	6.1abc	98.1ab	93.3ab	14.0bcd	12.2bcdef	17.1abcd	14.4abcde	11.8abcd	10.6abcd
Pendimethalin + imazethapyr (RM)	5.5def	5.1de	82.7cde	77.9cde	12.6de	10.9efg	16.7bcd	13.8abcde	11.4abcde	10.3bcde
Pendimethalin + imazethapyr (RM)	5.7de	5.4cde	86.5cd	82.6cd	12.8de	11.0defg	16.9bcd	14.0abcde	11.5abcde	10.3bcde
Pendimethalin + imazethapyr (RM)	5.9cd	5.7bcd	91.3bc	86.5bc	13.0cde	11.4cdefg	17.0bcd	14.2abcde	11.6abcde	10.5abcd
Pendimethalin + imazethapyr (RM) + one hoeing	7.0ab	6.6a	100.3a	99.6a	14.9ab	13.3abc	18.3ab	15.2abc	12.0ab	10.9ab
Weedy free	7.4a	7a	105.3a	100.2a	15.8a	14.2a	19.0a	15.9a	12.2a	11.4a
Weedy check	4.2h	3.8f	60.2h	55.4h	10.6f	8.7h	13.9e	10.5f	10.1f	9.2e
Two hoeing	7.1ab	6.8a	103.2a	98.3a	15.2ab	13.7ab	18.4ab	15.6ab	12.0ab	11.0ab

et al. (2018). The most effective herbicide treatment *i.e.* PRE application of pendimethalin + imazethapyr (RM) at 1500 g ha^{-1} + one hoeing at 3-4 leaf stage (2019 and 1799 kg ha^{-1}) recorded 137.0 and 145.7% higher seed yield in comparison to weedy check treatment in 2018-19 and 2019-20, respectively. Statistically similar results were obtained with PRE imazethapyr + imazamox (RM) at 70 g ha^{-1} + one hoeing at 3-4 leaf stage and PRE imazethapyr at 80 g ha^{-1} + one hoeing at the 3-4 leaf stage (Table 3). The superiority of said treatments might be due to the fact that initially weeds were managed by hand hoeing carried out at 30 DAS and whatever weeds emerged later were effectively removed by subsequent hand hoeing carried out at 60 DAS and in the case of herbicidal treatments prolonged persistence of herbicides and hand hoeing provided weed-free conditions. Similar results were reported by Fagaria *et al.* (2014), Verma *et al.* (2017), and Patel *et al.* (2018). The crop was deprived of basic resources from the start due to the excessive weed infestation in the weedy treatment. As a result, crop plants under stress were unable to reach their full growth potential, which ultimately resulted in a 43–45% reduction in grain productivity. Compared to the weedy treatment, the grain yield was significantly higher in all herbicide treatments. To determine the economic viability of the various treatments used in this experiment, the benefit-cost ratio was determined. The application of different pre-emergence herbicides had a significant effect on the B: C ratio. Among PRE herbicidal treatments, the highest B: C ratio (2.13 and 1.91) was observed in the case of PRE application of pendimethalin + imazethapyr (RM) at 1500 g ha^{-1} while the lowest B: C ratio was recorded with PRE application of pendimethalin at 1000 g ha^{-1} *i.e.,* 1.76 and 1.59 (Table 3).

Visual phyto-toxicity on crop

There was no phytotoxicity of any of the herbicidal treatments on the crop during both years. Data pertaining to phytotoxicity on fenugreek revealed that pre- as well as post-emergence application of any herbicide did not cause any phytotoxic effect on fenugreek at any stage (Table 4). No toxicity symptoms like stunting or chlorosis were exhibited by fenugreek at 7, 15, and 30 DAT. This implies that the application of imazethapyr and its ready mix combination with imazamox both as pre-emergence and at 3-4 leaf stage is equally safe for fenugreek crop.

Correlation studies

Plant height, dry weight, yield attributes of fenugreek, and weed control efficiency (WCE) had a significantly positive correlation with grain yield whereas weed dry weight and weed index had a negative correlation with grain yield during both years (Table 5 and 6). The highest and most significantly positive correlation was recorded between test weight and seed yield of fenugreek

Table 3. Effect of herbicidal treatments on growth, yield, and benefit-cost ratio of fenugreek (2018-19 and 2019-20)

Treatment	Plant height (cm)		Crop dry weight plant^{-1} (g)		Seed yield (kg ha^{-1})		B:C	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Imazethapyr	100.1c	94.7d	12.6g	7.1fg	1410fgh	1183efg	1.93	1.68
Imazethapyr + one hoeing	106.5abc	100.8abcd	17.9abc	12.5ab	1935ab	1716ab	1.90	1.74
Imazethapyr	99.7c	94.5d	12.2gh	6.9fg	1364gh	1142fg	1.87	1.62
Imazethapyr + imazamox (RM)	101.3c	96.2cd	13.4fg	8.0ef	1518defg	1290defg	2.04	1.79
Imazethapyr + imazamox (RM)	100.9c	95.3d	12.9fg	7.7efg	1470efgh	1268defg	1.97	1.76
Imazethapyr + imazamox (RM) + one hoeing	107.0abc	101.8abcd	18.4ab	13.0ab	1961a	1732ab	1.89	1.73
Pendimethalin	99.4cd	94d	11.9gh	6.2gh	1309h	1089g	1.81	1.56
Pendimethalin + one hoeing	105.7bc	100.1abcd	17.1bcd	11.7bc	1776bc	1557bc	1.76	1.59
Pendimethalin + imazethapyr (RM)	103.2bc	96.8bcd	14.8ef	9.2de	1563def	1339def	2.09	1.85
Pendimethalin + imazethapyr (RM)	103.5bc	97.8bcd	15.4de	10.2cd	1602de	1378cde	2.10	1.87
Pendimethalin + imazethapyr (RM)	103.7bc	98.2bcd	16.2cde	10.8c	1661cd	1439	2.13	1.91
Pendimethalin + imazethapyr (RM) + one hoeing	110.6ab	105.2abc	18.6ab	13.3a	2019a	1799a	1.89	1.74
Weedy free	115.2a	109.3a	19.2a	14.0a	2080a	1854a	1.36	1.26
Weedy check	90.2d	84.4e	10.5h	4.9h	852i	732h	1.30	1.16
Two hoeing	111.2ab	105.9ab	18.9ab	13.5a	2036a	1815a	1.65	1.52

Table 4. Effect of herbicidal treatments on visual phytotoxicity (%) of fenugreek (2018-19 and 2019-20)

Treatment	Phyto-toxicity (%)					
	7 DAT		15 DAT		30 DAT	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Imazethapyr	0	0	0	0	0	0
Imazethapyr + one hoeing	0	0	0	0	0	0
Imazethapyr	0	0	0	0	0	0
Imazethapyr + imazamox (RM)	0	0	0	0	0	0
Imazethapyr + imazamox (RM)	0	0	0	0	0	0
Imazethapyr + imazamox (RM) + one hoeing	0	0	0	0	0	0
Pendimethalin	0	0	0	0	0	0
Pendimethalin + one hoeing	0	0	0	0	0	0
Pendimethalin + imazethapyr (RM)	0	0	0	0	0	0
Pendimethalin + imazethapyr (RM)	0	0	0	0	0	0
Pendimethalin + imazethapyr (RM)	0	0	0	0	0	0
Pendimethalin + imazethapyr (RM) + one hoeing	0	0	0	0	0	0
Weedy free	0	0	0	0	0	0
Weedy check	0	0	0	0	0	0
Two hoeing	0	0	0	0	0	0

(0.982). Grain yield also had a positive and significant relationship with crop dry weight (0.966), branches/plant (0.981), pods/plant (0.969), and pod length (0.964) during 1st year. The correlation coefficient was significant and negative between grain yield and weed dry weight (0.954), and weed index (0.971). A similar trend was also observed in 2019-20.

Table 5. Correlation coefficient between different growth and yield attributes of **fenugreek and weeds during 2018-19**

Trait	Plant height (cm)	CDW	Branches/ Plant (no.)	Pods/ Plant (no.)	Pod length (no.)	Seeds/ Pod (no.)	Test weight (g)	Seed yield (g)	WDW	WCE	WI
Plant height (cm)	1										
CDW	0.930**	1									
Branches/plant (no.)	0.953**	0.980**	1								
Pods/plant (no.)	0.930**	0.995**	0.983**	1							
Pod length (no.)	0.958**	0.982**	0.988**	0.974**	1						
Seeds/pod (no.)	0.982**	0.928**	0.945**	0.926**	0.947**	1					
Test weight (g)	0.955**	0.967**	0.965**	0.977**	0.948**	0.955**	1				
Seed yield 9g)	0.971**	0.966**	0.981**	0.969**	0.964**	0.976**	0.982**	1			
WDW	-0.954**	-0.872**	-0.898**	-0.885**	-0.873**	-0.963**	-0.948**	-0.959**	1		
WCE	0.954**	0.872**	0.898**	0.885**	0.873**	0.963**	0.948**	0.959**	-1.000**	1	
WI	-0.971**	-0.966**	-0.981**	-0.969**	-0.964**	-0.976**	-0.983**	-1.000**	0.959**	-0.959**	1

*CDW: Crop dry weight; WDW: Weed dry weight; ** significant at 0.05 probability

Table 6. Correlation coefficient between different growth and yield attributes of fenugreek and weeds during 2019-20

Trait	Plant height (cm)	CDW	Branches/ Plant (no.)	Pods/ Plant (no.)	Pod length (no.)	Seeds/ Pod (no.)	Test weight (g)	Seed yield (g)	WDW	WCE	WI
Plant height (cm)	1										
CDW	0.931**	1									
Branches/plant (no.)	0.965**	0.982**	1								
Pods/plant (no.)	0.930**	0.996**	0.981**	1							
Pod length (no.)	0.962**	0.982**	0.988**	0.974**	1						
Seeds/pod (no.)	0.979**	0.933**	0.952**	0.931**	0.939**	1					
Test weight (g)	0.968**	0.972**	0.977**	0.967**	0.980**	0.962**	1				
Seed yield 9g)	0.969**	0.979**	0.991**	0.978**	0.977**	0.967**	0.971**	1			
WDW	-0.961**	-0.885**	-0.917**	-0.888**	-0.885**	-0.976**	-0.928**	-0.941**	1		
WCE	0.961**	0.885**	0.917**	0.889**	0.885**	0.976**	0.928**	0.941**	-1.000**	1	
WI	-0.969**	-0.979**	-0.991**	-0.978**	-0.977**	-0.967**	-0.971**	-1.000**	0.941**	-0.941**	1

** significant at 0.05 probability

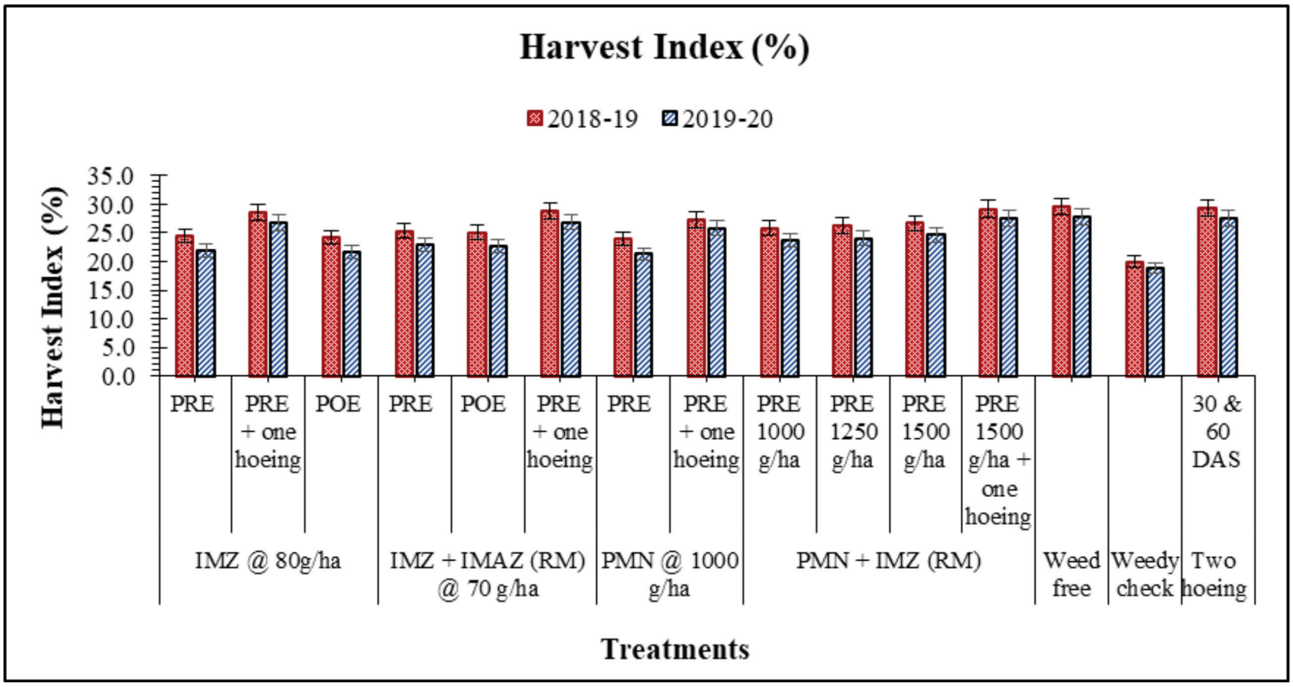

Fig. 1. Effect of herbicidal treatments on harvest index of fenugreek (2018-19 and 2019-20)

CONCLUSION

The continual emergence of resistance in weeds, attributed to the extensive reliance on herbicides and the diminished introduction and commercialization of novel herbicidal compounds in recent decades, underscores the necessity of integrating herbicides with non-chemical weed management strategies. This integration aims to preserve herbicidal resources for future use. Competition-based tactics not only afford short-term weed control within crops but also curtail long-term replenishment of the weed seed bank by mitigating weed seed inputs. The current investigation delineates an herbicide-centered Integrated Weed Management (IWM) strategy aimed at mitigating predominant weed species' impact, thereby enhancing fenugreek growth and yield. Addressing the challenge of inadequate efficacy in weed management, particularly in the north-western Indo-Gangetic Plains of India, farmers can opt for a pre-emergence (PRE) application of pendimethalin + imazethapyr (RM) at a rate of 1500 g ha-1, coupled with one hoeing at the 3-4 leaf stage. This approach proves to be a profitable and cost-effective alternative in addressing the escalating weed dilemma.

REFERENCES

Ahlawat I, Todarmal, Bhardwaj S, Abhishek and Rana A. 2023a. Response of weed population dynamics and communities on yield: A case study using *Trigonella foenum-graecum* L. Indian Journal of Ecology **50**(5): 1418-1424.

Ahlawat I, Todarmal, Bhardwaj S, Bhardwaj KK, Dahiya G, Abhishek and Rana A. 2023b. Response of IWM Strategies on Growth, Nodulation, Productivity and Profitability in Fenugreek (*Trigonella foenum-graecum* L.) under Haryana Conditions. Legume Research. DOI: 10.18805/LR-5164.

Chauhan BS, Matloob A, Mahajan G, Aslam F, Florentine SK and Jha P. 2017. Emerging challenges and opportunities for education and research in weed science. Frontiers of Plant Science **8:** 294498.

Chovatia PK, Vaghani JJ, Thesiya NM and Jadav KV. 2010. Weed dynamics and growth parameters of fenugreek seed crop as influenced by various irrigation levels and weed control measures. International Journal of Agricultural Sciences **6**(1): 39-42.

Chovatia PK, Vaghani JJ, Thesiya NM and Jadav KV. 2010. Weed dynamics and growth parameters of fenugreek seed crop as influenced by various irrigation levels and weed control measures. International Journal of Agricultural Sciences **6**(1): 39-42.

Clements DR, DiTommaso A and Hyvonen T. 2014. Ecology and management of weeds in a changing climate. In: BS Chauhan and G. Mahajan (Eds.), Recent Advances in Weed Management. Springer, New York, Pp. 13-37.

Fagaria VD, Gupta KC and Saxena R. 2014. Integrated weed management in fenugreek (*Trigonella foenum-graecum* L.) in semi-arid regions of Rajasthan.

International Journal of Agricultural Sciences **10**: 302-304.

Hedayetullah Md. and Kumar N. (2023). Bio-efficacy of different POE herbicides for broad-spectrum weeds management in chickpea (*Cicer arietinum* L.). Journal of food legumes **36**(1): 43-46.

Kamboj OP, Bhatia AK, Batra VK, Thakral KK, Makhan Lal and Mange Ram 2005. Chemical weed control in fenugreek seed crop. Haryana Agricultural University Journal of Research **35**(2): 105-107.

Kaur S, Kaur R and Chauhan BS. 2018. Understanding crop-weed fertilizer-water interactions and their implications for weed management in agricultural systems. Crop Protection **103**: 65-72.

Kumar A, Singh A, Arya M, Bhanu AN, Jaiswal A, Kumar S and Chaturvedi SK. 2023. Screening of chickpea (*Cicer arietinum* L.) germplasm accessions for tolerance against post-emergence herbicide imazethapyr. Journal of Food Legumes **36**(2&3): 136-142.

Kumar A, Tripathi SS, Singh G and Singh VP 2005. Efficacy of herbicides on weeds and seed yield of fenugreek. Indian Journal of Weed Science **37**(3&4): 279-280.

Kumar S, Bhatto MS, Punia SS and Punia R. 2015. Bioefficacy of herbicides in black gram and their residual effect on succeeding mustard. Indian Journal of Weed Science **47**(2): 211-213.

Meena DS Meena BL Patidar BK and Jadon C. 2018. Bio-efficacy of pendimethalin 30 EC + imazethapyr 2% SL premix against weeds of soybean. International Journal Science, Environment and Technology **7**(4): 1236 – 1241.

Padmaja B, Reddy MM and Reddy D. 2013. Weed control efficiency of pre-and post-emergence herbicides in pigeonpea (*Cajanus cajan* L.). Journal of Food Legumes **26**(1&2): 44-45.

Panse VC and Sukhatme PV. 1989. Statistical methods for agricultural worker, edition, ICAR publication, New Delhi, India.

Patel CN, Shah SN, Panchal PS and Shroff JC. 2018. Effect of vermicompost and weed management practices on weeds and yield of fenugreek (*Trigonella foenum-graecum* L.). Advances in Life Sciences **7**(1): 53-56.

Radosevich S, Holt J and Ghersa C. 1997. Weed Ecology: Implications for Management, second ed. John & Wiley Sons, Inc., New York, Pp. 573.

Sangwan M, Singh S and Satyavan. 2016. Efficacy of imazethapyr applied alone and mixed with pendimethalin or imazamox in cluster bean (*Cyamopsis tetragonoloba*) and their residual effect on mustard (*Brassica juncea*) in two texturally different soils. Indian Journal of Agricultural Sciences **86**(2): 256-266.

Singh SP, Yadav RS, Bairwa RC and Kumawat A. 2017. Herbicides efficacy for managing weeds in greengram and their residual effect on succeeding mustard. Indian Journal of Weed Science **49**(3): 248-251.

Verma A, Choudhary R and Choudhary RS. 2017. Efficacy of imazethapyr and its ready mix on weed growth and yield of black gram. Chemical Science Review and Letters **6**(24): 2474-2477.

Walia US. 2010. Weed Management, third ed. Kalyani Publishers, Ludhiana, p. 373.

Yadav DB, Yadav A, Punia SS and Chauhan BS. 2016. Management of herbicide-resistant *Phalaris minor* in wheat by sequential or tank-mix applications of pre- and post-emergence herbicides in north-western Indo-Gangetic Plains. Crop Protection **89**: 239-247.

Yadav DB, Yadav A, Punia SS and Chauhan BS. 2016. Management of herbicide-resistant Phalaris minor in wheat by sequential or tank-mix applications of pre-and post-emergence herbicides in north-western Indo-Gangetic Plains. Crop Protection **89**: 239-247.

Zimdahl B. 2017. Integrated Weed Management for Sustainable Agriculture. Burleigh Dodds Science Publishing Limited, Cambridge, Pp 480.