

**Effect of Weed Control Measures on Growth and Yield of
Fenugreek (*Trigonella foenum-graecum* L.)**

मेथी की वृद्धि एवं उपज पर खरपतवार नियंत्रण का प्रभाव

SURESH KUMAR DUDWAL

Thesis

Master of Science in Agriculture
(Agronomy)



उत्तमा वृत्तिस्तु कृषिकर्मव

2018

**Department of Agronomy
College of Agriculture, Bikaner
Swami Keshwanand Rajasthan Agricultural University
Bikaner (Raj.)**

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Thesis

Submitted to
Swami Keshwanand Rajasthan Agricultural University, Bikaner
in partial fulfillment of the requirement for
the degree of

**Master of Science in Agriculture
(Agronomy)**

By

SURESH KUMAR DUDWAL

2018

**Swami Keshwanand Rajasthan Agricultural
University, Bikaner
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Date - 08.10.2018

This is to certify that **Mr. Suresh Kumar Dudwal** had successfully completed the comprehensive examination held on 10.04.2018 as required under the regulation for the degree of **Master of Science in Agriculture (Agronomy)**.

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This is to certify that the thesis entitled “**Effect of Weed Control Measures on Growth and Yield of Fenugreek (*Trigonella foenum-graecum* L.)**” submitted for the degree of **Master of Science in Agriculture** in the subject of **Agronomy** embodies bonafide research work carried out by **Mr. Suresh Kumar Dudwal** under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been fully acknowledged. The draft of the thesis was also approved by the advisory committee on 02.08.2018.

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Place:: **Bikaner**

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ACRONYMS

@	At the rate of	t ha ⁻¹	tonnes hectare ⁻¹
%	Per cent	Mha	million hectares
B-c ratio	Benefit cost ratio	Mg	Milligram
°C	Degree Celsius	mg g ⁻¹	milligram gram ⁻¹
cm	Centimeter	Mg m ⁻³	Mega gram cubic metre ⁻¹
CD	Critical difference	min.	Minimum
DAS	Days after sowing	mm	Millimeter
d.f.	degree of freedom	N	Nitrogen
dS m ⁻¹	deci-Siemens per metre	°N	Degree north
EC	Electrical conductivity	No.	Number
<i>et al.</i>	and others	NS	Non-significant
etc.	and similar other things" or "and so on."	PET	Potential evapotranspiration
Fig.	Figure	R.H.	Relative humidity
ha	Hectare	S.Em _±	Standard error of mean
<i>i.e.</i>	(<i>id est</i>) that is	P	Phosphorus
S.No.	Serial number	<i>viz.</i>	(Videlicet) namely
kg ha ⁻¹	kilogram hectare ⁻¹	CGR	Crop growth rate
Max.	Maximum	RGR	Relative growth rate
m ²	square meter	Ec	Eulsifiable concentrates'
g	Gram	PPI	Pre plant incorporation
PE	Pre- emergence	nm	Nanometer

1. INTRODUCTION

India is renowned world over for its repository of spices and is popularly called as “The land of spices” and the largest producer, consumer and exporter of spices in the world. The seed spices are group of crops which denotes all those annuals whose dried fruit or seeds are used as spices. The seed spices are aromatic vegetable products of tropical region mostly used in pulverised state, primarily for seasoning or garnishing food and beverages. They are characterised by pungency strong odour and sweet or bitter taste. Gujarat and Rajasthan states have emerged as “Seed Spices Bowl” and together contribute more than 80 per cent of the total seed spices produced in the country. While, other states where spices commonly grown are Haryana, Punjab, Madhya Pradesh, Maharashtra, Bihar, Uttar Pradesh, West Bengal, Orissa, Tamil Nadu and Karnataka.

In India, fenugreek occupies an area of about 2,19,000 ha with annual production of about 2,95,000 tonnes having average productivity 1347 kg ha⁻¹ (GOI, 2017–18). In Rajasthan, it is cultivated mainly in Sikar, Nagaur, Jaipur, Kota and Pali districts occupying an area of about 67,657 ha with production of 95,960 tonnes exhibiting productivity of about 1418 kg ha⁻¹ (GOR, 2017-18). Its cultivation is now gaining popularity in Bikaner district also.

Fenugreek (*Trigonella foenum-graecum* L.), commonly known as *Methi*, is one of the important seed spices of India. Fenugreek is an annual plant belonging to sub family Papilionaceae of the family Leguminosae. It was named, *Trigonella*, from Latin language that means “little triangle” due to its yellowish-white triangular flowers. Fenugreek, like other legumes, is a worthy source of dietary protein for feeding by man and animals. From earliest times, Greeks as well as the Romans used

it as medicine, spice and cattle fodder and so it is still known as Greek hay. Seeds of fenugreek are used as a yellow dye, in cosmetics industry and for medicinal commitments. The seeds of fenugreek are used as a condiment and seasoning agent for garnishing and flavoring dishes. Its fresh tender leaves and pods are consumed as vegetable being rich in iron, calcium, protein and vitamins. Its chopped leaves are mixed in flour to prepare "parantha", grains are also used to prepare concentrate feed for animals. It is valued for its immense medicinal properties. It prevents constipation and removes indigestion and stimulates the digestive process. Fenugreek seeds have shown to have hypoglycemic and anticholesterolemic action and used in the treatment of dysentery, diarrhoea, ricket, aphrodisiac and diabetes. It is also used to prepare carminative mixture. The important steroid saponins and diosgenin content in seed is used for the synthesis of sex hormones and oval contraceptives. Its seeds are bitter in taste due to presence of alkaloid "trigonellin". Trigocoumarin, trimethyl coumarin and nicotinic acid mucilage are prominent constituents of seed. Its roots are endowed with nitrogen fixing ability, which further adds to its merit. Fenugreek is a good soil renovator and commonly used as a green manure. Being a legume crop, fenugreek has high nutritive value which contains 26.2% protein, 5.8% fat, 3.0% mineral matter and 4.41 %, carbohydrate.

In our country, weed is one of the important factors responsible for low yield of fenugreek. The weed problem in fenugreek is very serious due to its slow growing habits particularly during initial stages; it is highly infested with weeds which drastically reduce the seed yield. Mali and Suwalka (1987) reported that weeds were found hurdle to in be a serious in fenugreek production, mechanical removal of weed is laborious, time consuming and costly.

Weed reduced yield by competing with the fenugreek plant for resources, such as moisture, nutrients, space and sunlight not only throughout the growing season, but also create problem during harvesting and inverting procedures and reduce harvesting efficiency. Few weeds have allelopathic effect with fenugreek and they act as host for causal organisms of various diseases and insect pests. In the initial growth of crop there is relatively shallow canopy and it slowly shades the inter-row area, which allows bumper weeds growth and thus fenugreek becomes more susceptible to weed crop competition in the earlier growth period of the crop. This is an urgent need to explore the possibilities for increasing the productivity through better understanding of the constraints in production of fenugreek. Among the various biotic stresses resulting in low productivity, weeds are considered as a major constraint, especially under rainfed eco-systems, weeds cause much damage to the fenugreek crop during the first 45 days of its growth. The average yield loss due to weeds is about 30%, whereas under poor management yield loss by weeds may be 60%. The mechanical method is normally used by the farmers for weed management. But, adoption of this method is gradually becoming unviable due to high cost of labour and non-availability of labour during peak period of requirement. Under these circumstances, chemical weed control through the application of herbicide is gaining popularity among the farming community.

Pendimethalin is a selective herbicide used for control of most annual grasses and certain broadleaf weeds in maize, oil seeds, pulses and vegetables etc. Imazethapyr and imazamox are herbicides, kill weeds by inhibiting the enzyme acetohydroxy acid synthase (AHAS), which involve in the synthesis of three branches chain aliphatic amino acids, leucine, isoleucine and valine. This inhibition causes a disruption in protein synthesis, which leads to an interference in DNA synthesis and cell growth. Use of

herbicides for weed control in legumes has certainly contributed to the increased yield and improved quality.

The present investigation entitled “Effect of Weed Control Measures on Growth and Yield of Fenugreek (*Trigonella foenum-graecum* L.)” has been conducted in *rabi* 2017- 18 with the following objectives.

Objectives:

1. To study the effect of herbicide(s) on the growth, yield and quality of fenugreek
2. To study the effect of herbicide(s) on the weed flora in fenugreek crop
3. To find out the most effective and economically viable herbicide(s) for fenugreek

2. REVIEW OF LITERATURE

This chapter deals with the research work carried out on “Effect of Weed Control Measures on Growth and Yield of Fenugreek (*Trigonella foenum-graecum* L.)”. A brief summary of research work carried out by various research workers in India and abroad on different herbicidal weed control measures and their effect on growth and yield of fenugreek and similar research work done on other crops have been highlighted and reviewed under following heads.

2.1 Weeds

2.1.1 Weed flora

Thimmegowda *et al.* (2007) stated the predominant weeds in sandy loam soil were *Digitaria marginata*, *Dactyloctenium aegypticum*, *Chloris barbata*, *Echinochloa colonum*, *Eleusine indica*, *Commelina benghalensis*, *Amaranthus viridis*, *Euphorbia hirta*, *Euphorbia geniculata*, *Borreria hispida*, *Portulaca oleracea*, *Ageratum conyzoides*, *Spillanthus acmella*, *Acanthosperum hispidum*, *Cleome monophylla*, *Phyllanthus niruri*, *Achyranthus aspera* and *Cyperus rotundus*.

Kochar (2009) reported major weed flora in *rabi* season at Sriganganagar, Rajasthan are *Ageratum conyzoides* L., *Anagallis arvensis* L., *Arenaria serpyllifolia* L., *Argemone mexicana* L., *Asphodelus tenuifolius*, *Carthamus oxycantha*, *Chenopodium album* L., *Chenopodium murale* L., *Cichorium intybus* L., *Convolvulus arvensis* L., *Coronopus didymus* L., *Cynodon dactylon* L., *Eclipta alba* L., *Emex spinosa* L., *Euphorbia geniculata* Orteg, *Euphorbia hirta* L., *Fumaria indica* (Hausk.), *Gnaphalium luteo- album* L., *Lathyrus aphaca* L., *Launaea fallax* L., *Linum usitatissimum* L., *Medicago polymorpha* L., *Melilotus alba* Medic., *Melilotus indica* L., *Parthenium hysterophorus* L., *Psammogeton canescens* DC., *Rumex dentatus* L., *Silene conoidea* L., *Sonchus asper* Hill., *Spergula arvensis* L., *Stellaria media* L., *Trigonella corniculata* L., *Vaccaria pyramidata* Medic and *Vicia sativa* L.

Kasar and Chavan (2010) observed that the prominent weeds in clay loam soil were *Euphorbia geniculata*, *Physalis minima*, *Digeria arvensis*, *Lagasca mollis*, *Acalypha indica* and *Phyllanthus niruri* among the dicots and *Dinebra arabica*, *Commelina benghalensis*, *Poa annua*, *Cyperus rotundus* and *Cynodon dactylon* among the monocots.

Kiroriwal *et al.* (2012) reported that weed flora of the experimental field consisted of *Tribulus terrestris* L., *Cenchrus biflorus*, *Corchorus tridense*, *Cyperus spp.*, *Euphorbia microphylla*. However, the predominant weeds were *Tribulus terrestris*, *Cenchrus biflorus* and *Corchorus tridense*.

Singh *et al.* (2014) carried out a field experiment during *kharif* 2013 at SKRAU, Bikaner and reported that major weed flora of experiment as field were *Amaranthus viridis*, *Gisekia poiedious*, *Digeria arvensis*, *Chenchrus biflorus*, *Eragrostis pilosa* and *Eragrostis tennela* in Clusterbean.

Gupta *et al.* (2015) reported that the experimental field was heavily infested with mixed flora of broadleaved and grassy weeds, viz. *Amaranthus spinosus* L., *Euphorbia hirta* L., *Aristida depressa* L., *Portulaca oleracea* L., *Digeria arvensis* Forsk., *Gisekia poiedious*., *Cenchrus biflorus* L., *Tribulus terrestris* L., *Aervato tomentosa* Forsk., *Corchorus tridense* L., *Eleusine verticillata* L., *Eragrostis tennela* and *Trianthema portulacastrum* L.,

2.1.2 Losses caused by weeds

Rangasamy *et al.* (1993) reported that among several factors limiting its yield, weeds are considered to be one of the major yield limiting factors. In *kharif* season weeds cause more losses than either insect pests or plant diseases because of favorable climatic conditions. Reduction in yield due to weed alone is estimated to be 16-42 per cent depending on crop and location.

The crop management practices have a great influence on weed infestation and recorded 34% average yield loss under ordinary

management practices and as high as 60% under poor management practices (Dayal and Ghosh, 1999).

2.1.3 Critical period of crop-weed competition

Kalaiselvan *et al.* (1991) stated that weed free condition from 15 to 40 days after sowing was essential for getting maximum yield. Everaarts (1992) suggested an initial weed free period of 15 days from sowing and subsequently the competition should be avoided during 35 to 60 DAS for profitable crop yield.

2.1.4 Effect of weed control measures on weed.

Pre-emergence application of soil active herbicides could be appropriate not only in minimizing early weed control, but also for reducing the demand of labour during peak period of cultivation and to avoid at least one or two inter cultivations during first 3-4 weeks and control weeds in inter row as well as in the intra row (Baker and Terry, 1991).

Jain *et al.* (2000) confirmed that pre-emergence application of pendimethalin at 1.5 kg ha⁻¹ reduced the weed density, weed biomass and increased the weed control efficiency as well as number of pods plant⁻¹ and weight of pods. Whereas, Nayak *et al.* (2000) reported that the higher weed control efficiency was found in pendimethalin at 1 kg ha⁻¹ which was at par with two hand weeding on 25 and 40 DAS.

Reager *et al.* (2003) while conducting a weed control experiment in clusterbean at Jobner found that pre-emergence application of pendimethalin 1 kg ha⁻¹ supplemented with hand weeding resulted in the highest reduction in weed dry matter and weed density.

Nandekar *et al.* (2004) reported that pre-emergence application of pendimethalin @ 1.25 kg ha⁻¹ followed by hand weeding caused significant reduction in weed population and weed dry matter of weed in fenugreek.

Kumar *et al.* (2004) at Hisar noted the lowest density of carpet weed and purple nutsedge and dry matter accumulation of weeds in greengram using pendimethalin 1.5 kg ha⁻¹+ one hand weeding at 30 DAS. It was closely followed by one hand weeding at 30 DAS and pendimethalin at 1.5 kg ha⁻¹ treatments.

Rathi *et al.* (2004) at Kanpur noted the lowest density of *Cyperus rotundus*, *Parthenium hysterophorus*, *Trianthema monogyna* and *Phyllanthus niruri* and dry matter of weeds with two hand weedings at 20 and 45 DAS and was accompanied by pendimethalin 0.5 kg ha⁻¹ + one hand weeding at 30 DAS. It witnessed the weed control efficiency of 67.8 per cent.

Kamboj *et al.* (2005) reported in fenugreek that herbicides significantly reduced weed density and weed dry matter. The lowest weed dry weight (5.00 q ha⁻¹) was obtained with pendimethalin 1 kg ha⁻¹.

Savu *et al.* (2006) found that imazethapyr 80 g ha⁻¹ (PoE) showed significant reduction in weed population and dry matter production and produced significantly higher yield attributes and yield over weedy check.

Tiwari *et al.* (2006) reported that application of pendimethalin 1.0 kg ha⁻¹ + hand weeding at 25 DAS reduced the weed population and dry matter of weed in fenugreek.

Dixit and Varshney (2007) at Jabalpur reported that post-emergence application of imazethapyr 100 g ha⁻¹ was found the most effective in reducing weed density and weed biomass in soybean. Reduction in weed density due to this treatment was 39.79 % compared to weedy check. Likewise, the respective values for weed biomass reduction due to this treatment were 67.29 and 18.75 per cent.

Pre-emergence application of pendimethalin at 1 kg ha^{-1} recorded lower weed population, higher pod (15.95 q ha^{-1}) and haulm yield (4295 q ha^{-1}) due to control of weeds at early stage (Bhatt *et al.* 2008).

Chovatia *et al.* (2009) conducted an experiment to study the effect of weed control measures on growth and yield of fenugreek. Weed density of monocot, dicot and sedges was significantly lower under two hand weeding *i.e.* at 20 and 45 DAS, but was at par with the pre-emergence application of pendimethalin 0.75 kg ha^{-1} .

Sharma (2009) conducted a field experiment during *rabi* season and reported that two hand weedings at 20 and 40 days after sowing (DAS) recorded minimum dry weight of both monocot and dicot weeds.

Punia *et al.* (2011) observed that application of imazethapyr $80\text{-}100 \text{ g ha}^{-1}$ at 21 to 28 DAS provided season long control (85-95%) of clusterbean weeds and maximum seed yield (1424 kg ha^{-1}) of clusterbean with weed free check.

Meena *et al.* (2013 a) conducted an experiment on loamy sand soil of Instructional Farm, Department of Agronomy, C.P. College of Agriculture, S.D. Agricultural University, Sardar Krushinagar (Gujarat) during the *rabi* season of 2011-12 on weed control study in dill seed (*Anethum graveolens* L.). Besides weed free condition, application of pendimethalin 0.5 kg ha^{-1} (PE) at 20 DAS was found more effective in reducing the weed population (*viz.*, grassy, broad leaved and sedges) weeds (18.86 g m^{-2}). Treatment pendimethalin 0.5 kg ha^{-1} (PE) at 20 DAS was found equally effective in this respect.

Fagaria *et al.* (2014) reported that two hand weeding at 25 and 45 DAS recorded minimum dry matter of weeds. Among the herbicides pre-emergence application of pendimethalin 0.5 kg ha^{-1} + one hand weeding at 35 DAS was most effective in reducing dry matter of weeds.

2.2 Crop

2.2.1 Growth and yield

Gurjar *et al.* (2001) at Gwalior reported that pendimethalin (1.0 and 1.5 kg ha⁻¹) noted significantly higher seed yield, yield attributing characters and weed control efficiency in soybean compared to weedy check.

Dungarwal *et al.* (2002) reported that pre emergence application of pendimethalin 1 kg ha⁻¹ being at par with weed free was most effective in controlling weeds which enhanced growth and yield components and resulted in production of higher seed yield in fenugreek crop.

Gill *et al.* (2002) reported that hand weeding followed by pendimethalin 0.75 kg ha⁻¹ gave maximum seed yield of cumin and it was statistically at par with 2 hand weeding. Pendimethalin 0.75 kg ha⁻¹ + hand weeding was significantly higher than all individually applied treatments and control.

Rana (2002) reported that pendimethalin was the most effective herbicide in controlling weeds in rajmash. Pendimethalin at 1.50 kg ha⁻¹ increased pods plant⁻¹, seeds pod⁻¹ and yield significantly. Super imposition of hand weeding over pendimethalin did not record any significant benefit in terms of yield.

Moyer *et al.* (2003) conducted an experiment to determine the herbicides efficacy on various weeds. When imazamox/imazethapyrn or combinations of imazamoz/imazethapyr or imazethapyr was applied, weed counts were about 5% of the total dry matter and the herbicides did not reduce fenugreek yield compared to the hand-weeded check.

Nandekar *et al.* (2004) reported that pre-emergence application of pendimethalin 1.25 kg ha⁻¹ followed by hand weeding gave high seed yield (6.24 q ha⁻¹) of fenugreek.

Kamboj *et al.* (2005) reported that weed control treatments significantly increased the seed yield of fenugreek compared with the weedy control. The highest seed yield was obtained in the weed free control due to no crop weed competition for space, nutrients, light etc. throughout the crop season. However, among herbicide treatments, pendimethalin at 0.50 kg ha⁻¹ in combination with hand weeding recorded the highest seed yield.

Tiwari *et al.* (2006) reported that application of pendimethalin 1.0 kg ha⁻¹ + hand weeding at 25 DAS registered the highest grain yield and straw yield of fenugreek.

Mehta *et al.* (2010) conducted a field experiment to study the effect of weed management practices on growth and yield of fenugreek (*Trigonella foenum-graecum* L.) at Sardar Krushinagar (Gujarat). The study indicated that weed free treatment gave higher plant height, dry matter accumulation plant⁻¹, number of nodules and number of branches plant⁻¹ with weed control by pre-emergence application of pendimethalin 0.75 kg ha⁻¹ + Inter-culturing at 40 DAS and hand weeding at 20 and 40 DAS which were significantly higher over rest of treatments.

Meena *et al.* (2013 b) recorded that pre-emergence application of pendimethalin 1 kg ha⁻¹ + one hand weeding at 45 DAS gave significantly higher yield.

Meena *et al.* (2013) reported that maximum grain yield of 1294 kg ha⁻¹ and stover yield of 2255 kg ha⁻¹ were recorded in weed free treatment. The treatment involving weed free resulted in significantly higher oil content (3.95%) and oil yield (51.12 kg ha⁻¹).

2.2.2 Nutrient content and uptake.

Kumar *et al.* (1998) conducted a field experiment at Ranchi during 1994 and reported that the highest removal of N, P and K by

pigeonpea (202.4 N, 10.1 P and 73.1 K kg ha⁻¹) was recorded with the pendimethalin + hand weeding treatment.

2.3 Weed control efficiency and economics.

Dungarwal *et al.* (2003) reported that pre-emergence application of pendimethalin 1 kg ha⁻¹ being at par with weed free was most effective in recording highest net monetary return of ₹4210 ha⁻¹ with benefit cost ratio of 2.46 in fenugreek crop.

Madhu *et al.* (2006) reported that the maximum net income was obtained with weed free (₹ 12787 ha⁻¹) followed by pendimethalin (₹ 11966 ha⁻¹) combined with one inter cultivation and one hand weeding. Combinations of pendimethalin with one inter cultivation and one hand weeding recorded the highest B-C ratio (1.32).

Shete *et al.* (2007) at Maharashtra found the highest weed control efficiency with the application of imazethapyr 87.5 g ha⁻¹ followed by a dose of 75 g ha⁻¹ in soybean.

Bagri *et al.* (2014) conducted a field experiment during *rabi* season at Research Farm of RVSKVV, College of Horticulture, Mandsaur (Madhya Pradesh) to study the response of fenugreek (*Trigonella foenum-graecum* L.) to different chemical weed control measures. However, on the basis of net profit, application of pendimethalin 1.0 kg ha⁻¹ applied as pre-emergence proved best treatment among herbicides and gave maximum net return of ₹59820.00 ha⁻¹ with seed yield of 22.24 q ha⁻¹.

3. MATERIALS AND METHODS

A field experiment entitled “Effect of Weed Control Measures on Growth and Yield of Fenugreek (*Trigonella foenum-graecum* L.)” was conducted at Instructional Farm College of Agriculture, S.K. Rajasthan Agricultural University, Bikaner during *rabi* season of 2017-18. The details of experimental techniques, materials used and methods adopted for treatment evaluation during the course of investigation are described in this chapter.

3.1 Experimental site and location

The field experiment was conducted at Agronomy Farm, College of Agriculture, S.K. Rajasthan Agricultural University, Bikaner (Raj.). Bikaner is situated at 28° 01'N latitude and 73° 22'E longitude at an altitude of 234.70 meters above mean sea level. According to “Agro-ecological region map” brought out by the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Bikaner falls under Agro-ecological region No. 2 (MgE1) under arid ecosystem (Hot Arid Eco-region with desert and Saline soil), which is characterized by deep, sandy and coarse loamy, desert soils with low water holding capacity, hot and arid climate. As per NARP, Bikaner falls in Agro climatic zone 1c (Hyper Arid Partially Irrigated North Western Plain Zone). According to National Planning Commission, Bikaner falls under Agro-climatic zone XIV (Western Dry Region) of India.

3.2 Climate and weather conditions

Bikaner has arid climate with average annual rainfall of about 250 mm. More than 80 per cent of rainfall is received during *kharif* season (July-September) by the South West monsoon. During summer, the maximum temperature may go as high as 48° C while in the winters it may fall as low as 0° C. The periodical mean weekly

weather parameters recorded for the period of the experimentation presented in Table 3.1 and depicted in Fig. 3.1. The maximum temperature ranged between 20.5°C and 35.0°C during the crop growing season in the 50th and 11th standard meteorological weeks, respectively (Table 3.1). Likewise, the values of minimum temperature *i.e.* 3.8°C and 16.9°C was recorded in the 1th and 11th standard meteorological weeks, respectively. Crop received 4.0 mm of rainfall with 0 rainy days in the growing season. Pan evaporation ranged from 2.1 to 7.6 mm day⁻¹ during the crop growing period. The average relative humidity during experiment fluctuated in the range of 17.7 to 82.4 per cent (Fig.3.1).

3.3 Soil of the experimental field

In order to ascertain the physico-chemical characteristics of the soil, surface soil (0-15 cm depth) samples were collected from different spots of the experimental field in both the years. Representative composite samples obtained from random samples, were subjected to physical and chemical analysis separately. The physico-chemical characteristics of the soil of experimental field along with the methods followed for analysis are given in Table 3.2.

Table 3.1. Weekly meteorological data of Bikaner for the *rabi* 2017-18

SMW	Temperature (°C)		R.H.(%)		Total Rainfall (mm.)	No.of Rainy days**	Wind Velocity (km hr ⁻¹)	Evaporation (mm day ⁻¹)	BSSH
	Max.	Min.	Max.	Min.					
46	27.4	12.4	81.0	41.4	1.4	0.0	3.6	3.3	2.0
47	27.2	6.9	68.6	23.4	-	0.0	2.4	2.9	
48	30.5	9.8	55.7	22.7	-	0.0	3.0	3.1	
49	27.8	7.9	54.9	26.3	-	0.0	3.0	3.4	
50	20.5	7.1	81.3	46.1	2.0	0.0	4.6	2.1	
51	26.1	4.9	81.4	27.4	-	0.0	2.2	2.5	
52	29.9	6.0	76.0	27.7	-	0.0	2.6	2.5	
1	23.6	3.8	82.4	29.0	-	0.0	2.7	2.4	
2	25.8	5.0	74.1	26.3	-	0.0	2.8	2.3	
3	26.1	6.0	78.3	29.9	-	0.0	3.1	2.6	
4	24.4	5.5	81.6	35.4	-	0.0	3.8	2.3	
5	27.6	7.7	69.7	25.3	-	0.0	3.6	3.1	
6	26.6	7.9	55.3	20.4	-	0.0	4.4	3.3	
7	28.1	9.3	82.0	33.1	-	0.0	5.0	4.4	
8	32.6	13.7	73.9	30.4	-	0.0	5.1	4.9	
9	32.8	15.4	69.7	28.0	0.6	0.0	4.7	5.0	
10	34.0	14.2	61.3	20.4	-	0.0	5.1	5.6	
11	35.0	16.9	55.6	17.7	0.	0.0	6.3	7.6	6.8

Y = 2017-18; Data collected from Agromet Observatory, Agricultural Research Station, Bikaner, SMW = Standard Meteorological Weeks

Table 3.2. Physico-chemical characteristics of the experimental soil

Soil properties	2016-17	Methods used with references
A. Mechanical		
Sand (%)	82.5	Hydrometer method (Bouyoucos, 1962)
Silt (%)	10.7	
Clay (%)	6.8	
Textural class	Loamy Sand	Bouyoucos (1962)
B. Physical		
Bulk density (Mg m ⁻³)	1.50	Undisturbed core sampler method (Blake and Hartge, 1986)
Particle density (Mg m ⁻³)	2.70	Method No.33, USDA Hand Book No. 60 (Richard,1954)
Total porosity (%)	42.9	Method No.40,USDA Hand Book-60 (Richards, 1954)
C. Chemical		
Organic carbon (%)	0.10	Walkley and Black's rapid titration method (Walkley and Black, 1947)
Available N (kg ha ⁻¹)	120.7	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P ₂ O ₅ (kg ha ⁻¹)	18.9	Olsen's method (Olsen <i>et al.</i> , 1954)
Available K ₂ O(kg ha ⁻¹)	210.7	Flame photometric method (Pratt (1982))
EC (dS m ⁻¹ at 25 ⁰ C)	0.19	Method No. 4, USDA Hand Book No.- 60 (Richards, 1954)
pH	8.4	Method No. 21 (b), USDA Hand Book No. 60 (Richards, 1954)

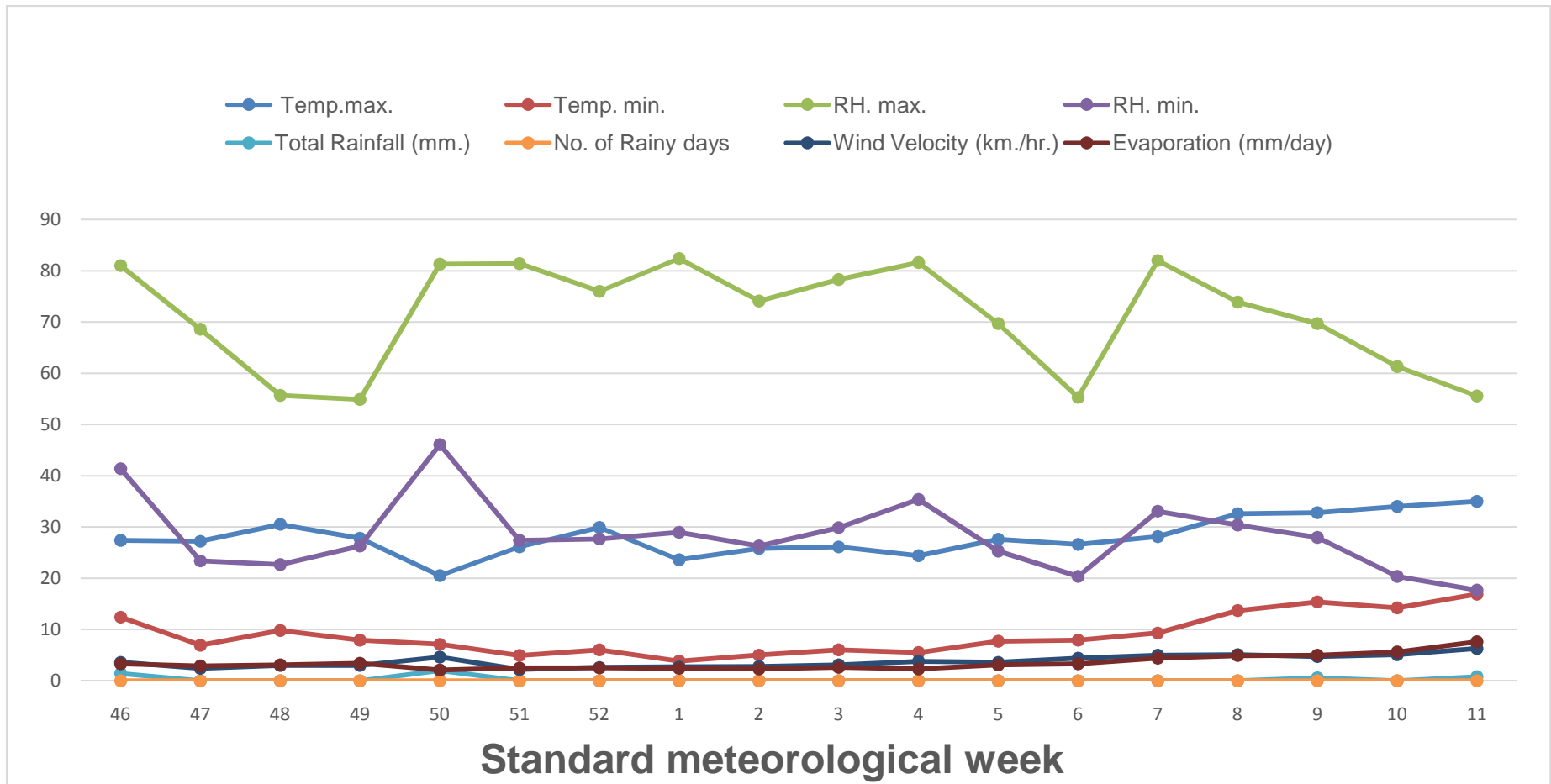


Fig: 3.1: Weekly meteorological data of Bikaner for the *rabi* 2017-18

3.4 Cropping history of experimental field

The cropping history of the experimental field for the last three years is given in Table 3.3

Table 3.3. Cropping history of the experimental field

Years	Seasons	
	Rabi	Kharif
2015-16	Mustard	Pearlmillet
2016-17	Cabbage	Clusterbean
2017-18	Fenugreek *	

* Experimental crop

3.5 Experimental details

3.5.1 Treatments

The field experiment during *rabi* season 2017-18 was laid out in randomized block design with three replications. The treatments and their symbols used are given in Table 3.4

Table 3.4. Details of the treatments with their symbols

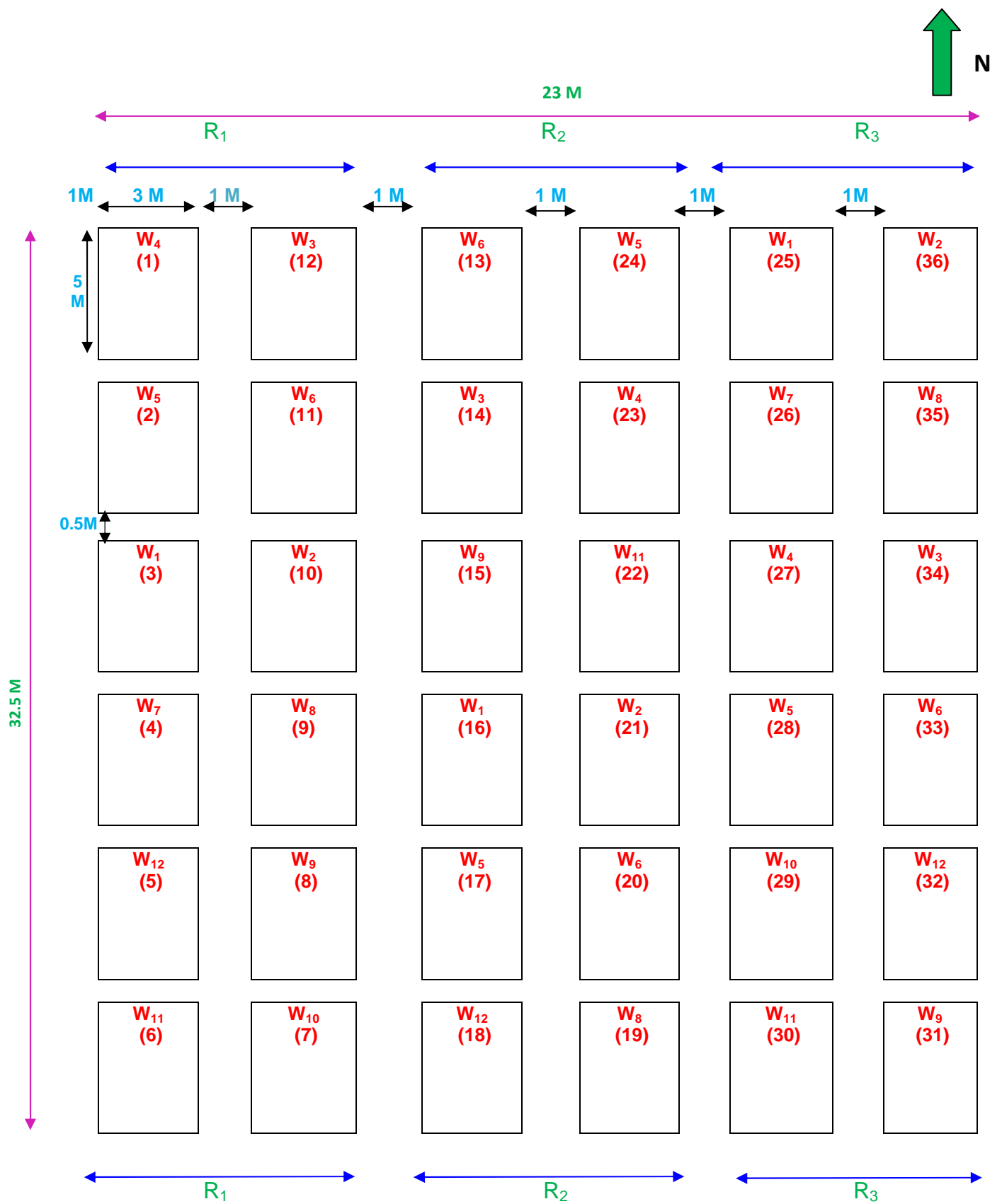
S.No.	Treatments	Symbols
1.	Weedy check	T ₁
2.	Weed free	T ₂
3.	Pendimethalin at 0.75 kg ha ⁻¹ (Dry sowing of crop)	T ₃
4.	Pendimethalin+ imazethapyr at 0.80 kg ha ⁻¹ (Dry sowing of crop)	T ₄
5.	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	T ₅
6.	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	T ₆
7.	Pendimethalin at 0.75 kg ha ⁻¹ as PE	T ₇
8.	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as	T ₈

- PE
9. Imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) T₉
 10. Imazethapyr + imazamox at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) T₁₀
 11. Imazethapyr at 70 g ha⁻¹ (3-4 leaf stage 25 DAS) T₁₁
 12. Imazethapyr + imazamox at 70 g ha⁻¹(3-4 leaf stage 25 DAS) T₁₂
-

3.5.2 Experimental design and layout

The experiment was laid out in randomized block design with three replications. The treatments were randomly allotted to different plots by using random number table (Fisher and Yates 1963). The plan of layout of experiments for fenugreek crop is given in Fig. 3.2 and other details of experiment are given below:

1.	Season	-	<i>Rabi</i> - 2017-18
2.	Test crop	-	Fenugreek
3.	Design	-	RBD
4.	Total number of treatments	-	12
5.	Total number of replications	-	3
6.	Total number of plots	-	36
7.	Gross plot size	-	5.0 m x 3.0 m
8.	Net plot size	-	4.0 m X 2.4m
9.	Crop geometry	-	30 cm X 10 cm
10.	Varieties	-	RMt 305
11.	Seed rate	-	24 kg ha ⁻¹



Plot size = 5 m x 3 m = 15 m²

Design = Randomized block design

Total number of treatments = 12

Replications = 3

Total number of plots = 36

Fig. 3.2. Plan of Layout

3.6 Varietal characters

RMt 305 variety developed through mutation breeding from variety RMt 1. The average yield is 1300 kg ha⁻¹, determinant type, multipodant, early maturing, wider adaptability, resistant to powdery mildew and root knot nematodes. Seeds bold, attractive and yellow in colour, duration 120-125 days.

3.7 Details of crop raising

Crops are raised as per packages of practices in zone Ic. The details of different operations under taken for raising the crops are given as under. The chronological record of crop raising is given in Table 3.5.

Table 3.5. Schedule of pre and post sowing operations carried out in the experimental field

Particulars	Date of operations	Remarks
Pre-sowing irrigation	02.11.2017	Sprinkler method
Field preparation	05.11.2017	Disc ploughing, harrowing and Planking in order to have optimum tilth
Lay out	06.11.2017	Manually
Application of fertilizers	07.11.2017	Manually by “kera” method
Sowing	07.11.2017	Manually by “kera” method
Thinning	27.11.2017	Manually
Irrigation (1 st)	23.11.2017	Sprinkler method
Irrigation (2 nd)	11.12.2017	Sprinkler method
Irrigation (3 rd)	29.12.2017	Sprinkler method
Irrigation (4 th)	21.01.2018	Sprinkler method
Irrigation (5 th)	14.02.2018	Sprinkler method
Harvesting	09.03.2018	Manually
Threshing and Winnowing	19.03.2018	Manually

3.7.1 Field preparation

The experimental field was ploughed thoroughly by tractor drawn disc plough followed by cross harrowing and planking. Thereafter the field was laid out manually into plots according to the plan of layout (Fig 3.2).

3.7.2. Fertilizer application

The calculated amount of chemical fertilizers (25 kg N, 40 kg P₂O₅ and 20 kg K₂O ha⁻¹) were applied through urea, diammonium phosphate and murate of potash, respectively. Whole nitrogen and phosphorous and potassium applied in field at the time of sowing in all plots as a basal dose.

3.7.3 Seed and sowing

The fenugreek variety RMT 305 was sown using 24 kg seed ha⁻¹ at the depth of 3 cm on 7th November, 2017 manually by “kera” method.

3.7.4 Application of treatment

As per the treatments, herbicide application in dry sowing treatment was done before pre irrigation of crop and sowing in dry soil, in PPI treatment application of herbicide was done after irrigation but before sowing, PE treatment applied one day after crop sowing. The other herbicide treatments applied at 25 DAS after sowing (3-4 leaf stage), two hand weeding (weeding at 15 and 30 DAS in weed free treatment) and in weedy check no weed control was done. The application of herbicide was done with the help of knap-sack sprayer.

3.8.4 Thinning

Thinning of the crop was done manually at 15 days after sowing (DAS) to maintain optimum plant population.

3.7.6 Irrigation

A pre sowing, irrigation was given before land preparation. Five irrigations were given during cropping period. The respective dates of irrigation to crops are presented in Table 3.5. The irrigations were applied through sprinkler system.

3.7.7 Plant protection

One spray of chloropyriphos 30 EC @ 1.0 litre hectare⁻¹ in 1000 litre water was done to protect the crop from termite as per schedule given in Table 3.5.

3.7.8 Harvesting

The crop plants of net plot were harvested separately, through splashing out the plants just above the ground with the help of sickle. The harvested material of each plot was collected and tied in bundles and tagged. These bundles were left on the threshing floor for sun drying.

3.7.9 Threshing and winnowing

After complete drying, the harvested produce of individual plot was weighed with the help of balance to record biological yield plot⁻¹. The threshing of net plot was done manually by beating with the wooden sticks and seeds were separated by winnowing. The seed yield was obtained by weighing the produce of net plot and expressed in terms of kilogram hectare⁻¹. The straw yield was computed by deducting the weight of seed yield from total biological yield.

3.8 Treatment evaluation

3.8.1 Weed analysis

3.8.1.1 Weed density

The weeds were count by quadrat method at 30, 60 DAS and at harvest. The size of quadrat was 1.0 m² (1.0 x 1.0 m). One quadrat was randomly thrown in each plot and counted the occurring weed species.

3.8.1.2 Weed dry weight

The weed under 0.25 m² area were removed from randomly selected area at 30, 60 DAS and at harvest and classified as, monocot and dicot weeds. These were dried at 65⁰C temperature in oven for 48 hours and weighed to obtain mean weed dry weight and at harvest all weeds of net plot were collected and categorized as broad- leaved and grassy weeds before drying and weighing.

3.8.1:3 N, P and K uptake by weeds at harvested

For estimation of nitrogen, phosphorus and potassium sample of weeds were taken at the time of harvesting. Each dry sample was ground in fine wiley mill for estimating the N, P and K. The uptake of N, P and K by weeds were estimated by using the formula:

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%)} \times \text{Weed dry matter (kg ha}^{-1}\text{)}}{100}$$

3.8.1.4: Weed index

Weed index was calculated by the following formula (Yadav and Mishra, 1982).

$$\text{Weed index} = \frac{X - Y}{X} \times 100$$

Where,

X = Yield from weed free plot (kg ha⁻¹)

Y = Yield from treated plot (kg ha⁻¹)

3.8.1.5: Weed control efficiency

Weed control efficiency was calculated using the following formula (Varshney, 1990).

$$\text{WEC} = \frac{\text{Density of weeds in weedy check plot (m}^{-2}\text{)} - \text{Density of weed in treated (m}^{-2}\text{)}}{\text{Density of weed in weedy check plot (No.m}^{-2}\text{)}} \times 100$$

3.8.2 Crop studies

3.8.2.1 Growth parameters

Five representative plants from each plot were selected randomly and tagged for observing the effect of different treatments. All biometric observations except dry matter were recorded periodically on these randomly selected and tagged plants. The details of observations on growth, yield attributes and yield, nutrient content, uptake and quality parameters of fenugreek crop are given as follows:

3.8.2.2.3 Plant stand

The number of plants m^{-2} was counted from randomly selected five locations in each plot at 20 DAS and harvesting. The mean plant stand m^{-2} was worked out and recorded as plants m^{-2} then value converted in ha^{-1} .

3.8.2.2 Plant height

Five plants were selected randomly from each plot and tagged permanently. Height of these five plants was measured at 30, 60 DAS and at harvest from the base of the plant to top of the main shoot by metre scale and their mean was expressed as plant height (cm).

3.8.2.3 Number of branches

The branches from five randomly selected plants from each plot were counted at harvest. The average was computed and expressed as number of branches plant^{-1} .

3.8.2.4 Number of nodules plant⁻¹

Five plants were selected randomly at 50 DAS in sample rows of each plot and uprooted carefully in wet soil with the help of *khurpi*. The soil mass embodying the roots of the plants was washed off with water and total root nodules were counted to record average number of nodules plant⁻¹.

3.8.2.5 Dry matter accumulation

Five plants were selected randomly and carefully uprooted from sample rows of each plot for estimation of dry matter accumulation at 30, 60, 90 DAS and harvest. After separating roots of the plants, the samples were dried in sun for 2-3 days and then in oven at 70 °C for about 72 hours to obtain constant weight. The average dry matter accumulation plant⁻¹ at the respective stages was worked out.

3.8.3 Yield attributes and yield

3.8.3.1 Number of pods plant⁻¹

The pods of five randomly selected plants from each plot at the time of harvesting were counted and average number of pods plant⁻¹ was recorded.

3.8.3.2 Number of seeds pod⁻¹

Number of seeds in five randomly selected pods harvested from observational plants were counted and average number of seeds pod⁻¹ was calculated.

3.8.3.3 Length of pod

The length of pod was measured from randomly selected five pods from each treatment with the help of scale and then average was recorded from each treatment in cm.

3.8.3.4 Test weight

One thousand seeds were counted in samples taken from the finally winnowed and clean produce of each plot. These seeds were weighed on electronic balance and the weight was recorded as test weight (g).

3.8.3.5 Seed yield

The seed yield of each net plot (inclusive of tagged plants) was recorded in kg plot⁻¹ after cleaning the threshed produce and it was converted in kg ha⁻¹.

3.8.3.6 Straw yield

Straw yield in kg plot⁻¹ was obtained by subtracting the grain yield from biological yield plot⁻¹ recorded earlier and expressed in kg ha⁻¹.

3.8.3.7 Biological yield

The harvested material from net area of each plot was thoroughly sun dried. After drying, the produce of individual net plot was weighed with the help of spring balance and recorded as biological yield in kg plot⁻¹. Later this was converted into kg ha⁻¹.

3.8.3.8 Harvest index (%)

The harvest index was calculated by using following formula and expressed as percentage (Singh and Stoskopf, 1971).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

3.8.4 Bio chemical analysis

3.8.4.1 Chlorophyll content

Chlorophyll content was worked out at flowering stage. Accordingly Hiscox and Israelstem (1979) demonstrated that the absorption spectrum (600-680 nm) for chlorophyll extracted in DMSO was virtually identical to that for extracted in 90 per cent acetone. Chlorophyll was extracted in DMSO and transmittance was recorded with spectrophotometer at 645 and 663 nm. Arnon's equation (1949) was used to work out chlorophyll content as here under:

$$\text{Chlorophyll "a"} \quad (12.7 \times A_{663}) - (2.69 \times A_{645}) \quad \text{Volume of DMSO} \\ (\text{mg g}^{-1} \text{ fresh} \quad = \frac{\quad}{1000} \quad \times \frac{\quad}{\quad} \\ \text{weight of leaves}) \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \text{Weight of leaf sample}$$

$$\text{Chlorophyll "b"} \quad (22.9 \times A_{645}) - (4.65 \times A_{663}) \quad \text{Volume of DMSO} \\ (\text{mg g}^{-1} \text{ fresh} \quad = \frac{\quad}{1000} \quad \times \frac{\quad}{\quad} \\ \text{weight of leaves}) \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \text{Weight of leaf sample}$$

Total chlorophyll content was worked out by adding chlorophyll "a" and chlorophyll "b" as under:

$$\text{Total Chlorophyll (mg g}^{-1} \text{ fresh weight of leaves)} = \text{Chlorophyll a} + \text{Chlorophyll b}$$

3.8.5 Quality parameters

3.8.5.1 Nutrient content and uptake

3.8.5.1.1 Plant nutrient analysis

For estimation of nitrogen, phosphorus and potassium, samples of seed and straw from each plot were taken at the time of threshing. Each dried straw sample was ground to fine powder in mill for the estimation of the nutrient content. For estimating the nutrient content in seed, each sample was ground by an electric grinder. Nutrient content in seed and straw were determined by using standard methods (Table 3.8).

Table 3.6. Methods of determination of N, P and K content in crop (seed and straw) and weed

S.No	Determination	Methods	References
1.	Nitrogen content	Estimation from digested aliquot of digestion I colour was developed with Nessler's reagent and recorded on colorimeter with green filter	Snell and Snell (1949)
2.	Phosphorus content	Estimated from digested aliquot of digestion II colorimetrically (spectrophotometer 106) using Vanado-molybdo-phosphoric yellow colour method	Jackson (1973)
3.	Potassium content	Estimated from digested aliquot of digestion II using flame photometer 129	Bhargava and Raghupathi (1993)

Method of plant analysis

Wet digestion I

100 mg plant samples was digested in concentrated H_2SO_4 and H_2O_2 and then volume of digested material was made upto 100 ml. Nitrogen content was determined from this digested aliquot.

Wet digestion II

One gram of powdered material of seed and straw was digested separately in triacid mixture of 10 : 1 : 4 HNO_3 , H_2SO_4 and $HClO_4$ (Nitric acid + sulphuric acid + perchloric acid). Then volume of digested material was made upto 50 ml with double distilled water and stored in polythene bottles. Total contents of phosphorus and potassium were determined in this digested aliquot as per details given in Table 3.8.

3.8.5.1.2 Nutrient uptake

The uptake of nitrogen, phosphorus and potassium by seed, straw as well as weeds were estimated by using the following formula.

$$\text{Nutrient uptake by seed (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content in seed (\%)} \times \text{seed yield (kg ha}^{-1}\text{)}}{100}$$

$$\text{Nutrient uptake by straw (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content in straw (\%)} \times \text{straw yield (kg ha}^{-1}\text{)}}{100}$$

$$\text{Nutrient uptake by weed (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content in weed (\%)} \times \text{weed dry weight (kg ha}^{-1}\text{)}}{100}$$

Total uptake of nutrients was computed by summing up the uptake by seed and straw. Likewise the uptake of nutrients by weeds was also calculated.

3.8.5.2 Protein content

The per cent protein content in seed of each plot was worked out by multiplying the nitrogen content in seeds with conversion factor 6.25 for fenugreek (A.O.A.C, 1960).

3.8.6 Statistical analysis

3.8.6.1 Analysis of variance and test of significance

In order to test the significance of variance in experiments, the data obtained for various treatment effects were statistically analysed as per procedure described by Panse and Sukhatme (1985). The critical differences were calculated to assess the significance of treatment means wherever, the “F” test was found significant at 5 per cent and 1 per cent level of significance. The analysis of variance for all the data presented and discussed and has been given in appendices at the end, (I to XV).

3.8.6.2 Correlation and regression studies

To assess inter-relationship between various characters, correlation coefficient was worked out. Further in order to establish cause and effect relationship linear regression equation were also fitted. All the statistical estimates were done by standard statistical procedure (Panse and Sukhatme, 1985).

3.8.7. Economics

3.8.7.1 Cost of cultivation

The cost of field preparation, cost of seed, sowing of seeds, thinning, weeding, fertilizer application, harvesting and cleaning contributed to fixed cost. The variable cost included the cost of irrigation charges and labour for application of irrigation.

3.8.7.2 Gross return

Gross return includes the returns by total cost of seed and straw yields (₹ ha^{-1}).

3.8.7.3 Net return

The economics of different treatments was worked out in terms of net return (₹ ha^{-1}) on the basis of prevailing market prices for inputs and output. The cost of cultivation for each treatment was subtracted from the gross return worked out for the respective treatment to arrive at net return for each treatment.

4. EXPERIMENTAL RESULTS

The results of the field experiment entitled “Effect of Weed Control Measures on Growth and Yield of Fenugreek (*Trigonella foenum-graecum* L.)” conducted at Instructional Farm, College of Agriculture, SKRAU, Bikaner, during *rabi* 2017-18 are being presented in this chapter. Data were statistically analysed to test the significance of the results. Analysis of variance for these data has been furnished in Appendices at the end.

4.1 Weed studies

4.1.1 Weed survey

Weed flora of experimental field consisted of rare monocot weed e.g. *Erograstic spp.* some density sedge (*Cyperus spp.*) and mostly dicot weed are *Rumex spp.* are found emerged as new with the above. At more or less all weeds were there.

4.1.2 Weed density

4.1.2.1. Dicot weeds at 30 DAS

An examination of data (Table 4.1) indicated that all the weed control treatments significantly reduced density of dicot weeds over weedy check. Data further indicated that weed free treatment recorded the lowest density of all dicot weeds compared to rest of the weed control treatments. Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry) and recorded minimum weed density at 30 DAS followed by pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI which remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE and pendimethalin at 0.75 kg ha⁻¹ as PE. However, treatments imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS) remained statistically at par with imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), imazethapyr at 70 g ha⁻¹ (25 DAS), imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) recorded higher dicot weed density at 30 DAS except weedy check.

4.1. Effect of weed control measures on density of dicot weeds in fenugreek

Symbols	Treatments	Weed density (No. m ⁻²)		
		30 DAS	60 DAS	At harvest
T ₁	Weedy check	8.36 (69.45)	8.64 (74.21)	8.75 (76.12)
T ₂	Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T ₃	Pendimethalin at 0.75 kg ha ⁻¹ (dry)	1.67 (2.30)	2.01 (3.67)	2.47 (5.69)
T ₄	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ (dry)	1.43 (1.57)	1.93 (3.26)	2.40 (5.27)
T ₅	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	2.06 (3.78)	2.64 (6.56)	3.34 (10.72)
T ₆	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	1.88 (3.05)	2.56 (6.09)	3.21 (10.16)
T ₇	Pendimethalin at 0.75 kg ha ⁻¹ as PE	2.18 (4.30)	2.61 (6.75)	3.66 (13.08)
T ₈	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PE	2.11 (4.00)	2.60 (6.33)	3.63 (13.00)
T ₉	Imazethapyr at 50 g ha ⁻¹ (3-4 leaf stage 25 DAS)	2.53 (5.92)	2.95 (8.47)	4.18 (16.99)
T ₁₀	Imazethapyr + imazamox at 50 g ha ⁻¹ (25 DAS)	2.41 (5.47)	2.90 (7.92)	3.94 (15.07)
T ₁₁	Imazethapyr at 70 g ha ⁻¹ (25 DAS)	2.49 (5.82)	2.91 (8.10)	4.14 (16.62)
T ₁₂	Imazethapyr + imazamox at 70 g ha ⁻¹ (25 DAS)	2.40 (5.30)	2.82 (7.49)	3.85 (14.44)
	SEm ±	0.13	0.22	0.24
	CD	0.42	0.73	0.77

❖ Values are $\sqrt{x+0.5}$ transformed and actual values are in parentheses

4.1.2.2. Dicot weeds at 60 DAS

A visualization of data Table 4.1 showed that dicot weed density was significantly affected with all weed control treatments. Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry), pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI, pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE and pendimethalin at 0.75 kg ha⁻¹ as PE followed by treatment imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS) and remained statistically at par with imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), imazethapyr at 70 g ha⁻¹ (25 DAS), imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and recorded minimum weed density as compared to weedy check.

4.1.2.3. Dicot weeds at harvest

An examination of data (Table 4.1) showed that all the weed control treatments significantly reduced density of dicot weeds over weedy check. Data further indicated that weed free treatment recorded the lowest density of all dicot weeds compared to rest of the weed control treatments. Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry) followed by pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PPI and pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE and pendimethalin at 0.75 kg ha⁻¹ as PE and recorded minimum weed density as compared to weedy check.

4.1.2.4 Monocot & sedges weed density at 30 DAS

An examination of data (Table 4.2) shows that all the weed control treatments significant reduced density monocot & sedge weeds over weedy check. Data further indicated that weed free treatment recorded the lowest density of all monocot & sedges compared to rest of the weed control treatments. Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with

pendimethalin at 0.75 kg ha⁻¹ (dry) and pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI followed by pendimethalin at 0.75 kg ha⁻¹ as PPI and remained statistically at par with pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE and pendimethalin at 0.75 kg ha⁻¹ as PE and recorded significantly minimum monocot weed density as compared to weedy check imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS), imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), imazethapyr at 70 g ha⁻¹ (25 DAS), imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and weedy check at 30 DAS.

4.1.2.5 Monocot & sedges weed density at 60 DAS

An examination of data (Table 4.2) shows that all the weed control treatments significantly reduced density of monocot & sedge as compared to weedy check. Data further indicated that weed free treatment recorded the lowest density of all monocot & sedge weeds compared to rest of the weed control treatments. Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry), pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI and pendimethalin at 0.75 kg ha⁻¹ as PPI followed by treatment Pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE to which remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PE, imazethapyr + imazamox at 70 g ha⁻¹(25 DAS), imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), imazethapyr at 70 g ha⁻¹ (25 DAS) and imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and recorded significantly minimum monocot weed density as compared to weedy check at 60 DAS.

4.1.2.6 Monocot & sedges weed density at harvest

An examination of data further (Table 4.2) showed that all the weed control treatments significantly reduced density monocot & sedge weeds over weedy check. Data further indicated that weed free treatment recorded the lowest density of all monocot & sedge weeds compared to rest of the weed control treatments.

4.2. Effect of weed control measures on monocot & sedges weed density in fenugreek

Symbols	Treatments	30 DAS (No. m ⁻²)	60 DAS (No. m ⁻²)	At harvest (No. m ⁻²)
T ₁	Weedy check	4.10 (16.33)	4.06(16.03)	4.04 (15.83)
T ₂	Weed free	0.71(0.00)	0.71 (0.00)	0.71 (0.00)
T ₃	Pendimethalin at 0.75 kg ha ⁻¹ (dry)	1.45(1.62)	1.57 (1.95)	1.59 (2.03)
T ₄	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ (dry)	1.30(1.21)	1.35(1.37)	1.39 (1.47)
T ₅	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	1.55(1.90)	1.59(2.04)	1.64 (2.20)
T ₆	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	1.52(1.83)	1.57(2.01)	1.63 (2.19)
T ₇	Pendimethalin at 0.75 kg ha ⁻¹ as PE	1.70(2.42)	1.74(2.53)	1.77(2.64)
T ₈	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PE	1.59(2.01)	1.73(2.52)	1.75 (2.60)
T ₉	Imazethapyr at 50 g ha ⁻¹ (3-4 leaf stage 25 DAS)	1.85(2.92)	1.90(3.11)	1.92 (3.21)
T ₁₀	Imazethapyr + imazamox at 50 g ha ⁻¹ (25 DAS)	1.77(2.66)	1.83(2.85)	1.86 (2.98)
T ₁₁	Imazethapyr at 70 g ha ⁻¹ (25 DAS)	1.79(2.71)	1.84(2.88)	1.87 (3.00)
T ₁₂	Imazethapyr + imazamox at 70 g ha ⁻¹ (25 DAS)	1.67(2.29)	1.75(2.59)	1.80 (2.79)
	SEm ±	0.06	0.09	0.08
	CD	0.22	0.29	0.28

❖ Values are $\sqrt{x+0.5}$ transformed and actual values are in parentheses

Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry), pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI and pendimethalin at 0.75 kg ha⁻¹ as PPI followed by treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PE, imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS), imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), imazethapyr at 70 g ha⁻¹ (25 DAS) and imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and recorded significantly minimum monocot & sedge weed density as compared to weedy check at harvest.

4.1.2.7 Total Weed density

4.1.2.7.1 Total weeds at 30 DAS

An examination of data (Table 4.3) showed that all the weed control treatments significantly reduced density of total weeds over weedy check. Data further revealed that weed free treatment recorded the lowest density of all dicot and monocots weeds compared to rest of the weed control treatments. Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry) and recorded minimum weed density at 30 DAS followed by pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI which remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PPI, Pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE and pendimethalin at 0.75 kg ha⁻¹ as PE. However, treatments imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS) remained statistically at par with imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), imazethapyr at 70 g ha⁻¹ (25 DAS), imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) recorded higher total weed density at 30 DAS except weedy check.

4.1.2.7.2 Total weeds at 60 DAS

A visualization of data Table 4.3 shows that total weed density was significantly affected with all weed control treatments.

Table 4.3. Effect of weed control measures on weed count at 30 DAS, 60 DAS and at harvest in fenugreek

Symbols	Treatments	Weed dry weight (g m ⁻²)								
		30 DAS			60 DAS			At harvest		
		Dicot	Monocot and sedges	Total	Dicot	Monocot and sedges	Total	Dicot	Monocot and sedges	Total
T ₁	Weedy check	8.36 (69.45)	4.10 (16.33)	9.29 (85.78)	8.64 (74.21)	4.06 (16.03)	8.5 (70.84)	8.75 (76.12)	4.04 (15.83)	9.61 (91.95)
T ₂	Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T ₃	Pendimethalin at 0.75 kg ha ⁻¹ (dry)	1.67 (2.30)	1.45 (1.62)	2.10 (3.92)	2.01 (3.67)	1.57 (1.95)	2.36 (5.18)	2.47 (5.69)	1.59 (2.03)	2.86 (7.72)
T ₄	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ (dry)	1.43 (1.57)	1.30 (1.21)	1.81 (2.78)	1.93 (3.26)	1.35 (1.37)	2.25 (4.61)	2.40 (5.27)	1.39 (1.47)	2.68 (6.74)
T ₅	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	2.06 (3.78)	1.55 (1.90)	2.48 (5.67)	2.64 (6.56)	1.59 (2.04)	2.65 (6.73)	3.34 (10.72)	1.64 (2.20)	3.66 (12.93)
T ₆	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	1.88 (3.05)	1.52 (1.83)	2.32 (4.88)	2.56 (6.09)	1.57 (2.01)	2.71 (6.96)	3.21 (10.16)	1.63 (2.19)	3.53 (12.35)
T ₇	Pendimethalin at 0.75 kg ha ⁻¹ as PE	2.18 (4.30)	1.70 (2.42)	2.68 (6.72)	2.61 (6.75)	1.74 (2.53)	2.60 (6.37)	3.66 (13.08)	1.77 (2.64)	4.01 (15.72)
T ₈	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PE	2.11 (4.00)	1.59 (2.01)	2.55 (6.01)	2.60 (6.33)	1.73 (2.52)	2.86 (7.78)	3.63 (13.00)	1.75 (2.60)	3.98 (15.60)
T ₉	Imazethapyr at 50 g ha ⁻¹ (3-4 leaf stage 25 DAS)	2.53 (5.92)	1.85 (2.92)	3.05 (8.83)	2.95 (8.47)	1.90 (3.11)	2.99 (8.71)	4.18 (16.99)	1.92 (3.21)	4.55 (20.20)
T ₁₀	Imazethapyr + imazamox at 50 g ha ⁻¹ (25 DAS)	2.41 (5.47)	1.77 (2.66)	2.93 (8.13)	2.90 (7.92)	1.83 (2.85)	3.04 (9.02)	3.94 (15.07)	1.86 (2.98)	4.30 (18.05)
T ₁₁	Imazethapyr at 70 g ha ⁻¹ (25 DAS)	2.49 (5.82)	1.79 (2.71)	3.00 (8.54)	2.91 (8.10)	1.84 (2.88)	3.22 (10.12)	4.14 (16.62)	1.87 (3.00)	4.48 (19.63)
T ₁₂	Imazethapyr + imazamox at 70 g ha ⁻¹ (25 DAS)	2.40 (5.30)	1.67 (2.29)	2.84 (7.59)	2.82 (7.49)	1.75 (2.59)	2.91 (8.22)	3.85 (14.44)	1.80 (2.79)	4.20 (17.23)
	SEm ±	0.13	0.06	0.64	0.22	0.09	2.12	0.24	0.08	2.63
	CD	0.42	0.22	2.64	0.73	0.29	4.88	0.77	0.28	5.22

❖ Values are $\sqrt{x+0.5}$ transformed and actual values are in parentheses

Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry), pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI, pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE and pendimethalin at 0.75 kg ha⁻¹ as PE followed by treatment imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS) and remained statistically at par with imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), imazethapyr at 70 g ha⁻¹ (25 DAS), imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and recorded minimum weed density as compared to weedy check.

4.1.2.7.3 Total weeds at harvest

An examination of data (Table 4.3) showed that all the weed control treatments significantly reduced density of total weeds over weedy check.

Data further showed that weed free treatment recorded the lowest density of all total weeds compared to rest of the weed control treatments. Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry) followed by pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PPI and pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE and pendimethalin at 0.75 kg ha⁻¹ as PE and recorded minimum weed density as compared to weedy check.

4.1.3 Weed dry weight

4.1.3.1 Dicot weeds dry weight at 30 DAS

An examination of data (Table 4.4) showed that all the weed control treatments significantly reduced dicot weeds dry weight over weedy check. Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry) followed by treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI

and remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE and pendimethalin at 0.75 kg ha⁻¹ as PE and recorded significantly minimum dicot weed dry weight as compared to imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS), imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), imazethapyr at 70 g ha⁻¹ (25 DAS) imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and weedy check at 30 DAS.

4.1.3.2 Dicot weeds dry weight at 60 DAS

An examination of data (Table 4.4) showed that all the weed control treatments significantly reduced dicot weeds dry weight over weedy check. Treatment pendimethalin+ imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry) followed by treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PPI and pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE, and recorded significantly minimum dicot weed dry weight as compared to pendimethalin at 0.75 kg ha⁻¹ as PE, imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS), imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), imazethapyr at 70 g ha⁻¹ (25 DAS) imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and weedy check at 60 DAS.

4.4. Effect of weed control measures on dicot weeds dry weight in fenugreek

Symbols	Treatments	30 DAS (g m ⁻²)	60 DAS (g m ⁻²)	At harvest (g m ⁻²)
T ₁	Weedy check	2.74 (7.01)	5.06 (25.10)	9.69 (93.45)
T ₂	Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T ₃	Pendimethalin at 0.75 kg ha ⁻¹ (dry)	1.57 (1.96)	2.93 (8.12)	5.67 (31.66)
T ₄	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ (dry)	1.54 (1.88)	2.93 (8.08)	5.53 (30.07)
T ₅	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	1.66 (2.26)	3.14 (9.35)	5.82 (33.32)
T ₆	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	1.63 (2.15)	3.10 (9.12)	5.76 (32.64)
T ₇	Pendimethalin at 0.75 kg ha ⁻¹ as PE	1.74 (2.52)	3.30 (10.38)	5.95 (34.87)
T ₈	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PE	1.72 (2.46)	3.15 (9.45)	5.87 (34.02)
T ₉	Imazethapyr at 50 g ha ⁻¹ (3-4 leaf stage 25 DAS)	2.05 (3.72)	3.56 (12.17)	6.20 (37.99)
T ₁₀	Imazethapyr + imazamox at 50 g ha ⁻¹ (25 DAS)	1.96 (3.34)	3.40 (11.05)	6.09 (36.64)
T ₁₁	Imazethapyr at 70 g ha ⁻¹ (25 DAS)	2.03 (3.64)	3.50 (11.72)	6.20 (37.97)
T ₁₂	Imazethapyr + imazamox at 70 g ha ⁻¹ (25 DAS)	1.92 (3.18)	3.37 (10.88)	6.07 (36.40)
	SEm ±	0.03	0.05	0.07
	CD	0.11	0.17	0.22

❖ Values are $\sqrt{x+0.5}$ transformed and actual values are in parentheses

4.1.3.3 Dicot weeds dry weight at harvest

An examination of data (Table 4.4) showed that all the weed control treatments significantly reduced dicot weeds dry weight over weedy check. Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry) followed by treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE and pendimethalin at 0.75 kg ha⁻¹ as PE and recorded significantly minimum dicot weed dry weight as compared to imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS), imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), imazethapyr at 70 g ha⁻¹ (25 DAS) imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and weedy check at harvest

4.1.3.4 Monocot & sedges weeds dry weight at 30 DAS

An examination of data (Table 4.5) showed that all the weed control treatments significantly reduced monocot & sedges weeds dry weight over weedy check. Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry) followed by treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE, pendimethalin at 0.75 kg ha⁻¹ as PE, imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS), imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS) and imazethapyr at 70 g ha⁻¹ (25 DAS) and recorded significantly minimum monocot & sedges weed dry weight as compared to imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and weedy check at 30 DAS.

4.1.3.5 Monocot & sedges weeds dry weight at 60 DAS

An examination of data (Table 4.5) showed that all the weed control treatments significantly reduced monocot & sedges weeds dry weight over weedy check. Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry) followed by treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE, pendimethalin at 0.75 kg ha⁻¹ as PE, imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS), imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS) and imazethapyr at 70 g ha⁻¹ (25 DAS) and recorded significantly minimum monocot & sedges weed dry weight as compared to imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and weedy check at 60 DAS.

4.1.3.6 Monocot & sedges weeds dry weight at harvest

An examination of data (Table 4.5) shows that all the weed control treatments significantly reduced monocot & sedges weeds dry weight over weedy check. Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry) followed by treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE, pendimethalin at 0.75 kg ha⁻¹ as PE, imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS), imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), imazethapyr at 70 g ha⁻¹ (25 DAS) and imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and recorded significantly minimum monocot & sedges weed dry weight as compared to weedy check at harvest.

4.5. Effect of weed control measures on monocot & sedges weed dry weight in fenugreek

Symbols	Treatments	30 DAS (g m ²)	60 DAS (g m ²)	At harvest (g m ²)
T ₁	Weedy check	2.77 (7.19)	3.96 (15.23)	4.24 (17.55)
T ₂	Weed free	0.71 (0.00)	0.71(0.00)	0.71 (0.00)
T ₃	Pendimethalin at 0.75 kg ha ⁻¹ (dry)	1.32 (1.28)	1.84 (2.90)	2.25 (4.55)
T ₄	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ (dry)	1.14 (0.83)	1.77 (2.65)	2.01 (3.55)
T ₅	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	1.53 (1.87)	2.30 (4.78)	2.63 (6.43)
T ₆	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	1.53 (1.86)	2.24 (4.55)	2.61 (6.33)
T ₇	Pendimethalin at 0.75 kg ha ⁻¹ as PE	1.64 (2.19)	2.40 (5.32)	2.80 (7.33)
T ₈	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PE	1.63 (2.18)	2.33 (5.00)	2.73 (6.95)
T ₉	Imazethapyr at 50 g ha ⁻¹ (3-4 leaf stage 25 DAS)	1.85 (2.94)	2.61 (6.34)	2.89 (8.00)
T ₁₀	Imazethapyr + imazamox at 50 g ha ⁻¹ (25 DAS)	1.74 (2.55)	2.54 (5.95)	2.75 (7.13)
T ₁₁	Imazethapyr at 70 g ha ⁻¹ (25 DAS)	1.82 (2.82)	2.58 (6..15)	2.86 (7.66)
T ₁₂	Imazethapyr + imazamox at 70 g ha ⁻¹ (25 DAS)	1.74 (2.54)	2.47 (5.66)	2.73 (6.96)
	SEm ±	0.09	0.11	0.11
	CD	0.30	0.34	0.36

❖ Values are $\sqrt{x+0.5}$ transformed and actual values are in parentheses

4.1.3.7 Weed dry weight

4.1.3.7.1 Total weeds dry weight at 30 DAS

An examination of data (Table 4.6) showed that all the weed control treatments significantly reduced total weeds dry weight over weedy check. Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry) followed by treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI and remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE and pendimethalin at 0.75 kg ha⁻¹ as PE and recorded significantly minimum total weed dry weight as compared to imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS), imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), imazethapyr at 70 g ha⁻¹ (25 DAS) imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and weedy check at 30 DAS.

4.1.3.7.2 Total weeds dry weight at 60 DAS

An examination of data (Table 4.6) showed that all the weed control treatments significantly reduced total weeds dry weight over weedy check. Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry) followed by treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PPI and pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE and recorded significantly minimum total weed dry weight as compared to pendimethalin at 0.75 kg ha⁻¹ as PE, imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS), imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), imazethapyr at 70 g ha⁻¹ (25 DAS) imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and weedy check at 60 DAS.

4.1.3.7.3 Total weeds dry weight at harvest

An examination of data (Table 4.6) shows that all the weed control treatments significantly reduced dicot weeds dry weight over weedy check. Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹

Table 4.6. Effect of weed control measures on weed dry weight at 30 DAS, 60 DAS and at harvest in Fenugreek

Symbols	Treatments	Weed dry weight (g m ⁻²)								
		30 DAS			60 DAS			At harvest		
		Dicot	Monocot and sedges	Total	Dicot	Monocot and sedges	Total	Dicot	Monocot and sedges	Total
T ₁	Weedy check	2.74 (7.01)	2.77 (7.19)	3.83 (14.20)	5.06 (25.10)	3.96 (15.23)	6.64 (43.66)	9.69 (93.45)	4.24 (17.55)	10.56 (111.01)
T ₂	Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.17 (0.00)
T ₃	Pendimethalin at 0.75 kg ha ⁻¹ (dry)	1.57 (1.96)	1.32 (1.28)	5.67 (3.24)	2.93 (8.12)	1.84 (2.90)	3.62 (11.02)	5.67 (31.66)	2.25 (4.55)	6.06 (36.22)
T ₄	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ (dry)	1.54 (1.88)	1.14 (0.83)	1.79 (2.71)	2.93 (8.08)	1.77 (2.65)	3.64 (10.73)	5.53 (30.07)	2.01 (3.55)	5.84 (33.62)
T ₅	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	1.66 (2.26)	1.53 (1.87)	2.15 (4.13)	3.14 (9.35)	2.30 (4.78)	4.04 (15.87)	5.82 (33.32)	2.63 (6.43)	6.34 (39.75)
T ₆	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	1.63 (2.15)	1.53 (1.86)	2.12 (4.01)	3.10 (9.12)	2.24 (4.55)	3.95 (15.21)	5.76 (32.64)	2.61 (6.33)	6.28 (38.97)
T ₇	Pendimethalin at 0.75 kg ha ⁻¹ as PE	1.74 (2.52)	1.64 (2.19)	2.28 (4.71)	3.30 (10.38)	2.40 (5.32)	4.16 (16.94)	5.95 (34.87)	2.80 (7.33)	6.53 (42.20)
T ₈	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PE	1.72 (2.46)	1.63 (2.18)	2.26 (4.64)	3.15 (9.45)	2.33 (5.00)	4.11 (16.45)	5.87 (34.02)	2.73 (6.95)	6.44 (40.97)
T ₉	Imazethapyr at 50 g ha ⁻¹ (3-4 leaf stage 25 DAS)	2.05 (3.72)	1.85 (2.94)	2.67 (6.66)	3.56 (12.17)	2.61 (6.34)	4.60 (20.73)	6.20 (37.99)	2.89 (8.00)	6.82 (45.99)
T ₁₀	Imazethapyr + imazamox at 50 g ha ⁻¹ (25 DAS)	1.96 (3.34)	1.74 (2.55)	2.53 (5.89)	3.40 (11.05)	2.54 (5.95)	4.34 (18.46)	6.09 (36.64)	2.75 (7.13)	6.65 (43.77)
T ₁₁	Imazethapyr at 70 g ha ⁻¹ (25 DAS)	2.03 (3.64)	1.82 (2.82)	2.64 (6.46)	3.50 (11.72)	2.58 (6.15)	4.45 (19.39)	6.20 (37.97)	2.86 (7.66)	6.79 (45.64)
T ₁₂	Imazethapyr + imazamox at 70 g ha ⁻¹ (25 DAS)	1.92 (3.18)	1.74 (2.54)	2.49 (5.72)	3.37 (10.88)	2.47 (5.66)	4.26 (17.79)	6.07 (36.40)	2.73 (6.96)	6.62 (43.36)
	SEm ±	0.03	0.09	0.30	0.05	0.11	0.79	0.07	0.11	1.15
	CD	0.11	0.30	0.98	0.17	0.34	2.52	0.22	0.36	3.69

(dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry) followed by treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE and pendimethalin at 0.75 kg ha⁻¹ as PE and recorded significantly minimum total weed dry weight as compared to imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS), imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), imazethapyr at 70 g ha⁻¹ (25 DAS) imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and weedy check at harvest.

4.1.3 Nutrients uptake by weeds

4.1.3.1 Nitrogen uptake by weeds

An appraisal of data (Table 4.7) showed that all weed control treatments significantly reduced N uptake by broad leaved and grassy weeds as well as total N uptake by the weeds compared weedy check. Data indicated that total N uptake by the weeds was minimum under pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry), followed pendimethalin at 0.75 kg ha⁻¹ (dry) and pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI as compared to other treatment.

4.1.3.2 Phosphorus uptake by weeds

An appraisal of data Table 4.7 showed that all weed control treatments significantly reduced P uptake by broad leaved and grassy weeds as well as total P uptake by the weeds except weedy check. Data further indicated that total P uptake by the weeds was minimum under pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry), followed by pendimethalin at 0.75 kg ha⁻¹ (dry), pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI, pendimethalin at 0.75 kg ha⁻¹ as PPI and pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE which remained at par with rest of treatments.

4.7. Effect of weed control measures on N, P and K uptake by weeds in fenugreek

Symbols	Treatments	Nitrogen uptake (kg ha ⁻¹)	Phosphorus uptake (kg ha ⁻¹)	Potassium uptake (kg ha ⁻¹)
T ₁	Weedy check	32.9	6.6	34.6
T ₂	Weed free	0.0	0.0	0.0
T ₃	Pendimethalin at 0.75 kg ha ⁻¹ (dry)	9.3	1.5	3.2
T ₄	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ (dry)	8.1	1.4	2.6
T ₅	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	11.4	1.7	5.1
T ₆	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	9.8	1.6	4.6
T ₇	Pendimethalin at 0.75 kg ha ⁻¹ as PE	13.7	2.1	6.9
T ₈	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PE	12.1	1.8	6.7
T ₉	Imazethapyr at 50 g ha ⁻¹ (3-4 leaf stage 25 DAS)	16.4	2.9	9.1
T ₁₀	Imazethapyr + imazamox at 50 g ha ⁻¹ (25 DAS)	13.7	2.8	7.9
T ₁₁	Imazethapyr at 70 g ha ⁻¹ (25 DAS)	15.0	2.9	8.7
T ₁₂	Imazethapyr + imazamox at 70 g ha ⁻¹ (25 DAS)	12.9	2.5	7.4
	SEm ±	0.72	0.18	0.67
	CD	2.32	0.58	2.13

4.1.3.3 Potash uptake by weeds

An appraisal of data Table 4.7 expose that all weed control treatments significantly reduced k uptake by broad -leaved and grassy weeds as well as total K uptake by the weeds except weedy check. Data further indicated that total K uptake by the weeds was minimum under pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry), followed pendimethalin at 0.75 kg ha⁻¹ (dry), and pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI, are remained statisticaly at par each otherover rest of other treatments.

4.1.4 Weed index

An appraisal of data Table 4.8 showed that highest weed index was recorded under pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) (73.2%) followed by Weedy check (69.5%), pendimethalin at 0.75 kg ha⁻¹ (dry) (68.2%), imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS) (40.0%), imazethapyr at 70 g ha⁻¹ (25 DAS) (37.0%), imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS) (35.7%) imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) (33.8%), pendimethalin at 0.75 kg ha⁻¹ as PE (21.6%), pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE (17.2%) , pendimethalin at 0.75 kg ha⁻¹ as PPI (12.5%) pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI (7.8 %) and lowest in weed free (0.0%)

4.1.5 Weed control efficiency

Data presented in Table 4.8 revealed that weed control efficiency at harvest based on total weed density fluctuated to a great extent under the influence of various weed control treatments. In general, all weed control treatments efficiently controlled weeds.

The highest weed control efficiency was recorded on total weed density under weed free 100% followed by pendimethalin + imazethapyr at

4.8. Effect of weed control measures on weed index and weed control efficiency in fenugreek

Symbols	Treatments	Weed index (%)	Weed control efficiency (%)
T ₁	Weedy check	69.5	0.00
T ₂	Weed free	0.0	100.00
T ₃	Pendimethalin at 0.75 kg ha ⁻¹ (dry)	68.2	91.61
T ₄	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ (dry)	73.2	92.67
T ₅	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	12.5	85.93
T ₆	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	7.8	86.56
T ₇	Pendimethalin at 0.75 kg ha ⁻¹ as PE	21.6	82.88
T ₈	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PE	17.2	83.06
T ₉	Imazethapyr at 50 g ha ⁻¹ (3-4 leaf stage 25 DAS)	33.8	78.03
T ₁₀	Imazethapyr + imazamox at 50 g ha ⁻¹ (25 DAS)	35.7	80.38
T ₁₁	Imazethapyr at 70 g ha ⁻¹ (25 DAS)	37.0	78.65
T ₁₂	Imazethapyr + imazamox at 70 g ha ⁻¹ (25 DAS)	40.0	81.26
	SEm ±	2.94	1.77
	CD	9.43	5.67

80 kg ha⁻¹ (dry) (92.67%), pendimethalin at 0.75 kg ha⁻¹ (dry) (91.61%), pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI (86.56%), pendimethalin at 0.75 kg ha⁻¹ as PPI (85.93%), pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE (83.06%), pendimethalin at 0.75 kg ha⁻¹ as PE (82.88%), imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS) (81.26), imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS) (80.395), imazethapyr at 70 g ha⁻¹ (25 DAS) (78.65%), imazethapyr at 50 g ha⁻¹ (25 DAS) (78.65%).

4.2 Crop Studies

4.2 Growth attributes

4.2.1 Plant stand

A perusal of data in Table 4.9 showed that all weed control measures influenced the plant population at both the stages growth at 20 DAS and at harvest.

Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry) and recorded significantly lower plant population at 20 DAS and harvest as compared to other treatments.

4.2.2 Plant height

Critical examination of data (Table 4.10) indicated that all the weed control treatments significantly affected the plant height at 30 DAS, 60 DAS and at harvest. At 30 DAS, the maximum plant height was recorded under weed free treatment (5.4 cm), which was statistically at par with pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI and pendimethalin at 0.75 kg ha⁻¹ as PPI treatments as compared to rest of treatments. However weed free was found at par among pendimethalin + imazethapyr

4.9. Effect of weed control measures on plant population of fenugreek

Symbols	Treatments	20 DAS ("000" ha ⁻¹)	At harvest ("000" ha ⁻¹)
T ₁	Weedy check	333	320
T ₂	Weed free	337	330
T ₃	Pendimethalin at 0.75 kg ha ⁻¹ (dry)	287	190
T ₄	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ (dry)	250	180
T ₅	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	333	326
T ₆	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	327	317
T ₇	Pendimethalin at 0.75 kg ha ⁻¹ as PE	333	325
T ₈	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PE	330	324
T ₉	Imazethapyr at 50 g ha ⁻¹ (3-4 leaf stage 25 DAS)	323	320
T ₁₀	Imazethapyr + imazamox at 50 g ha ⁻¹ (25 DAS)	333	323
T ₁₁	Imazethapyr at 70 g ha ⁻¹ (25 DAS)	330	320
T ₁₂	Imazethapyr + imazamox at 70 g ha ⁻¹ (25 DAS)	333	317
	SEm ±	15.41	15.77
	CD	49.37	50.51

Table 4.10. Effect of weed control measures on plant height in fenugreek

Symbols	Treatments	Plant height (cm)		
		30 DAS	60 DAS	At harvest
T ₁	Weedy check	3.2	19.1	46.6
T ₂	Weed free	5.4	25.9	56.4
T ₃	Pendimethalin at 0.75 kg ha ⁻¹ (dry)	3.0	19.9	40.7
T ₄	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ (dry)	2.8	19.2	39.3
T ₅	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	4.5	24.0	54.1
T ₆	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	4.6	24.2	55.2
T ₇	Pendimethalin at 0.75 kg ha ⁻¹ as PE	4.2	23.6	53.9
T ₈	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PE	4.0	23.5	53.7
T ₉	Imazethapyr at 50 g ha ⁻¹ (3-4 leaf stage 25 DAS)	3.9	23.1	50.3
T ₁₀	Imazethapyr + imazamox at 50 g ha ⁻¹ (25 DAS)	3.9	22.3	50.0
T ₁₁	Imazethapyr at 70 g ha ⁻¹ (25 DAS)	3.7	21.2	48.6
T ₁₂	Imazethapyr + imazamox at 70 g ha ⁻¹ (25 DAS)	3.6	20.7	48.1
	SEm ±	0.3	1.2	1.7
	CD	1.0	4.0	5.7

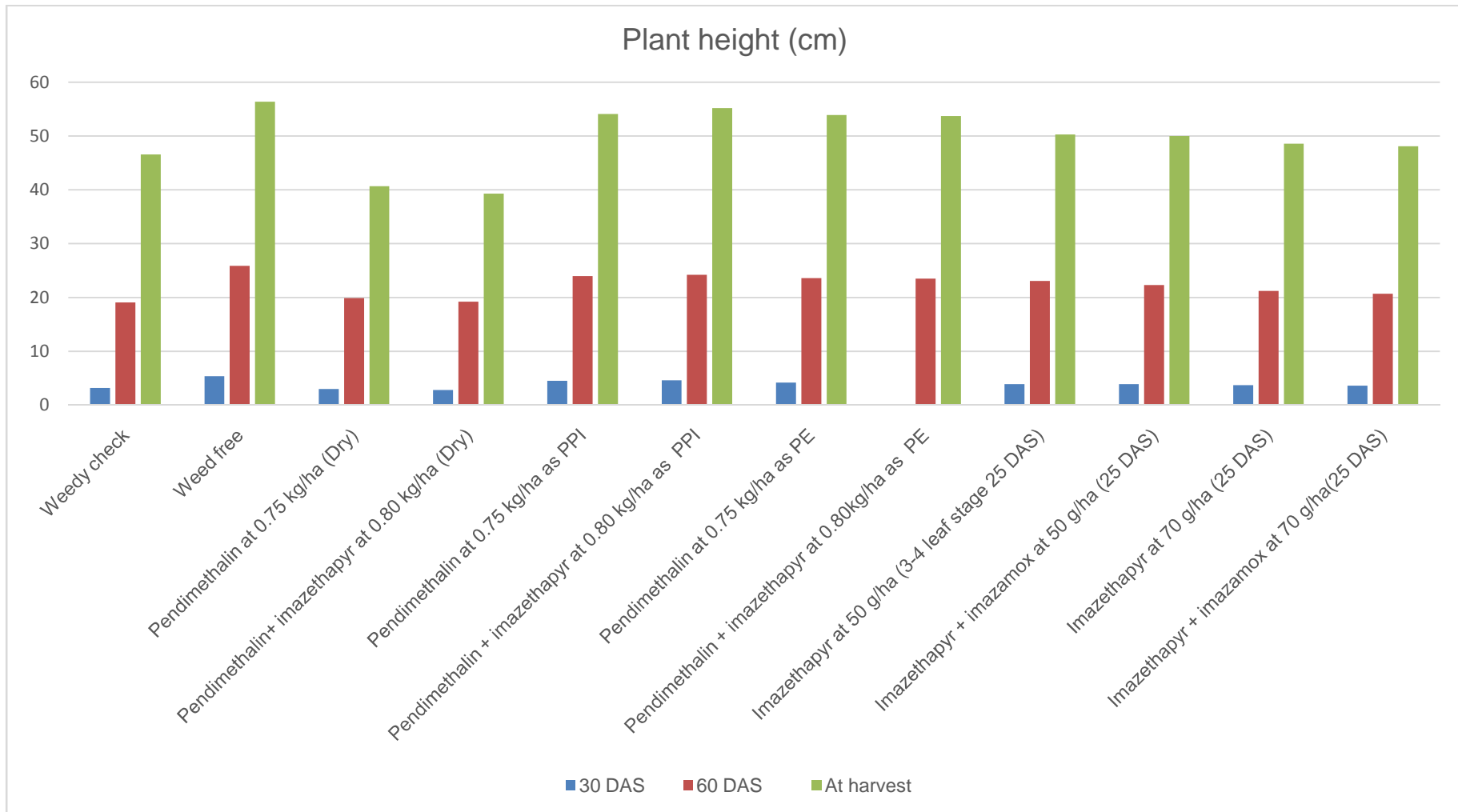


Fig. 4.1: Effect of weed control measures on plant height of fenugreek

at 0.80 kg ha⁻¹ as PPI, pendimethalin at 0.75 kg ha⁻¹ as PPI, imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS), pendimethalin at 0.75 kg ha⁻¹ as PE , pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE and imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS) and recorded significantly higher plant height at 60 DAS over rest of treatment.

Data further indicated that weed free treatment was found statistically at par with pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI, pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin at 0.75 kg ha⁻¹ as PE and pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE recorded significantly higher plant height as compared to all other remained treatments at harvest.

4.2.3 Number of branches plant⁻¹ at harvest

The data presented in Table 4.11 showed that number of branches plant⁻¹ at harvest influenced by different weed control measures.

The higher number of branches plant⁻¹ at harvest was found with weed free treatment. Treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI and pendimethalin at 0.75 kg ha⁻¹ as PPI are remained statistically at par with pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE, pendimethalin at 0.75 kg ha⁻¹ as PE, imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS) and recorded significantly higher number of branches as compared to imazethapyr at 70 g ha⁻¹ (25 DAS), imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS), pendimethalin at 0.75 kg ha⁻¹ (dry) and pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry).

4.2.4 Number of nodules plant⁻¹ at 50 DAS

The data presented in Table 4.11 showed that number of nodules plant⁻¹ at 50 DAS was influenced by different weed control measures.

4.11. Effect of weed control measures on number of branches plant⁻¹ at harvest and number of nodules plant⁻¹ at 50 DAS of fenugreek

Symbols	Treatments	Branches at harvest	Nodules at 50 DAS
T ₁	Weedy check	3.0	17.4
T ₂	Weed free	7.0	28.2
T ₃	Pendimethalin at 0.75 kg ha ⁻¹ (dry)	3.5	19.5
T ₄	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ (dry)	3.3	18.1
T ₅	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	6.4	23.3
T ₆	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	6.4	24.7
T ₇	Pendimethalin at 0.75 kg ha ⁻¹ as PE	5.8	25.3
T ₈	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PE	5.6	18.4
T ₉	Imazethapyr at 50 g ha ⁻¹ (3-4 leaf stage 25 DAS)	5.2	17.0
T ₁₀	Imazethapyr + imazamox at 50 g ha ⁻¹ (25 DAS)	5.2	16.3
T ₁₁	Imazethapyr at 70 g ha ⁻¹ (25 DAS)	4.7	18.0
T ₁₂	Imazethapyr + imazamox at 70 g ha ⁻¹ (25 DAS)	4.4	17.6
	SEm ±	0.4	1.1
	CD	1.4	3.5

The higher number of branches plant⁻¹ at harvest was found with weed free treatment. Treatment pendimethalin at 0.75 kg ha⁻¹ as PE remained statistically at par with pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI and pendimethalin at 0.75 kg ha⁻¹ as PPI and recorded

significantly higher number of nodule plant⁻¹ at 50 DAS as compared to rest of treatments.

4.2.5 Dry matter accumulation

An examination of data Table 4.12 showed that all the weed control treatments significantly affected the dry matter accumulation at 30, 60, 90 DAS and at harvest as compared to weedy check.

The maximum plant dry matter accumulation was recorded in weed free treatment followed by pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI, pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin at 0.75 kg ha⁻¹ as PE, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE, imazethapyr at 50 g ha⁻¹ (25 DAS), weedy check, imazethapyr + imazamox at 50 g ha⁻¹, imazethapyr at 70 g ha⁻¹, imazethapyr + imazamox at 70 g ha⁻¹, pendimethalin at 0.75 kg ha⁻¹ (dry) and pendimethalin + imazethapyr at 80 kg ha⁻¹ (dry).

4.3 Yield attributes

4.3.1 Number of pods plant⁻¹

An appraisal of data (Table 4.13) reflected that all weed control treatments produced significantly increased number of pods plant⁻¹ over weedy check. The number of pods plant⁻¹ was highest in weed free treatment. However, pendimethalin + imazethapyr at 80 kg ha⁻¹ (PE) was statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE, pendimethalin at 0.75 kg ha⁻¹ as PE, imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS), imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), imazethapyr at 70 g ha⁻¹ (25 DAS) and imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and recorded significantly higher number of pods plant⁻¹ as compared to weedy check, pendimethalin at 0.75 kg ha⁻¹ (dry) and pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry).

Table 4.12. Effect of weed control measures on plant dry weight of fenugreek

Symbols	Treatments	30 DAS (g plant⁻¹)	60 DAS (g plant⁻¹)	90 DAS (g plant⁻¹)	At harvest (g plant⁻¹)
T ₁	Weedy check	3.0	5.7	10.6	14.1
T ₂	Weed free	8.0	10.1	18.0	22.5
T ₃	Pendimethalin at 0.75 kg ha ⁻¹ (dry)	2.5	6.2	11.6	14.5
T ₄	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ (dry)	2.2	6.1	10.9	13.3
T ₅	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	6.3	9.3	15.3	21.2
T ₆	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	6.6	10.0	16.4	21.3
T ₇	Pendimethalin at 0.75 kg ha ⁻¹ as PE	5.9	9.2	15.0	21.0
T ₈	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PE	4.6	9.0	14.8	20.1
T ₉	Imazethapyr at 50 g ha ⁻¹ (3-4 leaf stage 25 DAS)	3.1	8.8	12.6	16.6
T ₁₀	Imazethapyr + imazamox at 50 g ha ⁻¹ (25 DAS)	3.0	7.9	13.5	18.0
T ₁₁	Imazethapyr at 70 g ha ⁻¹ (25 DAS)	3.0	6.7	13.2	16.8
T ₁₂	Imazethapyr + imazamox at 70 g ha ⁻¹ (25 DAS)	2.9	6.4	14.7	19.0
	SEm ±	0.4	0.7	0.8	1.3
	CD	1.4	2.3	2.7	4.4

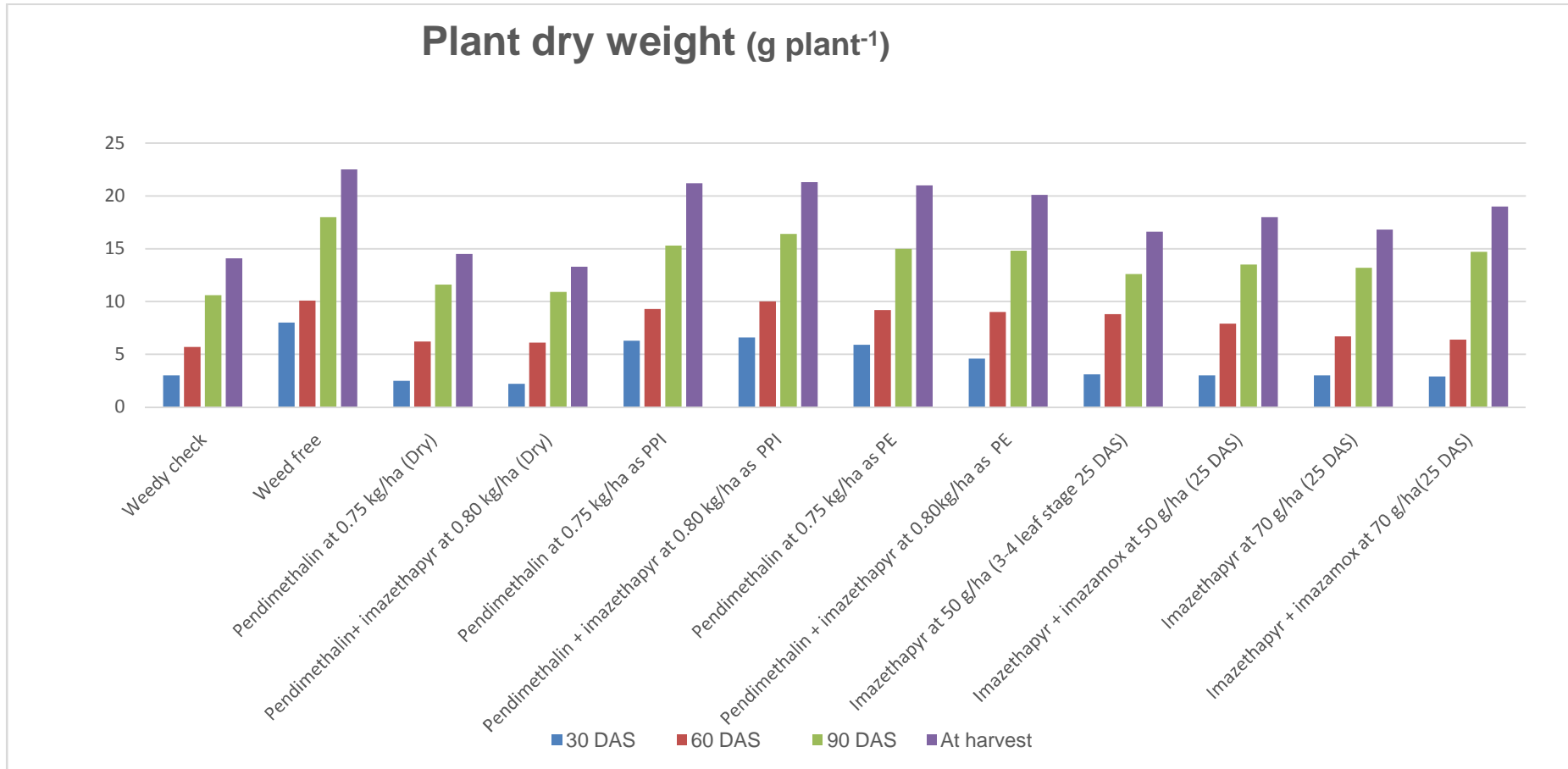


Fig: 4.2: Effect of weed control measures on plant dry weight of fenugreek

4.3.2 Number of seeds pod⁻¹

Data (Table 4.13) presented that all weed control treatments produced significantly increased number of pods plant⁻¹ over weedy check. The number of pods plant⁻¹ was highest in weed free treatment. However, pendimethalin + imazethapyr (30+2) premix 800 g ha⁻¹ (PE) was statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE, pendimethalin at 0.75 kg ha⁻¹ as PE, imazethapyr at 70 g ha⁻¹ (25 DAS) and imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and recorded significantly higher number of pods plant⁻¹ as compared to weedy check, pendimethalin at 0.75 kg ha⁻¹ (dry), pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS) and imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS).

4.3.3 Pod length (cm)

An appraisal of data (Table 4.13) reflected that all weed control treatments produced significantly increased number of pods plant⁻¹ over weedy check. The number of pods plant⁻¹ was highest in weed free treatment. However, pendimethalin + imazethapyr (30+2) premix 800 g ha⁻¹ (PE) was statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE, pendimethalin at 0.75 kg ha⁻¹ as PE, imazethapyr at 70 g ha⁻¹ (25 DAS) and imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and recorded significantly higher number of pods plant⁻¹ as compared to weedy check, pendimethalin at 0.75 kg ha⁻¹ (dry), pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS) and imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS).

4.13. Effect of weed control measures on yield attributes of fenugreek

Symbols	Treatments	No. of pods plant ⁻¹	No. of seeds pod ⁻¹	Pod length (cm)	Test weight (gm)
T ₁	Weedy check	19.0	10.0	9.0	13.3
T ₂	Weed free	28.0	16.0	13.5	14.3
T ₃	Pendimethalin at 0.75 kg ha ⁻¹ (dry)	15.7	10.1	7.3	11.1
T ₄	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ (dry)	17.5	10.3	7.8	10.2
T ₅	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	27.7	14.0	12.0	13.4
T ₆	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	27.7	15.7	13.0	13.2
T ₇	Pendimethalin at 0.75 kg ha ⁻¹ as PE	27.1	13.7	11.9	13.6
T ₈	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PE	26.6	13.3	11.8	13.6
T ₉	Imazethapyr at 50 g ha ⁻¹ (3-4 leaf stage 25 DAS)	26.2	12.7	10.5	12.9
T ₁₀	Imazethapyr + imazamox at 50 g ha ⁻¹ (25 DAS)	26.3	11.0	11.0	13.6
T ₁₁	Imazethapyr at 70 g ha ⁻¹ (25 DAS)	26.0	12.3	10.1	13.5
T ₁₂	Imazethapyr + imazamox at 70 g ha ⁻¹ (25 DAS)	25.8	12.0	10.0	13.2
	SEm ±	1.8	1.0	0.9	0.6
	CD	5.8	3.4	2.9	2.1

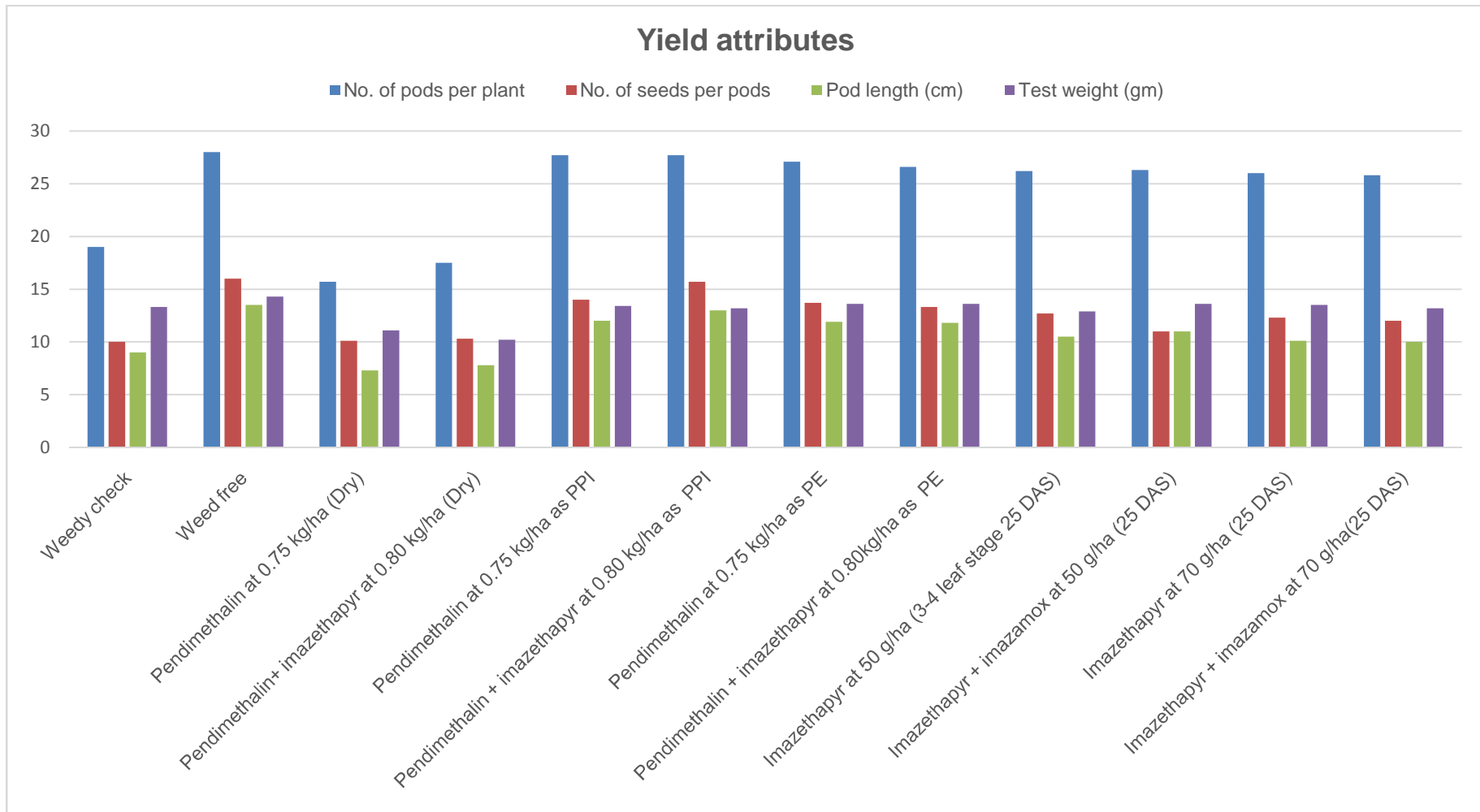


Fig: 4.3 Effect of weed control measures on yield attributes of fenugreek

4.3.4 Test weight

Data in Table 4.13 reflected that all weed control treatments produced significantly increased number of pods plant⁻¹ over weedy check. The number of pods plant⁻¹ was highest in weed free treatment. However, pendimethalin + imazethapyr (30+2) premix 800 g ha⁻¹ (PE) was statistically at par with pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE, pendimethalin at 0.75 kg ha⁻¹ as PE, imazethapyr at 70 g ha⁻¹ (25 DAS) and imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and recorded significantly higher number of pods plant⁻¹ as compared to weedy check, pendimethalin at 0.75 kg ha⁻¹ (dry), pendimethalin+ imazethapyr at 0.80 kg ha⁻¹ (dry) imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS) and imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS).

4.3.5. Seed yield

An examination of data in Table 4.14 indicated that all the weed control measures improved the kernel yield significantly in comparison to weedy check (603 kg ha⁻¹). Treatment weed free (1970 kg ha⁻¹) remained statistically at par with treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI (1814 kg ha⁻¹) and recorded significantly higher seed yield as compared to rest of treatments in fenugreek.

4.3.6. Straw Yield

Data (Table 4.14) showed that straw yield of fenugreek was influenced by different weed control measure. Treatment weed free remained statistically at par with treatment pendimethalin at 0.75 kg ha⁻¹ as PE, imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE, pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI, imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS), imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS), imazethapyr at 70 g ha⁻¹ (25 DAS) and weedy check.

4.3.7. Biological yield

Data (Table 4.14) showed that straw yield of fenugreek was influenced by different weed control measure. Weed free treatment remained statistically at par with treatment pendimethalin at 0.75 kg ha⁻¹ as PE, imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE, pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI, imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS) and imazethapyr at 70 g ha⁻¹ (25 DAS).

4.3.8. Harvest index

Data (Table 4.14) showed that straw yield of fenugreek was influenced by different weed control measures. Weed free treatment remained statistically at par with treatment pendimethalin at 0.75 kg ha⁻¹ as PE, imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE, pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI and imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS).

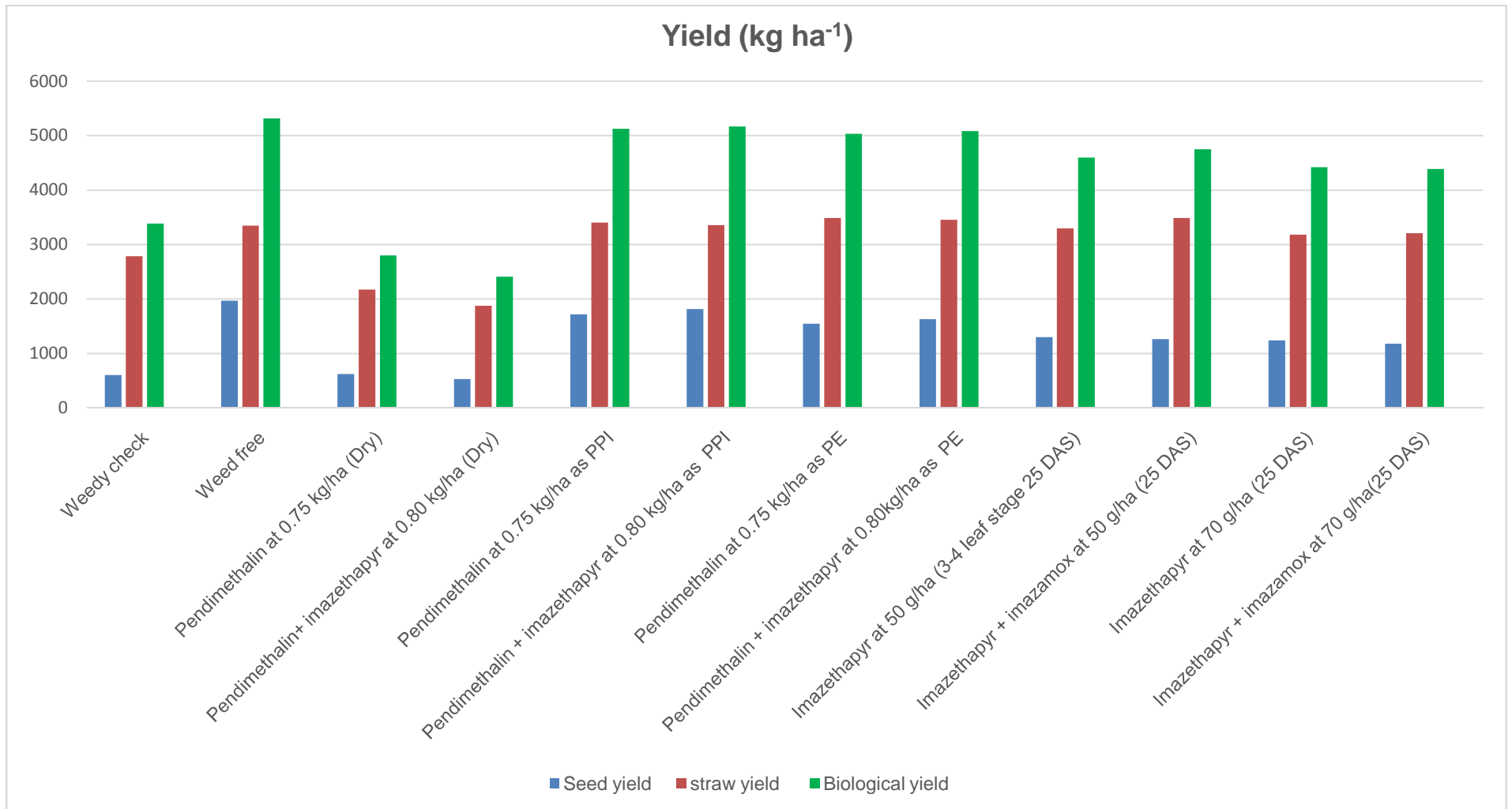


Fig: 4.4: Effect of weed control measures on yield Of fenugreek

4.14. Effect of weed control measures on yield of fenugreek

Symbols	Treatments	Seed yield (kg ha ⁻¹)	straw yield (kg ha ⁻¹)	Biological yield (kg ha ⁻¹)	Harvest index (%)
T ₁	Weedy check	603	2785	3387	17.7
T ₂	Weed free	1970	3348	5318	37.0
T ₃	Pendimethalin at 0.75 kg ha ⁻¹ (dry)	624	2175	2799	22.4
T ₄	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ (dry)	531	1878	2408	22.6
T ₅	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	1720	3405	5126	34.7
T ₆	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	1814	3357	5171	35.3
T ₇	Pendimethalin at 0.75 kg ha ⁻¹ as PE	1545	3488	5033	31.0
T ₈	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PE	1631	3456	5086	32.5
T ₉	Imazethapyr at 50 g ha ⁻¹ (3-4 leaf stage 25 DAS)	1302	3296	4597	28.5
T ₁₀	Imazethapyr + imazamox at 50 g ha ⁻¹ (25 DAS)	1265	3487	4752	26.7
T ₁₁	Imazethapyr at 70 g ha ⁻¹ (25 DAS)	1241	3182	4423	28.1
T ₁₂	Imazethapyr + imazamox at 70 g ha ⁻¹ (25 DAS)	1181	3209	4390	27.0
	SEm ±	55	299	288	2.66
	CD	176	959	924	8.53

4.4 Quality

4.4.1 Nitrogen content

A perusal of data (Table 4.15) showed that nitrogen content in seed and straw of fenugreek recorded under the influence of all weed control treatments did not vary significantly.

4.4.2 Phosphorus content

An assessment of data in Table 4.15 indicated that all the weed control treatments did not have any significant effect on phosphorus content of seed and straw of fenugreek.

4.4.3 Protein content

A perusal of data in Table 4.16 showed that protein content in seed of fenugreek recorded under the influence of all weed control treatments did not vary significantly.

4.4.4 Chlorophyll content

A perusal of data in Table 4.16 showed that all weed control measures caused non-significant effect on total chlorophyll at flowering stage in fenugreek.

4.15. Effect of weed control measures on nitrogen and phosphorus content in seed and straw of fenugreek

Symbols	Treatments	Nitrogen (%)		Phosphorus (%)	
		Seed	Straw	Seed	Straw
T ₁	Weedy check	2.26	1.72	0.39	0.22
T ₂	Weed free	2.50	1.57	0.41	0.23
T ₃	Pendimethalin at 0.75 kg ha ⁻¹ (dry)	2.28	1.57	0.40	0.21
T ₄	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ (dry)	2.49	1.64	0.41	0.24
T ₅	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	2.38	1.62	0.40	0.24
T ₆	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	2.47	1.67	0.39	0.21
T ₇	Pendimethalin at 0.75 kg ha ⁻¹ as PE	2.39	1.66	0.40	0.20
T ₈	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PE	2.51	1.64	0.39	0.20
T ₉	Ima zethapyr at 50 g ha ⁻¹ (3-4 leaf stage 25 DAS)	2.48	1.66	0.38	0.20
T ₁₀	Imazethapyr + imazamox at 50 g ha ⁻¹ (25 DAS)	2.36	1.61	0.38	0.21
T ₁₁	Imazethapyr at 70 g ha ⁻¹ (25 DAS)	2.44	1.59	0.37	0.21
T ₁₂	Imazethapyr + imazamox at 70 g ha ⁻¹ (25 DAS)	2.37	1.63	0.41	0.22
	SEm ±	0.12	0.04	0.01	0.01
	CD	NS	NS	NS	NS

Table 4.16. Effect of weed control measures on protein and chlorophyll content in fenugreek

Symbols	Treatments	Protein (%)	Chlorophyll content at flowering stage (mg g⁻¹)
T ₁	Weedy check	14.1	1.4
T ₂	Weed free	15.6	1.3
T ₃	Pendimethalin at 0.75 kg ha ⁻¹ (dry)	14.2	1.2
T ₄	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ (dry)	15.6	1.2
T ₅	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	14.9	1.3
T ₆	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	15.4	1.3
T ₇	Pendimethalin at 0.75 kg ha ⁻¹ as PE	15.0	1.2
T ₈	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PE	15.7	1.3
T ₉	Imazethapyr at 50 g ha ⁻¹ (3-4 leaf stage 25 DAS)	15.5	1.3
T ₁₀	Imazethapyr + imazamox at 50 g ha ⁻¹ (25 DAS)	14.8	1.3
T ₁₁	Imazethapyr at 70 g ha ⁻¹ (25 DAS)	15.2	1.3
T ₁₂	Imazethapyr + imazamox at 70 g ha ⁻¹ (25 DAS)	14.8	1.3
	SEm ±	0.77	0.04
	CD	NS	NS

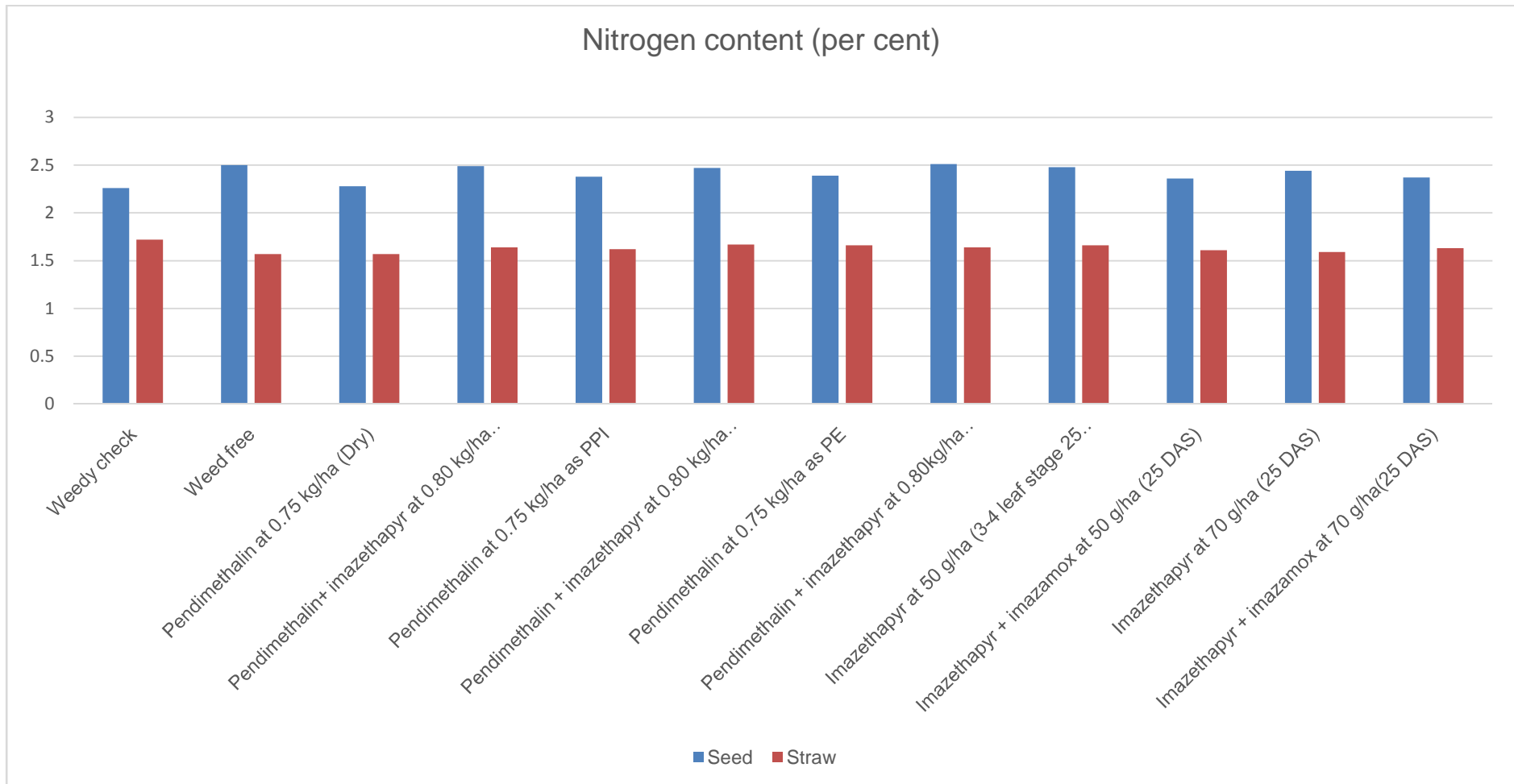


Fig: 4.5 Effect of weed control measures on nitrogen content in seed and straw of fenugreek

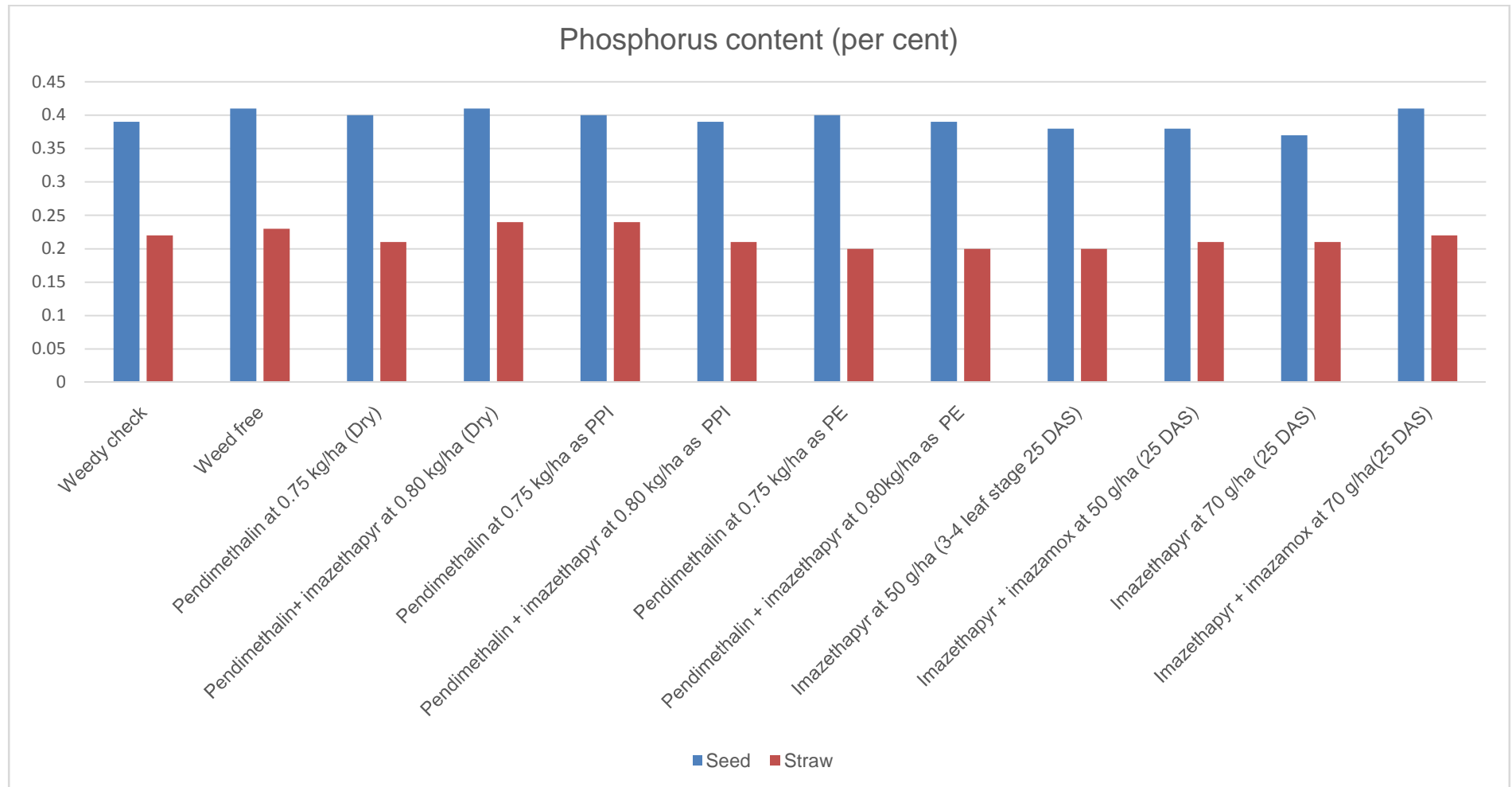


Fig: 4.6:Effect of weed control measures on phosphorus content in seed and straw of fenugreek

4.5 Economics

4.5.2 Gross return

Economic evaluation of different weed control treatments in fenugreek presented in Table 4.17 indicated that the maximum net return of ₹ 49240 ha⁻¹ was obtained with weed free treatment which was statistically at par with pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI (₹ 45350 ha⁻¹) pendimethalin at 0.75 kg ha⁻¹ as PPI.

4.5.3 Net return

Economic evaluation of different weed control treatments in fenugreek presented in Table 4.17 indicated that the maximum net return of ₹ 29752 ha⁻¹ was obtained with weed free treatment which was statistically at par with by pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI (₹ 27610 ha⁻¹) and pendimethalin at 0.75 kg ha⁻¹ as PPI (₹ 25588 ha⁻¹).

4.4 Correlation and regression

Simple correlation and regression were worked out between seed yield and plant height at harvest, dry matter accumulation of crop at harvest, pods plant⁻¹, seeds pod⁻¹, chlorophyll content, total N, P uptake by crop, total weed density, total weed dry weight and total N, P, K uptake by weeds. The correlation coefficient has been given in Table 4.18.

Correlation coefficient study showed that the crop yield was significantly and positively correlated plant height (cm), dry matter accumulation at harvest (g), pods plant⁻¹, seeds pod⁻¹, chlorophyll content, total N uptake by crop (kg ha⁻¹), while negatively correlated with total P uptake by crop (kg ha⁻¹), total weed density at harvest (No. m⁻²), total weed dry weight at harvest (g m⁻²), total N uptake by weeds (kg ha⁻¹),

4.17. Effect of weed control measures on cost of cultivation, gross return and net return of fenugreek

Symbols	Treatments	Cost of cultivation (₹ ha⁻¹)	Gross return (₹ ha⁻¹)	Net return (₹ ha⁻¹)
T ₁	Weedy check	16530	15067	-1463
T ₂	Weed free	19490	49240	29752
T ₃	Pendimethalin at 0.75 kg ha ⁻¹ (dry)	17420	15600	-1820
T ₄	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ (dry)	17740	13267	-4473
T ₅	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	17420	43008	25588
T ₆	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	17740	45350	27610
T ₇	Pendimethalin at 0.75 kg ha ⁻¹ as PE	17420	38625	21205
T ₈	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PE	17740	40767	23027
T ₉	Imazethapyr at 50 g ha ⁻¹ (3-4 leaf stage 25 DAS)	17380	32542	15162
T ₁₀	Imazethapyr + imazamox at 50 g ha ⁻¹ (25 DAS)	18070	31617	13547
T ₁₁	Imazethapyr at 70 g ha ⁻¹ (25 DAS)	17400	31017	13617
T ₁₂	Imazethapyr + imazamox at 70 g ha ⁻¹ (25 DAS)	18370	29517	11147
	SEm ±	0.00	1374	1374
	CD	0.00	4403	4403

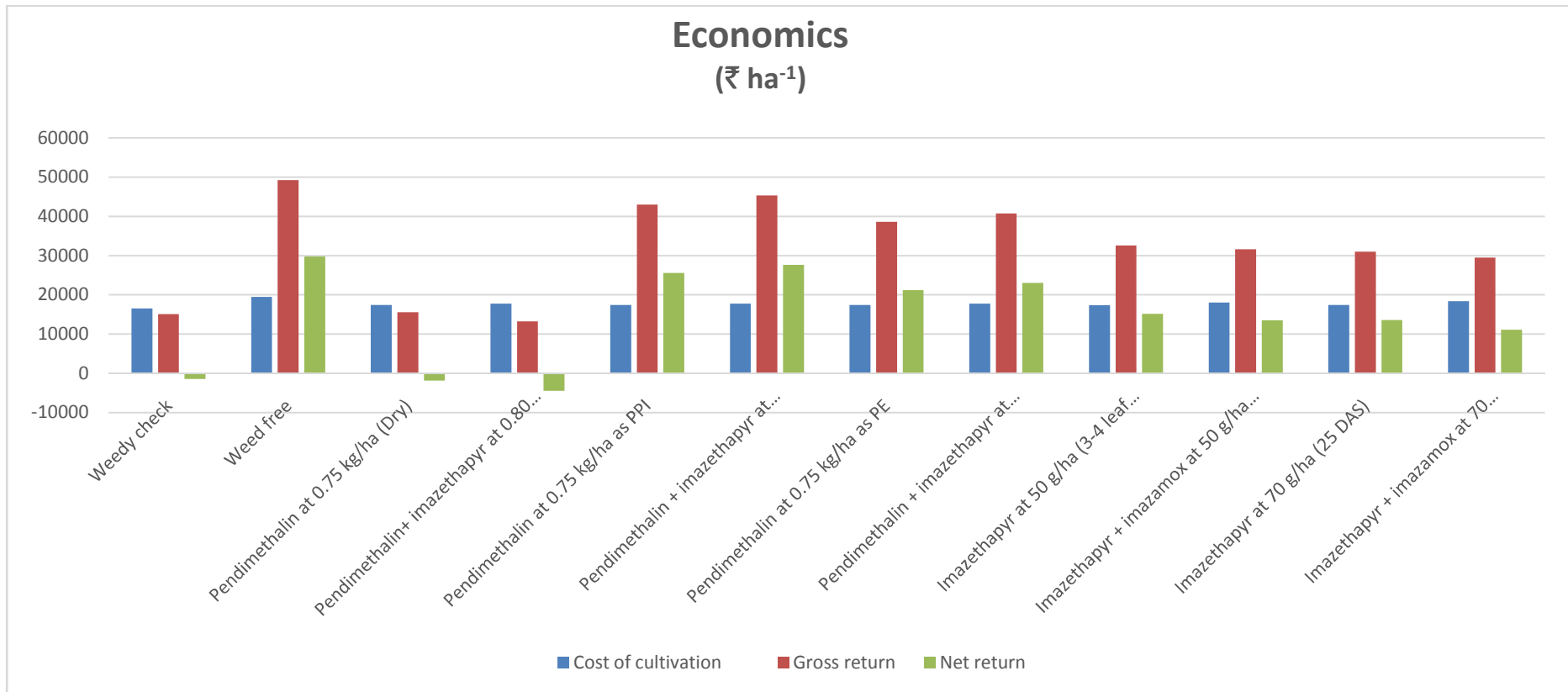


Fig: 4.7: Effect of weed control measures on cost of cultivation, gross return and net return of fenugreek

Table 4.18. Correlation coefficient and regression equation between dependent (y) and independent variables (x)

Dependent (y) Variables	Independent (x) Variables	'r' value	Regression equation
Seed yield (kg ha ⁻¹)	Plant height (cm)	0.95264	y = 0.223x + 48.29
Seed yield (kg ha ⁻¹)	DMA at harvest (g)	0.96586	y = 0.147x + 17.23
Seed yield (kg ha ⁻¹)	Pods plant ⁻¹	0.91945	y = 0.600x + 20.55
Seed yield (kg ha ⁻¹)	Seeds pod ⁻¹	0.94812	y = 0.011x + 12.51
Seed yield (kg ha ⁻¹)	Chlorophyll content	0.16016	y = -0.001x + 1.292
Seed yield (kg ha ⁻¹)	Total N uptake by crop (kg ha ⁻¹)	0.43337	y = 0.004x + 4.015
Seed yield (kg ha ⁻¹)	Total P uptake by crop (kg ha ⁻¹)	-0.14325	y = -0.003x + 0.632
Seed yield (kg ha ⁻¹)	Total weed density at harvest (No. m ⁻²)	-0.43940	y = -0.040x + 5.787
Seed yield (kg ha ⁻¹)	Total weed dry weight at harvest (g m ⁻²)	-0.51271	y = 0.096x + 7.771
Seed yield (kg ha ⁻¹)	Total N uptake by weeds (kg ha ⁻¹)	-0.46376	y = -0.022x + 13.09
Seed yield (kg ha ⁻¹)	Total P uptake by weeds (kg ha ⁻¹)	-0.49916	y = -0.006x + 2.364
Seed yield (kg ha ⁻¹)	Total K uptake by weeds (kg ha ⁻¹)	-0.42845	y = -0.517x + 11.42

* Significant at 5 % level of significance

Total P uptake by weeds (kg ha⁻¹), total K uptake by weeds (kg ha⁻¹) 0.95264, 0.96586, 0.91945, 0.94812, 0.16016, 0.43337, -0.14325, -0.43940, -0.51271, -0.46376, -0.49916, -0.42845, respectively.

The regression equation show that with the increase in one unit in pods plant⁻¹, seeds pod⁻¹, total N, P, uptake by crop and chlorophyll content, the corresponding seed yield increased by 20.55, 12.51, 4.015, 0.632 and 1.292, respectively.

5. DISCUSSION

During the course of presenting the results of field investigation entitled “Effect of Weed Control Measures on Growth and Yield of Fenugreek (*Trigonella foenum-graecum* L.)” in preceding chapter, many significant variations in the criteria used for treatment evaluation were obtained under the influence of different treatments. In the present chapter, efforts have been made to ascertain cause and effect of relationship among the various parameters found significant on fenugreek productivity were studied and the important data pertaining to the effects of different treatments have also been presented in this chapter. Wherever necessary, experimental findings or observation of other workers on the same crop or family have been cited to support the results of present experiment.

5.1 Effects of weed control measures

5.1.1. Effect on weed density and dry weight

The results revealed that all the weed management treatments significantly reduced the density of both broadleaved and grassy weeds (Table 4.1 and 4.2) and their dry weight (Table 4.4 and 4.5) at all the stages of observations compared to weedy check.

At 30, 60 DAS as well as at harvest weed free treatment recorded significantly lowest number of total weeds and dry weight followed by treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) remained statistically at par with pendimethalin at 0.75 kg ha⁻¹ (dry). While treatment weedy check registered significantly higher number of total weeds. This might be due to effective control of weeds either by manual weeding or herbicides approach. At 30 DAS more reduction in both density and dry

weight of grassy weeds with application of pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) might be due to the more effectiveness against grassy weeds (Table 4.1 to 4.4).

Data for weed density of weedy check indicated that in general, density of broadleaved weeds was more dominating at 30, 60 DAS and harvest stage of observations representing their square root transformed values as 8.36, 8.64 and 8.75 m⁻², respectively. The dry weight of broad leaved weeds (Table 4.3) also followed the same trend as that of weeds density at 30, 60 DAS and at harvest.

Weed free treatment successfully controlled all the categories of weeds as evidenced from their density (Table 4.1 & 4.2) as well as their dry weight (Table 4.4 & 4.5). The effectivity of this treatment was due to the fact that weed free treatment controlled the early as well as late flushes of weeds upto the most critical stage of crop weed competition. Hand weeding twice removed the weeds completely and created favorable condition for crop growth which ultimately resulted in lowest density of weeds and their lowest biomass at later stages with higher weed control efficiency during the crop growth period. The results of study also corroborate with the finding of Kumar *et al.* (2004), Vyas and Jain (2004), Punia *et al.* (2011) and Sangeetha *et al.* (2013).

Pendimethalin is a versatile pre-emergence herbicide, rapidly absorbed by germinating weeds and inhibit both cell division and cell elongation in the root and shoot meristems of the susceptible plants. The growth is inhibited directly following absorbing through hypocotyls and shoot region. The plants die shortly after germination or emergence from the soil (Gupta, 2008). The present results are in close proximity with finding of Malik *et al.* (2005), Kohli *et al.* (2006) and Yadav *et al.* (2011).

Imazethapyr and imazethapyr + imazamox are selective and applied as post emergence with a view to control late emerging weeds. It inhibits the plastid enzyme acetolactate synthases (ALS) in plants which catalyses the first step in the biosynthesis of essential branched chain amino acids (Valine, leucine, isoleucine). The ALS inhibitors thus stop cell division and reduce carbohydrate translocation in the susceptible plants (Das, 2008). Saltoni *et al.* (2004) have suggested that imazethapyr and imazethapyr + imazamox are imidazolinones herbicides, which are absorbed both by the roots and the shoots. These can effectively control a broad spectrum of weeds.

5.1.2 Nutrients uptake by weeds

The data in Table 4.7 indicated that N, P and K uptake by weeds almost followed the footsteps of weed biomass in trend. It was found that all weed control treatments significantly reduced the N, P and K uptake both by the individual weed categories and total weeds at harvest. The nil uptake of N, P and K by weeds was recorded with weed free treatment, followed by treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) which was at par with pendimethalin at 0.75 kg ha⁻¹ (dry) and pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI during the experimentation. Nutrient uptake is the product of per cent nutrient content and biomass, thus similarity in the trend of uptake and total weed biomass production was an expected outcome. It can also be explained in the light of the facts that these treatments controlled the weeds effectively, might have made more nutrients available to crop and consequently encouraged higher concentration of nutrients and more yield and thereby higher uptake of nutrients by crop. Reduced nutrient uptake by weeds under the influence of different weed control measures had been also reported by

Chhokar *et al.* (1995), Gaikwad and Pawar (2003), Chhodavadia *et al.* (2013) and Kavita *et al.* (2014).

5.1.3 Weed control efficiency and weed index

A perusal of data (Table 4.8) indicates that besides weed free treatment, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) and pendimethalin at 0.75 kg ha⁻¹ (dry) recorded higher weed control efficiency (92.67 and 91.61 %) and weed index (73.2 and 68.2 %). This might be due to elimination of weeds by manual weeding and interculturing or by herbicides. The integrated effect on dry weight of weeds and seed yield under these treatments might have been responsible for excellent weed indices. These findings are akin to report of Bhandari *et al.* (2004).

5.1.2. Effect on crop

5.1.2.1 Growth parameters

All weed management practices adopted during the experimentation resulted in significant increase in growth parameters like plant population, plant height, branches plant⁻¹, dry weight of nodules at 50 DAS and periodical dry matter production (Table 4.9, 4.10, 4.11 and 4.12) of fenugreek at successive stages *viz.*, 30, 60 DAS and at harvest compared to weedy check. Dry matter accumulation of fenugreek is determined by the ability of fenugreek canopy to absorb incidence photosynthetic phyton flux density (PPFD) which is a function of canopy extinction coefficient and shading of fenugreek canopy by weeds in crop weed mixtures. The maximum dry matter accumulation was recorded with weed free treatment followed by pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI, pendimethalin at 0.75 kg ha⁻¹ as PPI and rest of the herbicidal treatments proved their superiority over weedy check. This was attributed

to their higher weed control efficiency (Table 4.6) which proved favorable environment for growth of the crop. Results so obtained are in close conformity with the finding of Reager *et al.* (2003), Kumar *et al.* (2006).

The higher values of growth parameters *i.e.* plant height, number of branches plant⁻¹ and dry weight of nodules at 50 DAS under treatments weed free, followed by pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI, pendimethalin at 0.75 kg ha⁻¹ as PPI and rest of the herbicidal treatments proved their superiority over weedy check, ascribed to better control of weeds through hand weeding and inter culturing along with herbicides application as evidence by weed density (Table 4.1, and 4.2) and dry weight of weeds (Table 4.4 and 4.5). This might have resulted in better availability of moisture and nutrients to the crop in absence of weeds. Moreover increased nutrient and water uptake by crop, which could be increased photosynthates which supply more carbohydrates, resulted in increase cell division and elongation of cells resulted to increase plant height and number of branches.

The lowest values of growth parameters *viz.*, plant height and dry matter accumulation at 30 DAS, under treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) and pendimethalin at 0.75 kg ha⁻¹ (dry) followed by weedy check due to toxicity effect of herbicide on dry treatment. Further, lowest values of growth parameters *viz.*, plant height and dry matter accumulation at 60 DAS, dry weight of nodules and number of branches plant⁻¹ were recorded under weedy check plot 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. Similar findings were observed by Shaikh *et al.* (2002) and Malliswari *et al.* (2008).

5.1.2.2 Yield attributes and yield

The yield attributing characters *viz.* pods plant⁻¹, pod length, test weight and seeds pod⁻¹ were significantly improved under various weed control treatments as compared to treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry), pendimethalin at 0.75 kg ha⁻¹ (dry) and weedy check (Table 4.13) and the effect was more pronounced with weed free treatment closely followed by rest of the weed control treatments. This was attributed to minimum infestation of weeds (Table 4.1, 4.2) together with lesser competition for other growth resources *i.e.* light, space, water and nutrients. Thus, reduced crop-weed competition resulted into overall improvement in crop growth as reflected by plant height and dry matter accumulation (Table 4.10 and 4.12) consequently resulted into better development of reproductive structure and translocation of photosynthates to the sink. The results corroborate with the findings of Kumar *et al.* (2003) and Yadav *et al.* (2014).

It is evident from results (Table 4.15) that significant superiority of weed free treatment over all weed control methods significantly enhanced yield components *viz.*, pods plant⁻¹ and seeds pod⁻¹ with concomitant increased in seed, straw and biological yield. Higher seed yield were recorded under weed free followed by pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI and pendimethalin at 0.75 kg ha⁻¹ as PPI which was increase 226.8, 200.9 and 185.4 per cent, respectively compared to weedy check. The extents of increase in straw yield 20.2, 22.3 and 20.5 per cent and biological yield 56.9, 51.3 and 52.6 per cent of fenugreek under treatment weed free pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI and pendimethalin at 0.75 kg ha⁻¹ as PPI, respectively compared to weedy check.

It is an established fact that least crop weed competition during critical phase of crop growth exerts an important regulation function on complex process of yield formation due to better availability of water, space and nutrients to the crop plant. It also helps in improving aeration and nutrient uptake by plant resulting in higher metabolic activity (Lalitha Bai and Sinha, 1993). In preceding section it was, well emphasized that reduced crop-weed competition under weed free treatment as well as other herbicides, markedly influenced 'source' by virtue of higher photosynthetic and metabolic activity which in turn improved growth of crop and consequently yield components. The adverse effect of weed competition under present investigation is clearly reflected under weedy check, wherein dense population of weeds reduced crop growth *viz.*, dry matter accumulation compared to weed free treatment as well as other treatments. Thus ultimately reduced yield components *i.e.*, pods plant⁻¹ and seeds pods⁻¹. Nutrient stress caused by weeds might have also affected the seed bearing capacity of each pod. Not only this but even normally stable component like test weight was also adversely affected by weeds under weedy check (Table 4.14). Thus, the weeds were able to adversely affect vegetative as well as reproductive parts of crop plant ultimately crop yield.

The reduced crop weed competition caused significant increase in growth characters and yield ultimately led to higher seed yield of fenugreek. The significant improvement in seed yield as a result of weed free treatment and all herbicidal weed control treatments could be ascribed to the fact that yield of crop depends on several yield components which are interrelated. Under present investigation existence of high positive correlation between pods plant⁻¹ and seed pods⁻¹ on seed yield ($r = 0.91945$ and 0.94812 , respectively) also validate the aforesaid statement. Similarly, total weed dry weight at harvest was also negatively

correlated with seed yield ($r = -0.51271$) (Table 4.25). Under weedy situation, at early crop growth stage a greater part of resources present in soil and environment are depleted by weeds for their growth. The crop plant thus, faced stress which ultimately affected their growth, development and yield. Similar results were also reported by Bhadoria *et al.* (2000), Raskar and Bhoi (2002), Sumachandrika *et al.* (2003) and Upadhayay *et al.* (2013).

A like seed yield, straw yield was also significantly increased under various treatments of weed management during the experimentation over weedy check. Increase in straw yield might be due to the direct influence of various weed management treatments on the suppression of weeds. Thus, crop weed competition resulted into increased plant height, dry matter accumulation (Table 4.9 and 4.11) and nutrient uptake. The results so obtained for straw corroborate with the findings of Kumar *et al.* (2003) and Tiwari *et al.* (2014).

Biological yield is a function of seed and straw yield. Thus, significant increase in biological yield with various weed control treatments could be ascribed to the increased seed and straw yield (Table 4.12).

5.1.2.4 Economics

A perusal data presented in Table 4.17 showed that maximum net return of 29752 ₹ ha⁻¹ was realized under the weed free treatment and it was closely followed by by pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI (₹ 27610 ha⁻¹) and pendimethalin at 0.75 kg ha⁻¹ as PPI (₹ 25588 ha⁻¹), respectively. The higher seed yield recorded with this treatment might be responsible for higher net return.

6. SUMMARY AND CONCLUSION

The results of field experiment entitled “Effect of Weed Control Measures on Growth and Yield of Fenugreek (*Trigonella foenum-graecum*L.)” were presented and discussed in the proceeding chapter are summarized below:

6.1 Effect of weed control measures

6.1.1 Weed studies

6.1.1.1 Weed growth

- In weedy check plots, fenugreek was heavily infested with mixed flora of broad leaved and grassy weeds chiefly consisted of *Rumex spp.*, *Chenopodium album*, *Elusine indica*, *Cyperus rotundus* and *Erograstic turrel*.
- Application of pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) and pendimethalin at 0.75 kg ha⁻¹ (dry) recorded the very less weed density at harvest.
- All the weed control treatments significantly reduced dry weight of broad -leaved and grassy weeds at harvest over weedy check. The very less dry weight of broad -leaved, grassy and total weeds was recorded under pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) and pendimethalin at 0.75 kg ha⁻¹ (dry) while the respective.
- The lowest weed index was recorded under pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI (7.8)
- **6.1.1.2 Nutrient uptake**
- Significant decreases in total N, P and K uptake by weeds was recorded due to all weed control practices over weedy check. Very less uptake of N, P and K by weeds was recorded with pendimethalin

+ imazethapyr at 0.80 kg ha⁻¹ (dry) followed by pendimethalin at 0.75 kg ha⁻¹ (dry) and pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI.

6.1.2 Crop

6.1.2.1 Growth attributes

- All weed control measures caused significant effect on the plant stand at 20 DAS and at harvest compared to weedy check treatments.
- All weed control practices were found effective in enhancing plant height at 30, 60 as well as at harvest, nodules plant⁻¹ at 50 DAS. It was highest with weed free treatment compared to weedy check.
- The dry matter accumulation by the crop was significantly increased with all the weed control treatments over weedy check. The maximum dry matter accumulation at 30, 60, 90 DAS and at harvest were with weed free treatment with the corresponding increase of 11.11, 142, 51.74 and 99.20 per cent compared to weedy check.

6.1.2.2 Yield attributes and yield

- Yield attributing characters viz. pods plant⁻¹, seeds pod⁻¹, pod length and test weight were favorably and significantly influenced by all weed management practices compared to weedy check. Among all weed control treatments, weed free treatment recorded highest which was found statistically at par with pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI and pendimethalin at 0.75 kg ha⁻¹ as PPI all remaining treatments are significant effect.
- All weed management practices significantly seed yield over weedy check. There was no significant difference between seed yield with weed free pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI treatments. Weed free treatment produced the highest seed yield (1969.7 kg ha⁻¹) followed by pendimethalin + imazethapyr at 0.80 kg

ha⁻¹ as PPI (1814.0 kg ha⁻¹). While it was minimum under pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) and weedy check 530.7 kg ha⁻¹ and 602.7 kg ha⁻¹ respectively.

- The straw yield during experimentation was non-significantly with all the treatments of weed control except pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) and pendimethalin at 0.75 kg ha⁻¹ (dry). The maximum straw yield obtained with weed free treatment (3347.9 kg ha⁻¹) it was closely related with all treatment over pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry) and pendimethalin at 0.75 kg ha⁻¹ (dry) 1877.7 kg ha⁻¹ and 2175.3 kg ha⁻¹, respectively.
- The biological yield increased significantly by various weed control treatments. Among treatments, weed free treatment (5317.6 kg ha⁻¹) gave better results being at par with other remaining treatments except pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry), pendimethalin at 0.75 kg ha⁻¹ (dry) and weedy check.
- The harvest index was recorded maximum under weed free (37.0) and minimum under weedy check treatment (17.7) all weed control treatments.

6.1.2.3 Biochemical analysis

- All weed control measures caused non-significant effect on the chlorophyll content in fenugreek.

6.1.2.4 Nutrient content, uptake and quality

- N, P and K content of seed and straw remained unaffected with all weed management practices.

6.1.2.5 Economics

- The maximum net return of ₹ 29752 ha⁻¹ was obtained with weed free treatment followed by ₹ 27610 ha⁻¹ with pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI.

CONCLUSION

It is concluded that herbicidal treatment pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as (dry) or pendimethalin at 0.75 kg ha⁻¹ as (dry) both applied as pre-sowing of crop or pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE and pendimethalin at 0.75 kg ha⁻¹ as PE as post emergence controlled broadleaved as well as grassy weeds compared to weedy check treatment.

Herbicidal weed control treatments pendimethalin + imazethapyr at 0.80 kg ha⁻¹ or pendimethalin at 0.75 kg ha⁻¹ both applied as PPI or pendimethalin + imazethapyr at 0.80 kg ha⁻¹ and pendimethalin at 0.75 kg ha⁻¹ as PE controlled broad leaved as well as grassy weeds which were significantly inferior to weedy check.

Recommendations

Based on yield importance and net return, basis application of pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI or pendimethalin at 0.75 kg ha⁻¹ as PPI may be recommended in fenugreek to control grassy and broadleaved weeds.

Results are based on one year study; hence it needs to be validated by further experimentation before making final recommendation.

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**“Effect of Weed Control measures on Growth and yield of Fenugreek
(*Trigonella foenum-graecum* L.)”**

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ABSTRACT

A field experiment entitled “Effect of Weed Control Measures on Growth and Yield of Fenugreek (*Trigonella foenum-graecum* L.)” was conducted at the Agronomy Farm, Collage of Agriculture Bikaner, S.K. Rajasthan Agricultural University, Bikaner during *rabi* 2017-18. The experiment comprises of 12 treatment combinations *i.e.* weedy check, weed free, pendimethalin at 0.75 kg ha⁻¹ (dry), pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry), pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI, pendimethalin at 0.75 kg ha⁻¹ as PE, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE, imazethapyr at 50 g ha⁻¹ (3-4 leaf stage 25 DAS), imazethapyr + imazamox at 50 g ha⁻¹ (25 DAS), imazethapyr at 70 g ha⁻¹ (25 DAS) and imazethapyr + imazamox at 70 g ha⁻¹ (25 DAS). These treatments were replicated thrice in randomized block design.

The results showed that weed control methods markedly reduced crop-weed competition. Both treatments pendimethalin at 0.75 kg ha⁻¹ (dry) and pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry), were found significantly reducing weed density, dry weight and nutrient depletion by both broadleaved and grassy weeds. Pre plant incorporation of pendimethalin at 0.75 kg ha⁻¹ and pendimethalin + imazethapyr at 0.80 kg ha⁻¹ were more effective in controlling broadleaved as well as grassy weeds.

Weed free treatment, pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI, pendimethalin at 0.75 kg ha⁻¹ as PE and pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE, gave the higher value of growth characters *i.e.* plant height and dry matter as well as yield attributes *i.e.* pods plant⁻¹ and seeds pod⁻¹ which were found significantly higher over rest of treatments.

All weed control treatments were significantly increased seed yield of fenugreek compared to pendimethalin + imazethapyr at 0.80 kg ha⁻¹ (dry), (531 kg ha⁻¹), weedy check (603 kg ha⁻¹) and pendimethalin at 0.75 kg ha⁻¹ (dry) (624 kg ha⁻¹). Weed free treatment, pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI, pendimethalin at 0.75 kg ha⁻¹ as PPI, pendimethalin at 0.75 kg ha⁻¹ as PE and pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PE, registered 1970, 1814, 1720, 1630 and 1545 kg ha⁻¹ seed yield, respectively.

Among the weed control treatments, maximum net return was recorded under weed free treatment (29700 ₹ ha⁻¹) followed by pendimethalin at 0.75 kg ha⁻¹ as PPI (27600 ₹ ha⁻¹), pendimethalin + imazethapyr at 0.80 kg ha⁻¹ as PPI (25500 ₹ ha⁻¹).

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मेथी की वृद्धि एवं उपज पर खरपतवार नियंत्रण का प्रभाव

सुरेश कुमार दुदवाल *

शोधार्थी

डॉ. शिशपाल सिंह **

मुख्य सलाहकार

अनुक्षेपण

कृषि महाविद्यालय, स्वामी केशवानन्द राजस्थान कृषि विश्वविद्यालय, बीकानेर के शस्य विज्ञान प्रक्षेत्र पर रबी 2017-18 के दौरान मेथी की वृद्धि एवं उपज पर खरपतवार नियंत्रण का प्रभाव के अध्ययन हेतु एक क्षेत्र परीक्षण आयोजित किया गया, परीक्षण में 12 उपचार संयोजन काम में लिए गये जो खरपतवार मुक्त, खरपतवार युक्त, पेन्डिमिथालीन 0.75 किग्रा. प्रति हैक्टेयर (शुष्क), पेन्डिमिथालीन + इमाजिथापायर 0.80 किग्रा. प्रति हैक्टेयर (शुष्क), पेन्डिमिथालीन 0.75 किग्रा प्रति हैक्टेयर बुवाई पूर्व, पेन्डिमिथालीन + इमाजिथापायर 0.80 किग्रा. प्रति हैक्टेयर बुवाई पूर्व, पेन्डिमिथालीन अंकुरण से पूर्व 0.75 किग्रा. प्रति हैक्टेयर, पेन्डिमिथालीन + इमाजिथापायर अंकुरण से पूर्व 0.80 किग्रा. प्रति हैक्टेयर, इमाजिथापायर 50 ग्राम प्रति हैक्टेयर (3-4 पत्ती अवस्था एवं बुवाई के 25 दिन बाद), इमाजिथापायर + इमाजोमोक्स 50 ग्राम प्रति हैक्टेयर (बुवाई के 25 दिन बाद), इमाजिथापायर + इमाजोमोक्स 70 ग्राम प्रति हैक्टेयर (बुवाई के 25 दिन बाद) एवं इमाजिथापायर 70 ग्राम प्रति हैक्टेयर (बुवाई के 25 दिन बाद) थे। इन उपचारों को यादृच्छिक खण्ड अभिकल्पना में तीन पुनरावृत्तियों के साथ प्रतिपादित किया गया।

परिणाम दर्शाते हैं कि फसल खरपतवार प्रतिस्पर्धा को खरपतवार नियंत्रण विधियों ने प्रभावी ढंग से काम किया। पेन्डिमिथालीन 0.75 किग्रा. प्रति हैक्टेयर (शुष्क) एवम् पेन्डिमिथालीन + इमाजिथापायर 0.80 किग्रा. प्रति हैक्टेयर (शुष्क) दोनों ही उपचार समान पाये गये एवं इन उपचारों ने चौड़ी पत्ती वाले और घास कुल के खरपतवारों के खरपतवार घनत्व, शुष्क भार एवं पोषक तत्वों के उदग्रहण में सार्थक रूप से कमी की। बुवाई से पूर्व पेन्डिमिथालीन 0.75 किग्रा. प्रति हैक्टेयर एवं पेन्डिमिथालीन + इमाजिथापायर 0.80 किग्रा. प्रति हैक्टेयर के प्रयोग से चौड़ी पत्ती वाले एवं घास कुल वाले खरपतवारों के नियंत्रण में अधिक प्रभावी रहे।

खरपतवार युक्त उपचार, पेन्डिमिथालीन बुवाई से पूर्व 0.80 किग्रा. प्रति हैक्टेयर, पेन्डिमिथालीन अंकुरण से पूर्व 0.75 किग्रा. प्रति हैक्टेयर एवं पेन्डिमिथालीन + इमाजिथापायर अंकुरण से पूर्व 0.80 किग्रा. प्रति हैक्टेयर के प्रयोग से अधिक फसल वृद्धि कारकों जैसे पादप ऊंचाई, शुष्क भार एवं उपज घटकों जैसे प्रति पौधा फली, प्रति फली बीज अन्य उपचारों की तुलना में सार्थक रूप से अधिक पाये गये।

खरपतवार नियंत्रण के पेन्डिमिथालीन + इमाजिथापायर 0.80 किग्रा प्रति हैक्टेयर (शुष्क) खरपतवार युक्त (603 किग्रा. प्रति हैक्टेयर), (531 किग्रा. प्रति हैक्टेयर) एवं पेन्डिमिथालीन 0.75 किग्रा प्रति हैक्टेयर (शुष्क) (624 किग्रा. प्रति हैक्टेयर) को छोड़कर अन्य सभी उपचारों में सार्थक रूप से बढ़त पायी गयी। खरपतवार युक्त उपचार, पेन्डिमिथालीन + इमाजिथापायर 0.80 किग्रा. प्रति हैक्टेयर बुवाई से पूर्व, पेन्डिमिथालीन 0.75 किग्रा. प्रति हैक्टेयर बुवाई से पूर्व, पेन्डिमिथालीन 0.75 किग्रा. प्रति हैक्टेयर अंकुरण से पूर्व एवं पेन्डिमिथालीन + इमाजिथापायर 0.80 किग्रा. प्रति हैक्टेयर अंकुरण से पूर्व उपचारों से 1970, 1814, 1720, 1680 एवं 1545 किग्रा. प्रति हैक्टेयर बीज उपज प्राप्त हुई।

खरपतवार नियंत्रण उपचारों के तहत खरपतवार युक्त उपचार ने सर्वाधिक शुद्ध आय रूपये 29700 प्रति हैक्टेयर, पेन्डिमिथालीन बुवाई से पूर्व 0.75 किग्रा. प्रति हैक्टेयर द्वारा शुद्ध आय रूपये 27600 प्रति हैक्टेयर, पेन्डिमिथालीन + इमाजिथापायर बुवाई से पूर्व 0.80 किग्रा. प्रति हैक्टेयर द्वारा रूपये 25500 प्रति हैक्टेयर प्राप्त किया।

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Appendix-I

Analysis of variance for weed density 30 DAS, 60 DAS and at harvest

Source of variation	d. f.	Mean sum of square					
		Weed density (No. m ⁻²)					
		30 DAS		60 DAS		At harvest	
		Dicot	Monocot	Dicot	Monocot	Dicot	Monocot
Replications	2	0.0731	0.0126	0.0883	0.0072	0.0072	0.0091
Treatments	11	10.9772	1.9210	10.8743	1.8259	10.5204	1.7707
Error	22	0.0540	0.0144	0.1553	0.0252	0.1743	0.0234

* Significant at 5 % level of significance

Appendix-II

Analysis of variance for weed dry weight 30, 60 DAS and at harvest

Source of variation	d. f.	Mean sum of square					
		Weed dry weight (g m ⁻²)					
		30 DAS		60 DAS		At harvest	
		Dicot	Monocot	Dicot	Monocot	Dicot	Monocot
Replications	2	0.0035	0.0400	0.0198	0.0349	0.0144	0.0096
Treatments	11	0.6567	0.7149	2.7605	1.6540	11.3692	1.9093
Error	22	0.0033	0.0266	0.0084	0.0344	0.0142	0.0389

* Significant at 5 % level of significance

Appendix-III

Analysis of variance for plant population 20 DAS & at harvest and branches plant⁻¹

Source of variation	d. f.	Mean sum of square		
		Plant population ha ⁻¹		Branches plant ⁻¹ at
		20 DAS	At harvest	harvest
Replications	2	2143.3611	302.3333	0.0270
Treatments	11	2022.7551	8614.8485	5.1412
Error	22	712.7551	746.0909	0.5563

* Significant at 5 % level of significance

Appendix-IV

Analysis of variance for plant height 30, 60 DAS and at harvest

Source of variation	d. f.	Mean sum of square		
		Plant height (cm)		
		30 DAS	60 DAS	At harvest
Replications	2	0.9377	0.7346	4.7479
Treatments	11	1.6114	14.3430	90.2232
Error	22	0.2975	4.7583	9.4787

* Significant at 5 % level of significance

Appendix-V

Analysis of variance for dry matter accumulation and dry weight of nodules

Source of variation	d. f.	Mean sum of square				
		Dry matter accumulation (g) metre ⁻¹ row length				Dry weight of nodules at 50 DAS (mg plant ⁻¹)
		30 DAS	60 DAS	90 DAS	At harvest	
Replications	2	0.6007	0.4687	3.7999	0.4937	7.6016
Treatments	11	11.4685	7.9866	14.9952	29.3788	47.0058
Error	22	0.6060	1.4910	2.0763	5.7345	3.5302

* Significant at 5 % level of significance

Appendix-VI

Analysis of variance for yield attributes

Source of variation	d. f.	Mean sum of square			
		Pods plant ⁻¹	Seeds pod ⁻¹	Pod length (cm)	Test weight (g)
Replications	2	5.2400	0.9336	0.3103	0.2838
Treatments	11	57.4284	12.4302	11.1263	3.9651
Error	22	9.7268	3.3154	2.5445	1.2991

* Significant at 5 % level of significance

Appendix-VII
Analysis of variance for yield and harvest index

Source of variation	d. f.	Mean sum of square			
		Yield (kg ha ⁻¹)			Harvest index (%)
		Seed	Straw	Biological	
Replications	2	2067.0278	309706.1575	340906.3186	2.1051
Treatments	11	711891.5051	859628.2603	2875770.9108	102.0201
Error	22	9067.2702	269031.8742	249573.4686	21.7060

* Significant at 5 % level of significance

Appendix-VIII
Analysis of variance for chlorophyll content

Source of variation	d. f.	Mean sum of square
		Chlorophyll content at flowering stage (mg g ⁻¹)
Replications	2	0.0065
Treatments	11	0.0043
Error	22	0.0050

* Significant at 5 % level of significance

Appendix-IX

Analysis of variance for nitrogen content and uptake in seed and straw

Source of variation	d.f.	Mean sum of square				Protein content (%) in seed
		Nitrogen content (%)		Phosphorus content (%)		
		Seed	Straw	Seed	Straw	
Replications	2	0.0350	0.0079	0.0000	0.0003	1.3675
Treatments	11	0.0215	0.0055	0.0005	0.0005	0.8412
Error	22	0.0459	0.0060	0.0005	0.0002	1.7919

* Significant at 5 % level of significance

Appendix-X

Analysis of variance for nitrogen content and uptake in weeds

Source of variation	d. f.	Mean sum of square		
		Nitrogen uptake (kg ha ⁻¹)		
		Dicot	Monocot	Total
Replications	2	2.3546	0.1524	3.4737
Treatments	11	112.2541	6.8211	173.2265
Error	22	1.4154	0.2599	1.5749

* Significant at 5 % level of significance

Appendix-XI

Analysis of variance for phosphorus content and uptake in weeds

Source of variation	d. f.	Mean sum of square		
		Phosphorus uptake (kg ha ⁻¹)		
		Dicot	Monocot	Total
Replications	2	0.0567	0.0016	0.0393
Treatments	11	3.6068	0.7494	7.5623
Error	22	0.0899	0.0016	0.0993

* Significant at 5 % level of significance

Appendix-XII

Analysis of variance for potassium content and uptake in weeds

Source of variation	d. f.	Mean sum of square		
		Potassium uptake (kg ha ⁻¹)		
		Dicot	Monocot	Total
Replications	2	0.2986	0.0544	0.5116
Treatments	11	58.0301	55.6272	231.0411
Error	22	0.3094	0.4529	1.3302

* Significant at 5 % level of significance

Appendix-XIII

Analysis of variance for gross return, net return and B-c ratio

Source of variation	d. f.	Mean sum of square		
		Cost of cultivation	Gross returns	Net returns
Replications	2	0.0000	1291892.3611	1291892.3611
Treatments	11	1522545.4545	444932190.6566	419870660.3535
Error	22	0.0000	5667043.8763	5667043.8763

* Significant at 5 % level of significance

Appendix-XIV
Cost of cultivation of fenugreek

S. No.	Particulars of operation	Cost (₹ ha ⁻¹)	Inputs	Rate unit ⁻¹ (₹)
1	Harrowing	1200		
2	Planking	600		
3	Seed bed preparation and Sowing (10 labour)	2000		
4	Cost of seed (5 kg ha ⁻¹)	1080		
5	Irrigation (5)	3350		
6	Weeding, hoeing and thinning (15 labour)	0		
7	fungicides and insecticides	500		
8	Fertilizers	2000		
9	Harvesting of crops (15 labour)	2500		
9	Threshing and winnowing (10 labour)	1800		
10	Miscellaneous	500		
11	Total	16530		

Appendix-XV
Comparative economics of various treatments

S. No.	Treatments	Treatment cost	Common cost	Total cost	Seed yield	Seed return	Gross return	Net return	B-c ratio
1	Weedy check	0	16530	16530	602.6667	15067	15067	-1463	0.91
2	Weed free	2955	16530	19485	1969.667	49242	49242	29757	2.53
3	Pendimethalin at 0.75 kg ha ⁻¹ (dry)	891	16530	17421	624	15600	15600	-1821	0.90
4	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ (dry)	1208	16530	17738	530.6667	13267	13267	-4471	0.75
5	Pendimethalin at 0.75 kg ha ⁻¹ as PPI	891	16530	17421	1720.333	43008	43008	25587	2.47
6	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PPI	1208	16530	17738	1814	45350	45350	27612	2.56
7	Pendimethalin at 0.75 kg ha ⁻¹ as PE	891	16530	17421	1545	38625	38625	21204	2.22
8	Pendimethalin + imazethapyr at 0.80 kg ha ⁻¹ as PE	1208	16530	17738	1630.667	40767	40767	23029	2.30
9	Imazethapyr at 50 g ha ⁻¹ (3-4 leaf stage 25 DAS)	848	16530	17378	1301.667	32542	32542	15164	1.87
10	Imazethapyr + imazamox at 50 g ha ⁻¹ (25 DAS)	1538	16530	18068	1264.667	31617	31617	13549	1.75
11	Imazethapyr at 70 g ha ⁻¹ (25 DAS)	872	16530	17402	1240.667	31017	31017	13615	1.78
12	Imazethapyr + imazamox at 70 g ha ⁻¹ (25 DAS)	1838	16530	18368	1180.667	9517	29517	11149	1.61