**LR-5164**
**[1-6]**

RESEARCH ARTICLE Legume Research- An International Journal

# Response of IWM Strategies on Growth, Nodulation, Productivity and Profitability in Fenugreek (*Trigonella foenum-graecum* L.) under Haryana Conditions

Isha Ahlawat[1], Todarmal[1], Sumit Bhardwaj[1], K.K. Bhardwaj[2], Garima Dahiya[2], Abhishek[1], Anjali Rana[1]

**10.18805/LR-5164**

## ABSTRACT

**Background:** This research aims to analyze the effects of IWM strategies on growth, nodulation and nutrient uptake in *Trigonella foenum-graecum* L. under Haryana conditions.

**Methods:** Field experiments were conducted for two successive years with *Trigonella foenum-graecum* L. sown at Agronomy Research farm (29°10′N, 75°46′E), CCS Haryana Agricultural University, Hisar, Haryana during 2018-19 and 2019-20 to investigate the impact of factors on growth and economics of *Trigonella foenum-graecum* L.

**Result:** Among the integrated treatments, application of pendimethalin + imazethapyr (RM) at 1500 g ha$^{-1}$ + one hoeing at 3-4 leaf stage recorded maximum nitrogen, phosphorus and potassium uptake by seed and haulm and was found to be at par with weed free check. PRE pendimethalin + imazethapyr (RM) at 1500 g ha$^{-1}$ + one hoeing at 3-4 leaf stage provided highest net returns (Rs. 27,579 ha$^{-1}$) and highest B: C (2.13) was observed in PRE pendimethalin + imazethapyr (RM) at 1500 g ha$^{-1}$, respectively. This article aims to document the role of IWM and concludes that coupling pendimethalin and imazethapyr and supplementing them with one hand hoeing will provide effective weed management.

**Key words:** Economics, Hoeing, Imazethapyr, Nodulation, Nutrient.

## INTRODUCTION

Legume is recognized as the most beneficial plant because of having high grain protein contents and ability to fix biological nitrogen. The genus *Trigonella* is one of the largest genera of the tribe *Trifoliate* in the family *Fabaceae* and sub-family *Papilionaceae* (Balodi and Rao, 1991). Fenugreek (*Trigonella foenum-graecum* L.) prevalently known as its vernacular name "Methi" is an important condiment crop grown in northern India during *rabi* season. Fenugreek, a grain legume crop, occupying 169 thousand ha area with an annual output of 252 thousand MT and average productivity of 1.7 MT ha$^{-1}$ (Anonymous, 2021). It is considered to be one of the important pulse crops having a rich source of protein (23 to 24%), macro and micronutrients (Ca, P, K, Fe and Zn), vitamins (niacin, vitamin A, ascorbic acid and inositol), fiber, carbohydrate. (Semwal *et al*., 2023).

Crop types and soil properties have greatest influence on the occurrence of weed species in a particular crop (Lugowska *et al*., 2016). Some pre-emergence (PRE) and post-emergence (POE) herbicides efficacy have been evaluated against weed flora in legumes. Imazethapyr applied as PPI, PRE and POE controls monocot and dicot weeds and had a strong residual life (Punia *et al*., 2011). Herbicides applied pre-emergence (PRE) or early post-emergence (POE) may not always provide season long weed control necessitating the use of integrated techniques for effective control. Therefore, a better and more suitable weed control method is needed for season long effective control of weeds in fenugreek with no adverse effect on succeeding sensitive crops. Keeping these points in view, it was considered to carry out field experiment on the efficacy of imazethapyr applied alone and its ready mixture with pendimethalin or imazamox in fenugreek crop. A recent decline in commodity prices and increasing herbicide costs to manage herbicide resistant HR weeds has spurred research efforts to build a strong rationale for developing ecologically based integrated weed management (IWM) strategies in the Indo-gangetic Plains. This article aims to document the role of IWM that will ultimately aid in achieving sustainable weed management goals and preserving the

[1]Department of Agronomy, CCS Haryana Agricultural University, Hisar-125 004, Haryana, India.
[2]Department of Soil Science, CCS Haryana Agricultural University, Hisar-125 004, Haryana, India.

**Corresponding Author:** Sumit Bhardwaj, Department of Agronomy, CCS Haryana Agricultural University, Hisar-125 004, Haryana, India.
Email: sumitbhardwaj909@hau.ac.in

**How to cite this article:** Ahlawat, I., Todarmal, Bhardwaj, S., Bhardwaj, K.K., Dahiya, G., Abhishek and Rana, A. (2023). 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.

**Submitted:** 02-05-2023 **Accepted:** 12-10-2023 **Online**: 27-10-2023

natural resources. Nutrients are very much essential for growth and development of fenugreek crop and their deficiency will decrease the crop yield. Therefore, it is imperative to know the uptake of nutrients by crop. Hence, the present study was undertaken with the aim to investigate the impacts of integrated weed management techniques on the growth, nodulation and nutrient uptake of fenugreek crop.

## MATERIALS AND METHODS

Field experiments were conducted during the winter season of 2018-19 and 2019-20 at Agronomy Research farm (29° 10′N, 75°46′E), CCS Haryana Agricultural University, Haryana. Fenugreek (Variety: HM-51) was sown on 22 November, 2018 and 19 November, 2019 during 2018-19 and 2019-20, respectively and the plot size was 6 by 6 m with a row spacing of 20 cm and seeding rate 25 kg per hectare. The soil at the experimental site was determined as sandy loam in texture, slightly alkaline in reaction (pH 7.8) and normal in electrical conductivity (0.28 dS $m^{-1}$). Field trials were set up with three replications in a randomised complete block design using six row m² plots with fifteen treatments. To ensure a homogenous plant population, excess plants were thinned out. The crop received 28.6 and 32.4 mm of rainfall in the crop growing season during both seasons, respectively. The soil of experimental field was sandy-loam at Hisar (58% sand, 32% silt and 10% clay). It was medium in organic carbon (0.51%), low in nitrogen (181 kg $ha^{-1}$), medium in phosphorus (17 kg $ha^{-1}$) and high in potassium (285 kg $ha^{-1}$) at experimental area. Fields were fertilised with 20 and 40 kg $ha^{-1}$ of nitrogen and phosphorous, respectively through DAP before sowing during both seasons. The experiment was conducted in a field heavily infested with broad-leaved weeds.

The herbicide treatments evaluated consisted of fifteen treatments in total. Weed free and weedy treatments were included for comparison of efficacy. Experimental treatments comprised weedy check, weed free, PRE imazethapyr at 80 g $ha^{-1}$, PRE imazethapyr + imazamox (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. Plant protection measures and irrigations were followed as per recommendation. The pre-emergence herbicide was sprayed immediately after sowing on wet soil and post-emergence herbicides at 46 DAS as per treatment with knapsack sprayer.

Randomly five plants were selected from each plot and regular observations of crop and weed parameters were recorded from 30 DAS upto harvest. Nodule parameters *viz.* number and dry weight of nodules/plant were observed both at 40 and 60 DAS. Chlorophyll A and B content was recorded at 75 DAS (Kapoor *et al.,* 2017). To estimate the N, P and K content, samples were collected at harvest for crop. Nutrient uptake by seed and haulm was calculated on the basis of dry matter yield with the nutrient content and expressed in kg $ha^{-1}$. Estimation of nitrogen was done by colorimetric method using Nessler's reagent to develop colour. Phosphorus content was determined by Vanadomolybdo phosphate yellow colour method (Jackson, 1967) and potassium by Flame photometric method.

The data were subjected to analysis of variance and significant differences among treatments were tested. Differences among treatment means were determined using ANOVA and when the F-test was significant, means were compared with LSD test at 5% level of significance.

## RESULTS AND DISCUSSION

Broad-leaf weeds were present at comparatively higher densities and consisted mainly of *Melilotus indica* (7.7%), *Anagallis arvensis* (23.5%), *Rumex dentatus* (14.0%), *Lathyrus aphaca* (11.8%), *Medicago denticulata* (21.6%) and *Coronopus didymus* (7.7%) and among grassy weed *Phalaris minor* (13.7%) at 45 DAS.

Days taken to obtain 50% flowering (Table 1) were significantly higher under Pendimethalin at 1000 g $ha^{-1}$ PRE and imazethapyr at 80 g $ha^{-1}$ applied at 3-4 leaf stage as well as PRE and these were statistically at par with weedy check. The data revealed that Pendimethalin + imazethapyr (RM) at 1500 g $ha^{-1}$ + one hoeing at 3-4 leaf stage recorded minimum days to maturity excluding weed free treatment. Nodule parameters *viz.* number and dry weight of nodules/ plant were observed both at 40 and 60 DAS (Table 1). All the weed-control measures had significantly positive impact on number and dry weight of nodules of fenugreek as compared to weedy check at all the growth stages. Number of nodules/plant were maximum under pendimethalin + imazethapyr (RM) at 1500 g $ha^{-1}$ + one hoeing at 3-4 leaf stage and it was statistically at par with PRE pendimethalin + imazethapyr (RM) applied at 1000, 1250 and 1500 g $ha^{-1}$. Pendimethalin + imazethapyr (RM) at 1500 g $ha^{-1}$ + one hoeing at 3-4 leaf stage application recorded significantly higher dry weight of nodules amongst all the chemical treatments which was at par with weed free treatment. In case of efficient weed control treatments, better weed management provided professed root development and bacterial colonies, which ultimately resulted in more nodulation in crop especially in herbicidal treatments with PRE Pendimethalin + imazethapyr (Dubey *et al*., 2018). Pendimethalin + imazethapyr (RM) at 1500 g $ha^{-1}$ + one hoeing at 3-4 leaf stage depicted higher nodular count owing to infestation of Rhizobium in the growing roots as compared to more crop weed competition in unweeded check (Nirala *et al*., 2016; Sharma *et al*., 2017). Amongst herbicide treated plots, both chlorophyll A and B were significantly higher in

**Table 1:** Effect of herbicidal treatments on yield attributes of fenugreek (2018-19 and 2019-20).

| Treatment | Dose (g $ha^{-1}$) | Time of application | Days to 50% flowering | Days to maturity | No. of nodules/plant | | Dry weight of nodules (mg/plant) | | Chlorophyll content (mg/g fresh weight) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 40 DAS | 60 DAS | 40 DAS | 60 DAS | A | B |
| Imazethapyr | 80 | PRE | 52.2 | 116.2 | 5.4 | 11.6 | 8.7 | 24.2 | 1.31 | 0.77 |
| Imazethapyr + one hoeing | 80 | PRE and 3-4 leaf stage | 49.4 | 112.2 | 5.5 | 15.8 | 8.9 | 31.9 | 1.89 | 1.48 |
| Imazethapyr | 80 | 3-4 leaf stage | 52.3 | 116.7 | 4.3 | 11.1 | 7.8 | 23.9 | 1.25 | 0.73 |
| Imazethapyr + imazamox (RM) | 70 | PRE | 51.9 | 115.1 | 5.9 | 12.3 | 9.4 | 25.2 | 1.43 | 0.85 |
| Imazethapyr + imazamox (RM) | 70 | 3-4 leaf stage | 52.0 | 115.8 | 4.3 | 11.9 | 7.9 | 24.7 | 1.38 | 0.82 |
| Imazethapyr + imazamox (RM) + one hoeing | 70 | PRE and 3-4 leaf stage | 48.8 | 111.9 | 6.1 | 15.6 | 9.6 | 32.6 | 2.13 | 1.59 |
| Pendimethalin | 1000 | PRE | 52.3 | 116.8 | 5.1 | 10.9 | 8.4 | 23.3 | 1.20 | 0.69 |
| Pendimethalin + one hoeing | 1000 | PRE and 3-4 leaf stage | 49.9 | 112.8 | 5.1 | 15.1 | 8.5 | 31.4 | 1.75 | 1.34 |
| Pendimethalin + imazethapyr (RM) | 1000 | PRE | 51.7 | 114.1 | 6.6 | 13.3 | 10.2 | 27.7 | 1.56 | 0.97 |
| Pendimethalin + imazethapyr (RM) | 1250 | PRE | 51.2 | 113.7 | 6.9 | 13.9 | 10.7 | 29.2 | 1.61 | 1.06 |
| Pendimethalin + imazethapyr (RM) | 1500 | PRE | 50.4 | 113.3 | 7.3 | 14.3 | 12.1 | 30.1 | 1.69 | 1.15 |
| Pendimethalin + imazethapyr (RM) + one hoeing | 1500 | PRE and 3-4 leaf stage | 48.2 | 111.2 | 7.4 | 16.1 | 12.3 | 33.6 | 2.25 | 1.62 |
| Weedy free | - | - | 47.3 | 109.8 | 8.1 | 17.1 | 12.9 | 35.3 | 2.49 | 1.73 |
| Weedy check | - | - | 54.6 | 117.4 | 4.1 | 9.2 | 7.4 | 19.3 | 1.12 | 0.65 |
| Two hoeing | - | 30 and 60 DAS | 47.9 | 110.4 | 7.8 | 16.7 | 12.6 | 34.5 | 2.32 | 1.68 |
| LSD (P=0.05) | - | - | 2.4 | 3.0 | 0.8 | 1.7 | 0.9 | 3.9 | 0.4 | 0.1 |

pendimethalin + imazethapyr (RM) at 1500 g ha$^{-1}$ + one hoeing at 3-4 leaf stage which was at par with imazethapyr + imazamox (RM) at 70 g ha$^{-1}$ + one hoeing at 3-4 leaf stage in case of chlorophyll A. The increase in chlorophyll content of the crop under weed control treatment with PRE Pendimethalin + imazethapyr at 1500 g ha$^{-1}$ can be clearly attributed to the reduction in interference of the weeds as evident from the higher weed control efficiency which ultimately favoured better growth environment for the crop (Sharma *et al*., 2017). Thus, under lesser crop weed competition, adequate availability of light, temperature and space along with moisture and nutrients, improved physiological and morphological characters of plant as well as photosynthesis with greater rate ultimately leads to more chlorophyll content in plants (Duncan, 1971).

Nutrient content in seed was recorded and significantly the lowest content of nitrogen, phosphorus and potassium by seed was noted under unweeded control (Fig 1) and maximum was observed under pendimethalin + imazethapyr (RM) at 1500 g ha$^{-1}$ + one hoeing at 3-4 leaf stage. Significant increase in total N, P and K content in haulm was recorded due to all weed management practices over weedy check (Fig 2). The highest nutrient content in haulm was recorded under weed free up to harvest. Similarly, all the weed control treatments significantly increased N, P and K uptake by seed and straw of fenugreek over weedy check (Table 2). Weed free treatment resulted in significantly highest total uptake of N (65.2 kg/ha), P (9.8 kg/ha) and K (12.7 kg/ha) by the crop compared to weedy check (21.2, 2.6 and 3.7 kg/ha), respectively. Among the integrated treatments, application of pendimethalin + imazethapyr (RM) at 1500 g ha$^{-1}$ + one hoeing at 3-4 leaf stage recorded maximum nitrogen, phosphorus and potassium uptake by seed and haulm and was found to be at par with weed free check. This might be due to better development of crop resulting from lesser crop weed competition, further, the higher content and higher dry matter accumulation by crop under these treatments boosted the nutrient uptake. Lower nitrogen, phosphorous and potassium uptake was recorded in unweeded control due to poor root growth and establishment as a consequence of severe crop-weed competition. Significantly lower value of growth parameters *viz.* number and dry weight of nodules,

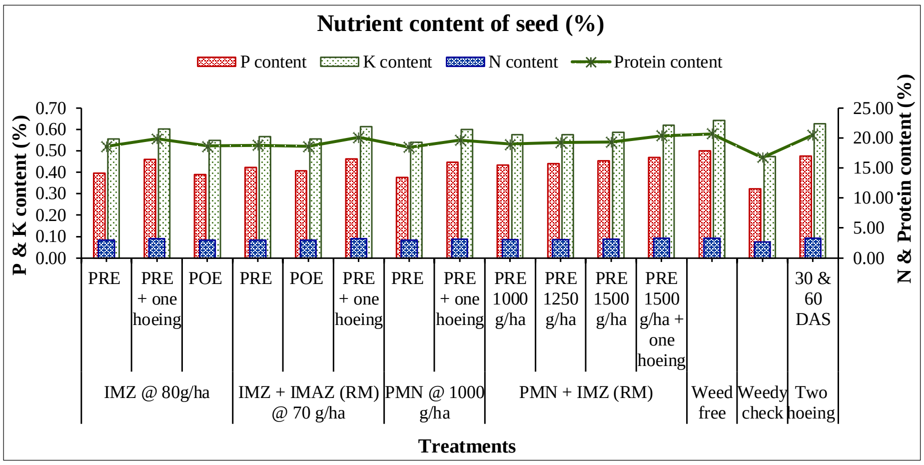


**Fig 1:** Effect of herbicidal treatments on nutrient and protein content of seed (%) in fenugreek (2018-19 and 2019-20) (p= 0.05).

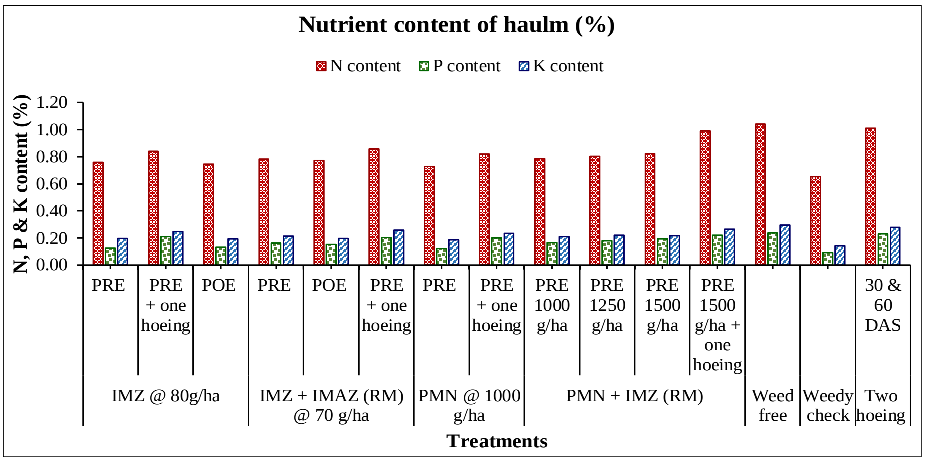


**Fig 2:** Effect of herbicidal treatments on nutrient of haulm (%) in fenugreek (2018-19 and 2019-20) (p= 0.05).

**Table 2:** Effect of herbicidal treatments on nutrient uptake of seed in fenugreek (2018-19 and 2019-20).

| Treatment | Dose ($g\ ha^{-1}$) | Time of application | Nitrogen ($kg\ ha^{-1}$) | | Phosphorus ($kg\ ha^{-1}$) | | Potassium ($kg\ ha^{-1}$) | | Protein yield ($kg\ ha^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| | | | Seed | Haulm | Seed | Haulm | Seed | Haulm | |
| Imazethapyr | 80 | PRE | 38.6 | 32.5 | 5.1 | 5.4 | 7.2 | 8.4 | 242 |
| Imazethapyr + one hoeing | 80 | PRE and 3-4 leaf stage | 58.0 | 40.0 | 8.4 | 10.0 | 11.0 | 11.7 | 363 |
| Imazethapyr | 80 | 3-4 leaf stage | 37.5 | 31.3 | 4.9 | 5.6 | 6.9 | 8.1 | 234 |
| Imazethapyr + imazamox (RM) | 70 | PRE | 42.3 | 34.5 | 5.9 | 7.2 | 8.0 | 9.4 | 264 |
| Imazethapyr + imazamox (RM) | 70 | 3-4 leaf stage | 40.8 | 33.6 | 5.6 | 6.7 | 7.6 | 8.5 | 255 |
| Imazethapyr + imazamox (RM) + one hoeing | 70 | PRE and 3-4 leaf stage | 59.5 | 40.9 | 8.6 | 9.7 | 11.3 | 12.2 | 372 |
| Pendimethalin | 1000 | PRE | 35.5 | 29.6 | 4.5 | 5.0 | 6.5 | 7.6 | 222 |
| Pendimethalin + one hoeing | 1000 | PRE and 3-4 leaf stage | 52.5 | 37.5 | 7.4 | 9.2 | 10.0 | 10.7 | 328 |
| Pendimethalin + imazethapyr (RM) | 1000 | PRE | 44.1 | 34.6 | 6.3 | 7.3 | 8.4 | 9.2 | 276 |
| Pendimethalin + imazethapyr (RM) | 1250 | PRE | 45.9 | 35.4 | 6.6 | 7.9 | 8.6 | 9.7 | 287 |
| Pendimethalin + imazethapyr (RM) | 1500 | PRE | 48.0 | 36.8 | 7.0 | 8.6 | 9.1 | 9.7 | 300 |
| Pendimethalin + imazethapyr (RM) + one hoeing | 1500 | PRE and 3-4 leaf stage | 62.2 | 47.5 | 9.0 | 10.6 | 11.8 | 12.8 | 389 |
| Weedy free | - | - | 65.2 | 50.7 | 9.8 | 11.5 | 12.7 | 14.5 | 407 |
| Weedy check | - | - | 21.2 | 21.5 | 2.6 | 3.0 | 3.7 | 4.7 | 133 |
| Two hoeing | - | 30 and 60 DAS | 63.4 | 48.9 | 9.2 | 11.1 | 12.1 | 13.6 | 396 |
| LSD (P=0.05) | - | - | 8.0 | 6.6 | 1.0 | 0.9 | 1.7 | 1.6 | 13 |

**Table 3:** Effect of herbicidal treatments on yield and economics of fenugreek (pooled mean of 2018-19 and 2019-20).

| Treatment | Dose ($g\ ha^{-1}$) | Time of application | Seed yield | Cost of cultivation | Net returns | Additional returns over control | B-C ratio |
|---|---|---|---|---|---|---|---|
| Imazethapyr | 80 | PRE | 1297 | 21145 | 17045 | 12656 | 1.80 |
| Imazethapyr + one hoeing | 80 | PRE and 3-4 leaf stage | 1825 | 29545 | 24253 | 19864 | 1.82 |
| Imazethapyr | 80 | 3-4 leaf stage | 1253 | 21145 | 15763 | 11374 | 1.74 |
| Imazethapyr + imazamox (RM) | 70 | PRE | 1404 | 21590 | 19771 | 15382 | 1.92 |
| Imazethapyr + imazamox (RM) | 70 | 3-4 leaf stage | 1369 | 21590 | 18977 | 14588 | 1.86 |
| Imazethapyr + imazamox (RM) + one hoeing | 70 | PRE and 3-4 leaf stage | 1846 | 29990 | 24425 | 20036 | 1.81 |
| Pendimethalin | 1000 | PRE | 1199 | 20951 | 14365 | 9976 | 1.68 |
| Pendimethalin + one hoeing | 1000 | PRE and 3-4 leaf stage | 1666 | 29351 | 19756 | 15367 | 1.68 |
| Pendimethalin + imazethapyr (RM) | 1000 | PRE | 1451 | 21660 | 21089 | 16700 | 1.97 |
| Pendimethalin + imazethapyr (RM) | 1250 | PRE | 1490 | 22129 | 21770 | 17381 | 1.98 |
| Pendimethalin + imazethapyr (RM) | 1500 | PRE | 1550 | 22597 | 23073 | 18684 | 2.02 |
| Pendimethalin + imazethapyr (RM) + one hoeing | 1500 | PRE and 3-4 leaf stage | 1909 | 30997 | 25264 | 20875 | 1.81 |
| Weedy free | - | - | 1967 | 44145 | 13825 | 9436 | 1.31 |
| Weedy check | - | - | 792 | 18945 | 4389 | 0 | 1.23 |
| Two hoeing | - | 30 and 60 DAS | 1926 | 35745 | 21002 | 16613 | 1.59 |

seed yield were recorded in weedy check treatment. This might be due to severe competition by weeds for resources, which made the crop plant inefficient to take up more moisture, nutrients and ultimately growth was adversely affected due to less supply of carbohydrates.

The monetary returns were found to be significantly influenced by different weed control treatments (Table 3). The maximum net returns of Rs. 25264 /ha and additional returns over control Rs. 20875 were obtained with pendimethalin + imazethapyr (RM) at 1500 g ha$^{-1}$ as pre-emergence supplemented with one hoeing at 3-4 leaf stage. Among all the weed control treatments, maximum B-C ratio (2.02) was recorded with treatment pendimethalin + imazethapyr (RM) at 1500 g ha$^{-1}$ as pre-emergence. All the weed management strategies were almost equally important in controlling weeds and improving the crop yield. Weed free treatment was superior most with respect to growth parameters, seed yield (44,145 kg ha$^{-1}$) and quality. The next best treatment with respect to net returns (Rs. 25264/ha) and B:C ratio (2.02) was pendimethalin + imazethapyr (RM) at 1500 g ha$^{-1}$ as pre-emergence with one hand hoeing at 3-4 leaf stage and PRE pendimethalin + imazethapyr (RM) at 1500 g ha$^{-1}$, respectively. So, Pendimethalin + imazethapyr (RM) at 1500 g ha$^{-1}$ + one hoeing at 3-4 leaf stage was observed to be the best treatment in terms of yield, nodules, chlorophyll content as well as in monetary terms.

## CONCLUSION

The findings of the present study provide herbicide options for the management of predominant weed flora in fenugreek. Research study indicate that alone PE or PoE herbicide treatments are not effective against effective weed management in this legume crop. The farmers can adopt this strategy to tackle the problem of poor efficacy of herbicides in particularly in north-western Indo- Gangetic Plains of India. However, growers and land managers will face increasing pressure to reduce overall pesticide use in food and feed production systems. There are myriad research and development needs for growers and land managers to successfully transition to a limited herbicide world. The metric for successful integrated weed management is lowest weed seed banks as possible concurrent with reduced herbicide use. In area there is paucity of labour, it is advisable to apply pendimethalin + imazethapyr (RM) at 1500 g ha$^{-1}$ as pre-emergence supplemented with one hoeing at 3-4 leaf stage under Haryana conditions.

**Conflict of interest:** None.

## REFERENCES


Anonymous, (2021). Ministry of Agriculture and Farmers Welfare, Government of India.

Balodi, B. and Rao, R.R. (1991). The genus *Trigonella* L. (Fabaceae) in the Northwest Himalaya. J. Econ. Taxon. 5: 11-6.

Dubey, S.K., Kumar, A., Singh, D., Partap, T. and Chaurasiya, A. (2018). Effect of different weed control measures on performance of chickpea under irrigated condition. International Journal of Current Microbiology and Applied Sciences. 7(5): 3103-3111.

Duncan, W.G. (1971). Leaf angle, leaf area and canopy photosynthesis. Crop Science. 11:482-485.

Jackson, M.L. (1967). Soil Chemical Analysis. Prentice-Hall of India Pvt. Ltd., New Delhi, 498p.

Kapoor, N., Verma, A. and Pande, V. (2017). Evaluating Photosynthetic attributes as indicator of salt tolerance in Fenugreek. Research Journal of Chemical and Environmental Sciences. 5(6): 77-83.

Lugowska, M., Pawlonka, Z. and Skrzyczynska, J. (2016). The effects of soil conditions and croptypes on diversity of weed communities. Acta Agrobotanica. 69(4): 1687. DOI: 10.5586/aa.1687.

Nirala, H., Sonit, A. and Rathore, A.L. (2016). Post-emergence herbicides for weed control in blackgram. Indian Journal of Weed Science. 48(1): 76-78.

Punia, S.S., Singh, S. and Yadav, D. (2011). Bioefficacy of imazethapyr and chlorimuron-ethyl in cluster bean and their residual effect on succeeding rabi crops. 43. Indian Journal of Weed Sciences. (1 and 2): 48-53.

Semwal, P., Painuli, S., Begum, J.P.S., Jamloki, A., Rauf, Olatunde, A., Rahman, M., Mukherjee, N., Khalil, A.A., Aljohani A.S.M., Abdulmonem, W.A. and Simal-Gandara, J. (2023). Exploring the nutritional and health benefits of pulses from the Indian Himalayan region: A glimpse into the region's rich agricultural heritage. Food Chemistry. 422: 136259. https://doi.org/10.1016/j.foodchem.2023. 136259.

Sharma, N.K., Mundra, S.L. and Kalita, S. (2017). Effect of weed management practices on rhizobium nodules, their dry weight and bio-chemical parameter of soybean. Journal of Pharmacognosy and Phytochemistry. 6(5): 220-222.