# Studies on Herbicidal Weed Management in Black gram

[Vigna mungo (L.) Hepper]

## **Thesis**

Submitted to the



**Banda University of Agriculture & Technology** 

Banda-210001, Uttar Pradesh, India

By

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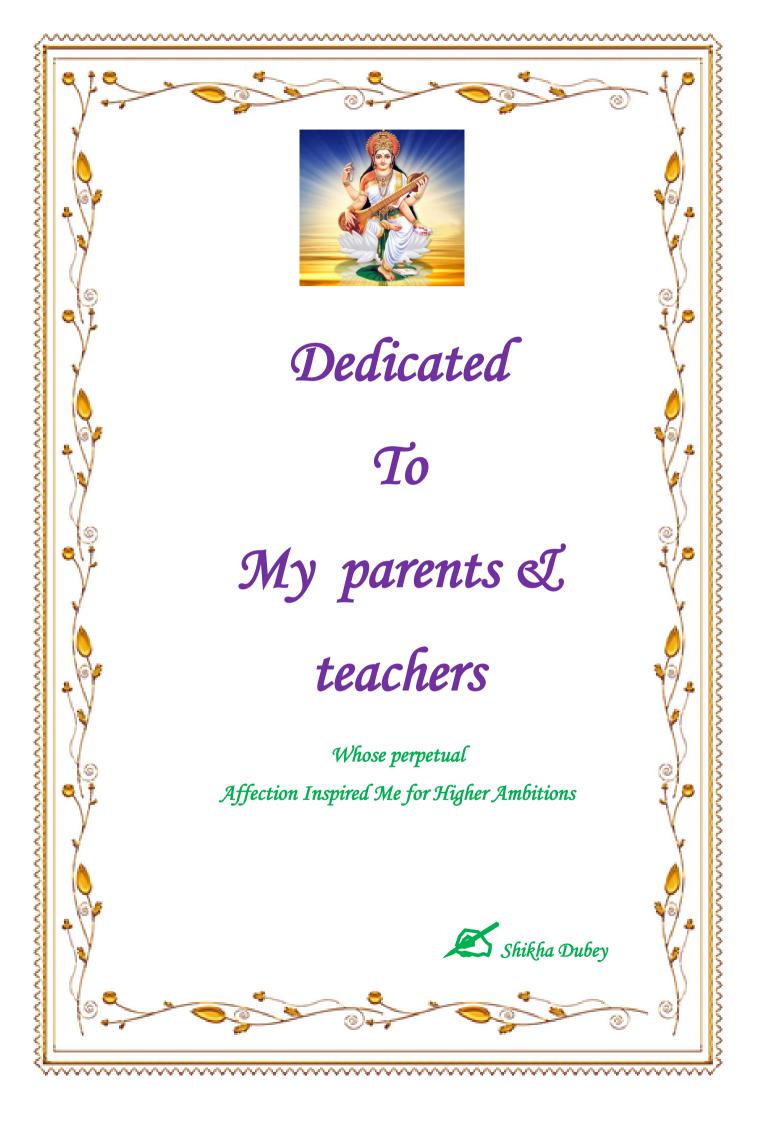
# IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE (AGRICULTURE)

IN

**AGRONOMY** 

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# BANDA UNIVERSITY OF AGRICULTURE & TECHNOLOGY, BANDA



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This is to certify that the thesis entitled "Studies on herbicidal weed management in black gram [Vigna mungo (L.) Hepper]." submitted in partial fulfillment of the requirement for award of the degree of Master of Science (Agriculture) in Agronomy, Banda University of Agriculture & Technology (Banda), is a genuine record of bona fide research work carried out by Ms. Shikha Dubey under my guidance and supervision. The results of the investigation in this thesis have not so far been submitted for any other degree or diploma.

It is further certified that the help or information received during the course of investigation and preparation of the thesis have been duly acknowledged.

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BUAT, Banda (Shikha Dubey)

Date

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### LIST OF SYMBOLS AND ABBREVIATIONS

SYMBOLS			
&	and		
₹	Rupee		
@	at the rate		
%	Per cent		

ABBREVIATIONS			
BCR	Benefit: cost ratio		
C.D.	Critical difference		
C.V.	Co-efficient of variation		
Cm	Centimeter		
a. i.	Active ingradient		
D. f	Degree of freedom		
DAP	Di ammonium phosphate		
DAS	Days after sowing		
E.C.	Electrical conductivity		
et al.	And others		
Fig.	Figure		
Kg	Kilogram		
No.	Number		
NS	Non significant		
N	Nitrogen		
Plant <sup>-1</sup>	Per plant		
На	hectare		
HW	Hand weeding		
g/m <sup>-1</sup>	Gram per square meter		
BLW	Broad leaf weed		
SEm	Standard error of mean		
°C	Degree celsius		
PE	Pre emergence		
PoE	Post emergence		
AHAS	Acetohydroxy acid synthase		
ALS	Acetolactate synthase		

# 

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### **ABSTRACT**

A field experiment entitled "Studies on herbicidal weed management in black gram [Vigna mungo (L.) Hepper]" conducted during kharif 2019 at Research block, Banda University of Agriculture and Technology, Banda (UP). The experiment was laid out in Randomized Complete Block Design with three replications. The weed control treatments were: T<sub>1</sub> (Imazethapyr @ 70g a.i/ha PE), T<sub>2</sub> (Imazethapyr @ 80g a.i./ha PE), T<sub>3</sub> (imazethapyr @ 70g a.i./ha at 3-4 leaf stage), T<sub>4</sub> (Imazethapyr @ 80g a.i./ha at 3-4 leaf stage), T<sub>5</sub> (imazethapyr + imazamox RM @ 70g a.i./ha PE), T<sub>6</sub> (Imazethapyr + imazamox RM @ 80g a.i./ha PE), T<sub>7</sub> (imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage), T<sub>8</sub>-Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage), T<sub>9</sub> (pendimethalin @ 1000g), T<sub>10</sub> (imazethapyr + pendimethalin RM @ 1000g PE), T<sub>11</sub>(sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000 ml POE), T<sub>12</sub> (Hand Weeding twice 15 and 30 DAS), T<sub>13</sub>(weedy check (control), T<sub>14</sub>(Weed free). The experiment was conducted to find out the cost-effective herbicide for controlling weeds and to fine tune the dose of herbicide with the impact of weed management practices on growth and yield of black gram. Application of imazethapyr + pendimethalin RM @ 1000g PE and imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage significantly influence all growth parameters among herbicidal treatments.

The maximum value of plant growth parameters viz plant height, branches per plant, number of leaves, dry matter accumulation, root length, leaf area index were associated with weed free treatments followed by (hand weeding twice at 15 & 30 DAS at 60 DAS. The maximum values of yield attributing characters viz. number of pods plant<sup>-1</sup>, pod length, grains/pod and 100 seed weight were recorded in weed free treatments. Among the herbicidal treatments the maximum values of yield attributes were observed in imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage. The seed yield of black gram was maximum under weed free conditions (12.4 q/ha) followed by hand weeding twice. Among the herbicidal treatment,

application of imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage yielded highest seed yield to the tune of 11.34 q/ha which was significantly superior over rest of the treatments. In case of weed density, weed dry weight and weed control efficiency application of imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage proved superior over others and recorded minimum weed density, weed dry matter per square meter area with maximum weed control efficiency which was closely followed by PoE of imazethapyr + imazamox RM @ 70g a.i./ha. The density of total weed was lowest in hand weeding twice at both the stages of observation. Among the herbicidal treatment lowest weed density was observed with the application of imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage which remains at par with PoE of imazethapyr + imazamox RM @ 70g a.i./ha. Uncontrolled weeds reduced the grain yield of black gram by 61.29%. Among herbicidal treatments minimum yield loss to the tune of 8.51% was observed with the application of imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage followed by sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000 ml POE (10.24%), higher net return and benefit cost ratio (2.06) was obtained with postemergence application of imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage. Field study reveals that post emergence application of imazethapyr + imazamox RM @ 70g a.i./ha was found effective in managing weeds and higher monetary benefits.

(G.S. Panwar) (Shikha Dubey)

Advisor

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# Chapter- 1



# Introduction

Pulses are major source of protein in India particularly for the vegetarian population. Therefore, pulses production is important for the achievement of nutritional security in country. Further, the unique ability of pulses to perform better in stress condition and improve soil health through fixation of nitrogen increases its importance.

Among pulses, Black gram [Vigna mungo (L.) Hepper] is one of the important pulses grown all over the country in different agro-ecological regions during both summer and rainy season. It is also known as urdbean or mashbean which belong to the family leguminaceae and subfamily papilionaceae. It is the fourth most important pulse crop in India after chickpea, pigeonpea and greengram. Black gram has wide adaptability and have capability to tolerate stress condition. It is a self pollinated leguminous crop which contains 24 per cent protein, 60 per cent carbohydrate, 1.3 per cent fat, 3.2% minerals, 0.9 % fibre, 154 mg calcium, 385 mg phosphorus, 9.1 mg iron and small amount of vitamin-B complex (Islam et al. 2011). High value of lysine is an excellent complement to rice in terms of balanced human nutrition

Blackgram is originated from wild type i.e. *Phaseolus sublobatus*. Black gram plant possesses deep root system which binds soil particles and thus prevents soil erosion besides builds up soil fertility as it fixes about 70-90 kgN/ ha. Being a short duration crop, it fits well in various multiple and intercropping systems. After removing pods, its plant may be used as good quality green or dry fodder or green manure.

India ranked first in world in term of production of black gram. Black gram contributes about 13 per cent of total area in pulses and 10 per cent of their total production in our country. This crop occupies 31 lakh ha area and contributed nearly 14 lakh tones to pulse production with an average productivity of 451.61 kg/ha. It is extensively grown in the states of Madhya Pradesh, Maharashtra, Andhra Pradesh, Tamil Nadu and Uttar Pradesh. The crop can be grown on all types of soils ranging from sandy loam to heavy clay except the alkaline and saline soil. However, it does well on heavier soils such as black cotton soils which retain moisture better. Further, the pulse production of the country can be increased by the refinement of existing agronomic practices. Black gram is usually grown under rainfed

condition during *kharif* season in which weed is a major reason for the low productivity of the crop. Among the various factors responsible for the low yield of black gram, weeds have been considered to prime importance. The losses caused by weeds exceed the losses from any other category of agricultural pest like insect, nematode, disease, rodents etc. Weeds have been observed to cause losses in silent and unnoticed manner.

This crop usually accompanied by luxuriant weed growth during rainy (kharif) season owing to abundant rainfall receives during monsoon leading to serious crop losses. The crop is not a good competitor against weeds during early stage (Chaudhary et al. 2012). Weeds at critical period of crop-weed competition caused a reduction of 80-90% in black gram yield depending upon type and intensity of weed infestation (Kumar et al. 2018). The critical period of crop-weed competition in black gram usually falls between 15 and 45 days after sowing (DAS), (Aggarawal et al. 2014). Uncontrolled weeds have been reported to cause a considerable reduction (46-53%) in seed yield of black gram (Singh et al. 2016). Generally, weeds are control by mechanical, chemical and biological method either alone or combination of more than one method. To control weed, the traditional method of weed control i.e. hand weeding although is very effective but it is expensive tedious and time consuming (Yadav et al. 2009). Uncontrolled weeds not only reduce the grain yield of black gram from 29 to 62% (Aggarwal et al. 2014) but also remove a lot of nutrients from the soil (Kaur et al. 2010). More over hand weeding and mechanical weeding are difficult due to continuous rainfall and less availability of labors at the critical stage of crop weed competition. Use of herbicide not only improve crop yield but also makes labor for other productive activities (Tiwari et al. 2018). Therefore, removal of weeds at appropriate time using a suitable method is essential to achieve high yields of black gram.

Control of the weeds by using herbicides could be an alternative to manage the weeds and thereby increasing the yield of black gram. Since application of single herbicide may not be effective in providing broad-spectrum weed control, application of pre and post-emergence herbicides in sequence or tank mix or integrated with manual weeding may be more beneficial. In general farmers do not follow chemical weed control in pulses because lacking of location specific recommendation of herbicide for effective weed control. Only few farmers are using pre-emergence herbicides followed by one or two hand weeding. Application of post-emergence herbicide to control the second flush of weeds in pulses and to reduce human labor herbicidal option is good (Singh et al. 2014). Imazethaypr, a broad-spectrum herbicide, has soil and foliar activity that allows flexibility in its application timing

and has low mammalian toxicity (**Tan** et al. 2005). Pendimethalin is basically a preemergence herbicide effectively managed weeds in pulses.

Weeds grow quickly during this time taking the advantage of its slow initial growth. Weeds smother this crop at every stage of its growth by competing for moisture, nutrients, light and space. They take a heavy toll of the applied as well as the native nutrients. The problem is further increased under moisture stress conditions where, most of the available soil moisture in root zone depth is exhausted by dense foliage cover of fast growing weeds. The weeds compete to a great extent with crop for nutrients, moisture, light and space. Singh et al 1991 reported that major weed species in urdbean during the monsoon season were Echinochloa colonum, E. crusgalli, Eleusine indica, Cynodon dactylon, Dactyloctenium aegyptium, Digitaria sanguinalis, Phylanthus niruri, Sorghum halepense. Cyperus rotundus, C. iria, Trianthema monogyna, Celosia urgentea, Amaranthus virdis, Cleome viscose, Commelina benghalensis, Cucumis trigonus and physalis minima infested black gram field. Echinochloa colonum alone one of the major weed in black gram (Rao and Rao 2003). Herbicidal weed management professed as most economical weed management has been in vogue to certain extend in extensively cropped areas but it has been mainly concentrated upon the use of pre emergence herbicide like that of trifluaralin, Fluchlaralin and pendimethalin belonging to the dinirtoaniline group of herbicide. This has left the farmer with major limitation in herbicidal weed management in cases when the skips the pre-emergence application where no further option are available with him to check huge weed flushes during the juvenile phase of the crop. New mycoherbicide molecules have been registered for use as pre emergence, early post emergence and post emergence for effective control of weed flushes starting from prior to crop emergence up to 3-4 leaf stage. Imazethapyr herbicide of imidazolinone group is registered for soybean, groundnut and other legumes. Imazethapyr is applied as pre plant incorporation (PPI), pre emergence and post emergence to control grasses and broadleaved weed in pulses crop. Other herbicide in combination of imazethapyr is also available in the market.

Black gram is major pulse crop of the Bundelkhand region. However, the productivity of Blackgram in region is far behind the potential yield of the cultivars. The better weed management could be one of the option for the improvement of crop productivity. The use of herbicide in a region is very limited due to various reasons including the suitable recommendation of herbicide for the region. The manual weeding is not economically viable option for the farmers to control the weeds.

Keeping the above considerations in view the present investigation entitled "Studies on Herbicidal Weed Management in Black gram (*Vigna mungo* (L.) Hepper)" is conducted with the following objectives -

- 1. To study the bio-efficacy of different herbicides against weeds.
- 2. To study the weed dynamics of black gram crop.
- 3. To study the effect of weed management on growth, yield and yield attributes of black gram.

# Chapter- 2



### **Chapter-2**

# **Review of Literature**

A resume of work done in India and abroad on weed management practices in Black gram, which has direct and indirect bearing on the specific objectives investigation, is presented in this chapter under following headings:

### 2.1. Dynamics of weed Flora

- 2.2. Critical period of crop weed competition in black gram
- 2.3. Effect of herbicide on weed flora.
- 2.3.1. Imazethapyr
- 2.3.2. Imazethapyr+ imazamox
- 2.3.3. Pendimethalin
- 2.3.4 .Imazethapyr + pendimethalin
- 2.3.5. Sodium acifluorfen 16.5% + Clodinafop propargyl 8% EC
- 2.3.6. Hand weeding
- 2.4. Effect of weed management treatments on growth, yield and yield attributes
- 2.4.1. Growth parameter.
- 2.4.2. Yield and yield attributes.
- 2.5. Effect of weed management treatment on weed indices
- 2.6. Effect of weed management treatment on different micro flora
- 2.7. Effect of weed management treatment on relative economics
- 2.8. Effect of weed management treatment on phytotoxicity in black gram.

### 2.1. Weed flora in black gram

Chaudhary et al. (1989) in an experiment found that weed flora prevalent in the urdbean and mungbean field included 78% grassy weeds (*Echinochloa colona*, Dactylotenium aegyptium, Cynodon dactylon and Sorghum helepense) 17 % and 5% sedge (Cyperus rotandus) and 17% and 13% broad leaved weed (Digera arvensis, Euphorbia prostrate, Tribulus terrestris and Convolvulus arvensis.

Randhawa et al. (2002) observed *Trianthema portulacastrum*, *Convolvulus* arvensis, *Cyperus rotandus*, *Cynodon dactylon*, *Eluecine aegyptica* as major weed in summer urdbean crop.

**Singh** *et al.* (2002) reported that during kharif season, *Echinochloa spp*, *Cyperus spp*, *Trianthema portulacustrum* were major weed in urdbean field.

**Bhan and Kewat** (2003) observed that *Phylanthus niruri*, *Echinochloa crusgalli*, *Cyanotis auxiliaries*, *Commelina commulis* and *Dinebra arabica* were the rampant weed in soybean ecosystem Besides, these *Eclipta alba*, *Ageratum conyzoidus*, *Parthenium hysterophorus*, *Chicorium intybus*, *Cynodon dactylon and cyperus rotandus* also marked their presence in small number.

Rathi et al. (2004) revealed that the dominance of Cyprus rotandus, Parthenium hysterophorus, Trianthema monogyna, Phylanthus niruri during kharif season in urdbean. In Annamalainagar Tamil Nadu, the predominant weed species in the experimental field are comprised of Trianthema portulacastrum, Cyprus rotandus, Euphorbia hirta, Phylanthus niruri, Commelina benghalensis and Digera arvesnsis. They also obtained maximum dry weight of weed (104g/m²).

**Begum and Rao** (2006) reported that the rampant weeds in the experimental field cropped with black gram was comprised of *Echinochloa colona, Echinochloa crusgalli, Leersia hexandra, Panicum repens, Cyprus rotandus, Eclipta alba, Grangea madeteraspatana, Cardenthera uliginosa, Xanthium strumarium, Ammania baccifera and commelina benghalensis.* 

The studies by Rao (2008) also revealed that the experimental field was dominated by *Echinochloa colona* which constituted the 80% of the total weed population. Other weeds like *Dinebra retroflexa* (5%), *Cyperus rotandus* 3% and broad leaf weed like Xanthium

strumarium (2%), *Cleome chelidoni* (3%), and *Euphorbia virgatus* (2%) *Nasturitum indicum* (1%) were also present in less number.

Nandan *et al.* (2011) reported that *Echinochloa colona* (80%), *Cynodon dactylon* (15%), *Cyprus rotandus* (5%) in monocots whereas among dicot weeds commelina benghalensis (75%) and Ageratum conyzoids (15%) were predominant in urdbean.

Mundra and Maliwal (2012) studying on weed management at Udaipur, Rajasthan and reported *Echinochloa spp.* and *Cynodon dactylon* among narrow-leaved weeds, *Cyperus rotundus and Cyperus difformis* among sedges, *Digera arvensis* and *Eleusine indica* among grasses and *Parthenium hysterophorus*, *Amaranthus viridis*, *Triantherma portulacstrum* etc among broad-leaved weeds as major weed flora in black gram among all weeds.

Choudhary et al. (2014) studying on weed management in blackgram at Kanpur reported the major weed species viz., Parthenium hysterophorus, Cyperus rotundus, Digera arvensis and Leptochloa chinensis as major weed flora among of total weed density.

Jakhar et al. (2015) observed Amaranthus viridis, A. spinosus and Trianthema portulacastrum, Euphorbia hirta, Verbesina encelioides, Digera arvensis, Corchorus acutangulus, Phyllanthus niruri and Physalis minima were dicot weeds found to infest the experimental field. They also reported that Cyperus rotundus, Dactylactenium aegypticum, Cynodon dactylon, Digitaria sanguinalis and Cenchrus biflorus were found to be the prominent monocot weed species in blackgram crop among of total weed density.

Naidu et al. (2012) reported that the predominant weed flora of the experimental field of blackgram at Naira, Andhra Pradesh were *Vicia sativa*, *Cardiospermum halicacabum* L. var. *lurid um*, *Grangea maderaspatana*, *Chrozophora rottleri*, *Phyllanthusmaderaspatensis and Xanthium strumarium*.

Das et al. (2014) conducted an experiment on black gram at Nadia, West Bengal and recorded that the natural infestation of broad leaf weed (BLW) like Ageratum conyzoids, Boreria hispida, Commelina banghalensis and grasses like Echinochloa colona, Cynodon dactylon, Paspalum scrobiculatum, Digiteria sanguinalis and sedges like Cyperus rotundus.

According to Aggarwal et al. (2014) the major weed flora in the experimental fields of blackgram at Ludhiana, Punjab were included Dactyloctenum aegyptiacum (crowfoot grass), Cyperus rotundus (purple nutsedge), Cynodon dactylon (bermuda grass), Commelina benghalensis (Bengal dayflower), Eragrostis pilosa (soft love grass), Trianthema portulacastrum (horse purslane) and Digitaria arvensis (wild crab grass).

The major weeds were *Echinochloa colonum* (L.) Link, *Echinochloa crusgalli* and *Panicum repens* (L.) among grasses, *Cyperus rotundus* (L.) and *Cyperus difformis* (L.) among sedges and *Sphaeranthus indicus* (L.), *Eclipta alba* (L.) Hassk and *Cleome viscosa* (L.) among broad leaves weeds. *Eleusine indica, Cynodon dactylon, Bidens pilosa* and *Mimosa pudica* were the dominant weed species under North Eastern Hill region of India in black gram (Sahay et al. (1999).

Most problematic weeds in black gram were *Echinochloa colona*, *Digitaria sanguinalis*, *Trianthema portulacastrum*, *Amaranthus viridis* and *Cyperus rotundus* under lateritic soils as reported by **De and Modak** (1993).

**Reddy** *et al*, (2000) observed the major weeds giving stress to black gram were Cyperus rotundus, E. colonum, Panicum sp. and Trianthema portulacastrum

Rana et al. (2008) reported that Trianthema portulacastrum, Digera arvensis, Echinochloa crusgalli, Parthenium hysterophorus, Phyllanthus niruri and Cynodon dactylon were the most predominating weeds in blackgram.

Blackgram was dominated by natural infestation of broad leaved weeds like *Grangea* maderaspatana, *Gnaphalium polycaulon*, *Nasturtium indicum*, *Chrozophora rottleri*, *Cardanthera uliginosa*, *Xanthium strumarium* and grasses like *Echinochloa colona*, *Dinebra retroflexa*, *Leptochloa chinensi* **Rao et al.** (2010).

Singh et al. (1991) reported that the major weed species during the monsoon seasons in blackgram were Echinochloa colonum, Dactyloctenium aegyptium, Eleusineindica, Digitaria sanguinalis, Celosia argentea, Phyllanthus niruri, Cleome viscosa, Cyperus rotundus and C. iria. During the summer seasons E. colonum, D. aegyptium, Physalis minima, Portulaca quadrifida and C. rotundus were the major weed species.

**Tomar** *et al.* (2011) revealed that the dominant grassy weed flora in *kharif* blackgram were *Digitaria sanguinalis, Echinochloa colona, Echinochloa crus-galli and Eleusine indica,* while among the sedge, weed flora was dominated by *Cyperus rotundus*.

The dominant weed species found in *kharif* season blackgram crop were *Celosia* argentia, Cynodon daclylon, Phyllanthus niruri and Cyperus rotundus were found throughout the crop growth period **Nirala** et al. (2012)

Black gram is infested with different categories of weeds. Among broad leaved weeds Parthenium hysterophorus, Phyllanthus niruri, Amaranthus viridis, Celosia argentea, Cleome viscosa, Trianthema portulacastrum; among grassy Echinochloa spp., Setaria glauca, Digera arvensis, Elusine indica, Dectyloctenium aegyptium, Cynodon dactylon and among sedges Cyperus rotundus, Cyperus difformis dominate. Echinochloa colona alone, one of the major weeds in black gram, may reduce the seed yield to the extent of 49% (Pankaj et al. 2017).

**Hemlata** *et al.* (2012) found the dominant weed species viz., *Celosia argentea*, *Cynodon daclylon*, *Phyllanthus niruri* and *Cyperus rotundus* throughout the crop growth period of black gram at Raipur, Chhattisgarh.

Susmitha *et al.* (2019) reported that during the crop growth period, weed flora belonging to seven taxonomic families were observed of which four species were grasses, one species was sedge and six species were broad leaved weeds, of which predominant weed species observed in experimental field were *Dactylactenium aegyptium, Cyperus iria, Amaranthus viridis, Digera arvensis* and *Parthinium hysteroporus*. Hand weeding at 20 and 40 DAS recorded lesser weed dry weight due to reduced weed growth because of complete removal of all types of weeds like grasses, sedges and broad leaved weeds during early stages of crop growth. Among the chemical weed management practices pendimethalin 30%EC + imazethapyr 2% EC @ 1.0 kg a.i. ha-1 as pre-emergence application + sodium acifluorfen 16.5% SL+ clodinafop-propargyl 8% EC @ 165 + 80 g a.i. ha-1 at 2-3 leaf stage of weeds recorded lowest weed dry weight due to interruption of cell division, inhibition of acetolactase synthase leading to chlorosis and necrosis and then desiccated at these rates.

### 2.2. Critical period of crop-weed competition in Black gram

From an experiment **Rao** (2008) reported that, **th**e association of weeds occurs naturally with crop growth period, still need to catch out the exact time when the weeds are reducing the maximum crop productivity which as period or stage as 'critical period of crop weed competition. In this, situation or condition is the best for effectively manage or control the weed species with real weed control techniques. The adverse effect of weeds on black gram would be severe in the early growth stages as in other short duration crops.

**Jagraj** *et al.* (2002) reported that the critical period of weed competition in pulses crops is generally during the first 30 DAS. They concluded that the reduction in the yield due to weed competition was throughout the cropping period (46.8 per cent). When weedy conditions were maintained for first 20, 30 and 40 DAS reduction in black gram grain yield was 4.1, 22.1 and 44.7 per cent respectively.

The maximum crop weed competition in black gram was observed during the period from 10 to 30 DAS as reported by **Sumachandrika** *et al.* (2002).

**Bhandari** *et al.* (2004) revealed that in summer black gram, maximum crop weed competition occurred during the period up to 30 DAS. They stated that an initial period of 20 to 40 days is very critical and season long weed competition has been found to reduce black gram yield to the extent of 87 per cent depending on the type and intensity of weed flora. While according to **Vivek** *et al.* (2008) weed free situation was kept for 30 to 45 DAS to prevent the potential loss in black gram grain yield. Therefore, it can be revealed that cropweed competition period in black gram from 15-45 DAS.

The critical period for weed competition in blackgram was 20 - 40 DAS, which results yield losses from 40 -85 % in Pantnagar, Uttaranchal (Sharma and Yadav 2006) Kushwah and Vyas (2005) and (Parvender *et al.* 2006).

Based on the intensity and nature of weed flora, 30-50% yield reduction was observed by **Mishra and Bhanu (2006)** at Jabalpur, Madhya Pradesh.

**Sardana** *et al.* (2006) reported that the black gram crop faces severe weed competition due to its slow initial growth and lack of effective control measures at Nawanshahr, Panjab.

**Chattha** *et al.* (2007) conducted a field study in Islamabad, Pakistan and reported that 20-40 days duration as critical period of crop weed competition in black gram.

**Singh** (2011) reported that the critical period of crop -weed competition in summer black gram was 10 - 40 days at Ludhiana, Punjab, whereas **Randhawa** *et al.* (2002) observed 25-35 days after sowing as critical period which can cause yield loss of 41.6 %.

### 2.3. Effect of herbicides on weed flora.

### 2.3.1. Imazethapyr

**Mishra** *et al.* **(2004)** applied imazethapyr at 50 g/ha at 20 DAS in urdbean which significantly checked the cuscuta infestations compared to other weed control treatments.

**Begum and Rao** (2006) found that imazethapyr @ 75 g/ha applied 15 DAS resulted in minimum dry weight of sedges and BLW in urdbean.

**Kushwah and Vyas (2006)** found that post emergence application of imazethapyr @ 75 g/ha reduced the population of *Caesulia axillaris*, *Anolis monhulani* and *Aclypha indica* 

significantly compared to all pre and rest of the post emergence application of herbicides in soybean.

**Singh** *et al.* **(2006)** reported that chlorimuran - ethyl at 10 g/ha applied 21 DAS in soybean significantly reduced the growth of *Euphorbia geniculata* over the rest of treatment.

**Singh and Kumar (2008)** found that post emergence application of imazethapyr @ 75 and 100 g/ha reduced the density and the dry matter of the BLW and NLW significantly as compare to the PPI, pre and rest of the post emergence herbicides under study in soybean.

**Sikkema** *et al.* (2005) reported that application of imazethapyr @ 30 g/ha as post emergence and combination with surfactant provide effective control of common lamsquarter, wild mustard, pale smart weed, and green foxtail in pea.

**Meena** *et al.* **(2011)** revealed that application of imazethapyr 10 % SL @ 150 g/ha as post emergence significantly reduced the density of all grassy weeds, BLW, sedge and their dry weight in soybean as compare to weedy check and imazethapyr 10 % @ 50g/ha.

**Sasikala** *et al.* (2014) from Tamil Nadu reported that post emergence application of imazethapyr @100 g/ha as 15 DAS provided excellent control of grasses and BLW in urdbean.

### 2.3.2. Imazethapyr + Imazamox

The nature of applied herbicides may drastically change when they are applied in mixture and can be good option for broad spectrum weed management.

**Upadhyay** *et al.* **(2012) re**ported that the application of imazethapyr + imazamox (odyssey + adjuvant 87.5 g/ha + 100ml/ha significantly reduced the dry weight of weeds than the weedy check and other herbicides at 40 DAS and at harvest in soybean. The weed control efficiency was highest at 40 DAS and at harvest (69.82 and 81.82 %) with the application of odyssey.

**Jhadhav and Galade** (2012) evaluated the post emergence herbicide in soybean in Maharashtra and reported that two hand weeding at 20 and 40 DAS reduced weed density and dry weight at 30 and 60 DAS and was at par with imazethapyr + imazamox @ 30 g/ha as post emergence over weedy check.

**Prachand** *et al.* (2015) carried out a field experiment to study the weed management in soybean with pre and post emergence herbicide and reported that the lowest weed density and dry biomass of weeds with pre and post emergence application of imazethapyr 0.100

kg/ha+ quizalofop-ethyl 0.075 kg/ha which was statistically at par with post emergence application of imazethapyr+ imazamox 0.080 kg/ha and imazethapyr+ imazamox 0.070 kg/ha.

Yadav et al. (2015) studied the weed management in urdbean and found that all the weed species were effectively controlled by pre mix herbicides i.e. imazetahpyr + imazamox and pendimethalin + imazethapyr as compare to alone application of pendimethalin as PE and imazethapyr as post emergence. Both doses of pre-mix herbicide imazethapyr + imazamox and imazethapry + pendimethalin were equally effective as that in case of two hand weeding at 20 and 40 DAS and they were statistically at par with each other whereas all the weed control treatment were significantly superior to weedy check in respect to reduce the weed population and dry weight of weeds at 60 DAS stage of crop growth.

**Komal** *et al.* (2015) studied the effect of weed management on growth yield and nutrient uptake of greengram in Rajasthan and found that among herbicide treatments pendimethalin 0.75kg/ha as pre emergence+ imazethapyr + imazamox 40 g/ha at 30 DAS as post emergence and imazethapyr+ imazamox 60 g/ha at 20 DAS were found to be at par with eachother and recorded significantly least no of weed and weed drymatter.

**Kumar** *et al.* **(2015)** carried out a field experiment on bioefficacy of herbicides in urdbean and residual effect on succeeding mustard and found that post emergence application of imazethapyr + imazamox at 60-80 g/ha exhibited 78-83 % control of weeds.

**Punia** *et al.* (2015) studied the bioefficacy of herbicides in greengram and found that postemergence application of imazethapyr +imazamox at 60, 70 and 80 g/ha proved very effective in minimizing weed density and dry weight of weeds.

The pre-mixed formulation of imazethapyr and imazamox in most of the studies proved to be better option for effective weed management in these food legumes.

#### 2.3.3. Pendimethalin

Pendimethalin has its prominent place in herbicidal weed management in a variety of crops starting from cereal to vegetables and pulses in particular primarily as pre emergence application. However, its efficacy has to be monitored with respect to the kind of weeds associated with a particular crop at a given situation.

Kumar et al. (2006) reported that minimum weed number and dry matter accumulation were in plots, where the application of pendimethalin at 0.75 kg /ha

supplemented with one hand weeding at 45 DAS in urdbean. Similarly **Shaikh** *et al.* (2002) reported that pre emergence application of pendimethalin 750 g/ha were found effective in controlling the weeds in urdbean.

**Chaudhary** *et al.* (2012) studied the integrated weed management in urdbean and reported that two HW at 15 and 25 DAS recorded the lowest weed density and weed dry weight which was statistically at par with pendimethalin @ 1.5 l/ha + HW at 25 DAS.

Singh *et al.*(2011) at Ludhiana, conducted field experiment on weed management in summer and kharif season urdbean and observed that weedy check had the highest weed dry matter, which on an average, was 23.60 and 20.90 q/ha during summer and kharif season, respectively. All other treatments were very effective in controlling weeds thereby resulting in significantly lower dry matter of weeds compared with the weedy check. Among the these, the treatments of two hand weeding at 25 and 40 DAS recorded the lowest weed density and weed dry matter in summer as well as kharif season which was statistically at par with pendimethalin @ 0.750 l/ha.

**Randhawa** *et al.*(2002) conducted a field experiment in Punjab on crop weed competition studied in summer urdbean and observed that application of pendinethalin @ 1.5 kg/ha recorded significantly lower weed population and lower weed dry weight at harvest.

Therefore, pendimethalin has still a main stay in herbicidal weed management of pulses particularly in urdbean.

### 2.3.4. Imazethapyr + Pendimethalin

Pre mixed imazethapyr + pendimethalin again may provide a good option for broad spectrum weed management in urdbean.

Yadav et al. (2015) studied on weed management in urdbean and found that all the weed species were effectively controlled by pre mixed herbicide i.e. pendimethalin + imazethapyr and imazethapyr + imazamox as compare to alone application of pendimethalin as pre emergence and imazethapyr as post emergence. Both pre - mixed herbicide pendimethalin + imazethapyr and imazethapyr + imazamox were equally effective that of two hand weeding at 20 and 40 DAS and they were statistically at par with each other whereas all the weed control treatment was significantly superior to weedy check in respect to reducing the weed population and dry weight of weeds at 60 DAS stage of crop growth.

**Kumar** *et al.* (2015) carried out an field experiment on bio efficacy of herbicides in urdbean and evaluated their residual effect on succeeding mustard and found that pre emergence application of imazethapyr + pendimethalin 1000 g/ha provided excellent control (90 %) of Trianthema portulacastrum up to 30 DAS. Whereas, at 60 DAS percent control with this treatment decreased to 73 % which was at par with two hoeing employed at 20 and 40 DAS and pendimethalin at 1000 g/ha

**Punia** *et al.* (2015) studied the bio efficacy of herbicide in greengram and found that pre emergence application of pendimethalin + imazethapyr 2 % at all application rates 800-1000 g/ha was very effective in controlling weed up to 45 DAS.

**Kaur** *et al.* (2016) studied the imidazolinone herbicide for weed control in greengram and found that pendimethalin + imazethapyr @ 800-1000 g/ha provided effective control of all the grassy weeds and created weed free conditions till 40 DAS.

**Mishra** *et al.* (2016) carried out an experiment to study the bio efficacy of pre and post emergence herbicide in sorghum and reported that pre emergence ready mix application of pendimethalin + imazethapyr (750 + 50 g/ha) was more effective in controlling weeds than its tank mix application (750 + 100 g/ha).

#### 2.3.5 Sodium acifluorfen 16.5% + Clodinafop propargyl 8% EC

**Elankavi** *et al.* (2019) carried out an experiment to study the Effect of new generation herbicides on weed parameters of black gram and reported that sodium acifluorfen 16.5% + clodinafop propargyl 8% EC @ 1250 ml ha-1 as post emergence provided effective controls of broad leaves weeds and grasses.

### 2.3.6. Hand weeding

Hand weeding has been the primarily option available for weed management in urdbean before the herbicidal intervention took over owing to rise in scarcity of cheap farm labour as was the case 3-4 decades back.

**Nirala and Dewangan (2012)** observed the lowest weed density and dry matter production of weed were with hand weeding twice 20 and 40 DAS, followed by imazethapyr at 25 g/ha PE in urdbean.

**Dhaker** (2009) reported that application of imazethapyr at 100 g/ha as post emergence along with one HW at 30 DAS in clusterbean registered the significantly lowest N and P depletion by weeds than individual application of herbicide and weed check treatments.

**Kohli et al.** (2006) in their study carried out at Hisar noted that pendimethalin at 1.0 kg/ha + HW at 35 DAS and alachlor at 0.75 kg/ha + HW at 35 DAS resulted in significantly higher N and P uptake by greengram, Whereas, the maximum grain protein content was recorded with two hand weeding performed at 20 and 30 DAS.

**Kumar** *et al.* (2003) reported that different weed control treatments resulted in significantly higher uptake of nutrients by grain and straw in mung bean as compared to weedy check. The maximum uptake of N, P and K was recorded in weed free plot. It was followed in the order of pendimethalin at 1.5 kg/ha+ HW at 30 DAS, pendimethalin at 1.5 kg/ha alone and one HW at 30 DAS treatments.

**Dhaka and Yadav** (2011) reported that remaining at par with HW twice at 20 and 40 DAS, imazethapyr at 0.15 kg/ha + HW at 30 DAS significantly reduced the depletion of N,P and K by weeds and enhanced their concentration in seed and stalk as well as uptake by sesame than rest of the treatments..

### 2.4. Effect of weed management treatment on black gram

### a) Growth parameter

In general, weed management induces better growth of crop and more so in case of use of herbicide which besides suppressing weeds also acts to some extend as growth parameters.

**Gupta** *et al.* (2014) reported that maximum crop growth rate CGR of urdbean was associated with weed free, HWs fallowed by imazethapyr (Post emergence) 40 and 25 g/ha at 20 DAS to the tune of 3.3, 3.3, 3.0, and 2.8 g/m²/day.

**Upadhyay** *et al.* **(2012)** reported that application of imazethapyr + imazamox (odyssey + adjuvant@ 87.5g+ 100ml/ha) recorded significantly highest leaf area index and dry matter accumulation of soybean.

Yadav et al. (2015) reported from Gwalior that the highest plant height (96.6 cm and 96.2 cm) and number of leaves (35.7 and 35.2) of urdbean was obtained with the post emergence application of imazethapyr + imazamox (pre mix) at 0.05 kg /ha and pre emergence application of pendimethalin + imazathapyr (pre mix) at 1.0 kg/ha, respectively and were at par with weed free treatment.

Nirala et al.(2016) studied that effect of post emergence herbicides for weed control in urdbean and revealed that hand weeding twice at 20 and 40 DAS produced significantly

taller plant, number of leaves, dry matter accumulation and crop growth rate as compared to others., though it was imazethapyr at 25 g/ha.

**Sharma** *et al.* (2016) studied the effect of weed control on growth and productivity of soybean and reported that weed free treatment recorded the maximum plant height, crop dry matter, leaf area index and branches at different stages of observation which was closely followed by pre emergence application of pendimethalin 0.75 kg/ha as pre emergence + hand 30 DAS and two hand weeding 15 and 30 DAS

### b) Effect of weed management treatment on yield and yield attributes

**Sosode** *et al.* **(2018)** obtained maximum number of grains/pod with the post emergence application of imazethapyr + imazamox 80 g/ha fb pre-emergence pendimethalin + imazethapyr 1000 g/ha. However, post-emergence application of imazethapyr 70 g/ha gave the maximum number of grains/pod fb higher dose of imazethapyr 80 g/ ha. They also found the highest seed yield as 924 kg/ha was recorded under two hand weeding at 20 and 40 DAS, but among different herbicide treatments application of imazethapyr + imazamox at 80 g/ha as PoE recorded maximum seed yield fb pre-emergence herbicide application of pendimethalin + imazethapyr at 1000 g/ha. The alone application of imazethapyr 80 g/ha as post-emergence resulted in higher yield compared to application of lower dose of imazethapyr 70 g/ha as post emergence.

Shyam and Tilgam (2019) reported that different weed-control treatments had a significant influence on biological yield and grain yield. Highest biological yield was obtained with two hand weeding at 20 and 40 DAS which was statistically at par with imezathypr + imazamox (pre-mix) 80 g/ha PoE and pendimethalin + imezathypr (pre-mix) 1000 g/ha PE except with pendimethalin 1000 g/ha PE and weedy check. Application of two hands weeding at 20 and 40 DAS and imezathyper + imezamox (pre-mix) 80 g/ha PoE and pendimethalin + imezathyper (pre-mix) 1000 g/ha PE gave the highest grain yield of black gram which was at par with imezathyper 80g/ha PoE but significantly higher than all other weed-control treatments. Different weed-control treatments had a significant influence on harvest index. Highest harvest index (%) was obtained with two hand weeding at 20 and 40 DAS which was statistically at par with all other weed-control treatments except with weedy check.

Gupta et al. 2017 conducted a field experiment at Crop Research Centre, Chirauri, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) and

revealed that all weed control treatments significantly increased the grain yield over weedy check. The maximum grain yield (1143 kg ha-1) was found with weed free treatment which was significantly higher than other weed control treatments. Among the herbicidal treatments, higher grain yield (1020 kg ha<sup>-1</sup>) was recorded with POE application of Imazethapyr +imazamox (RM) @ 80 g ha-1 followed by POE application of Imazethapyr +imazamox (RM) @ 70 g ha-1 (928 kg ha-1) which was higher than other herbicidal treatments. Grain yield was significantly increased in weed free (242.3 %), two hand weeding (222%) and POE application of imazethapyr +imazamox (RM) @ 80 g ha-1(205 %) than weedy check. The other herbicidal treatments also maintain their superiority over weedy check and also found that the maximum straw yield (1858 kg ha-1) was recorded in weed free treatment followed by two hand weeding (1768 kg ha-1) at 20 and 40 DAS. Among the herbicidal treatments, maximum straw yield (1652 kg ha-1) was recorded with POE application of imazethapyr + imazemox (RM) @ 80 g ha-1 followed by POE application of imazethapyr +imazemox (RM) comparison to all other treatments. The other herbicidal treatments also found superiour than weedy check@ 70 g ha-1 (1553 kg ha-1). Straw yield was significantly lower in weedy check.

Chin and Pandey (1991) from IARI, New Delhi reported that one hand weeding and pre-emergent imazethapyr at 0.05 and 0.075 kg/ha in urdbean resulted significant improvement in pods per plant and seed yield than fluchloralin at 1.0 and 1.5 kg/ha, fenoxaprop-ethyl at 0.12 and 0.18 kg/ha and weedy check treatments.

Chandel and Saxena (2001) conducted a weed control experiment on silt loam soil at Pantnagar and reported that the highest seed yield and seed production efficiency in soybean were obtained under two HW at 30 and 45 DAS treatment followed by imazethapyr at 100 g/ha.

**Chand** *et al.* (2003) at Pantnagar studied the effect of different weed management practices on productivity of late planted urdbean during kharif season and reported that weed free treatment produced significantly higher number of pods per plant, grains per pod, grain yield and test weight over remaining treatments. It was accompanied by two HW done at 20 and 40 DAS, pre emergence application alachlor 1.5 kg/ha + one HW at 40 DAS and metolachlor at 0.75 kg/ha + one HW at 40 DAS treatments, respectively.

A field experiment comprising alachlor at 1.5 and 2.0 kg/ha, pendimethalin at 0.75 and 1.0 kg/ha, metolachlor at 0.75 and 1.0 kg/ha, trifluralin at 0.75 and 1.0 kg/ha, fluchloralin

at 0.75 and 1.0 kg/ha, weed free and weedy check treatments was conducted by **Dungarwal** *et al.* (2003). They recorded the highest number of pods per plant, seeds per pod and seed yield of greengram with alachlor at 2.0 kg/ha. It was followed by trifluralin at 1.0 kg/ha and pendimethalin at 1.0 kg/ha. It also fetched the maximum net monetary returns with a maximum B: C ratio of 2.95.

**Singh** *et al.* (2003) from sumerpur in Rajasthan also reported that maximum number of pods per plant, seeds per pod, seed yield and net returns in greengram were obtained with alachlor at 2.0 kg/ha Remaining at par, it was followed in the order of trifluralin at 1.0 kg, pendimethalin at 1.0 kg, alachlor at 1.5 kg, metolachlor at 1.0 kg and fluchloralin at 1.0 kg/ha. Weed free treatment also produced seed yield equal to alachlor at 2.0 kg/ha, however, it proved lesser remunerative than the best treatment.

**Sumachandrika** *et al.* (2003) reported that number of pods per plant, seed yield per plant and grain yield of blackgram were obtained higher with two HW at 20 and 40 DAS as compared to different treatments such as soil solarisation with 0.50 and 0.10 mm plastic sheet, weeding at 20 DAS, thiobencarb at 0.05 kg/ha, fluchloralin at 1.0 kg/ha and imazethapyr at 0.1 kg/ha.

**Tewari** *et al.* (2004) from Kanpur reported that imazethapyr at 0.10 kg/ha as pre emergence gave effective weed control and increased the grain yield of mungbean as compared to two hand weedings.

A field experiment was conducted by **Mishra** *et al.* **(2004)** during kharif 2003 at Jabalpur. They observed that pendimethalin at 1.0 kg/ha gave significantly higher seeds per pod, test weight and grain yield of blackgram as compared to pendimethalin at 0.5 kg/ha, squadran at 1.5 and 3.0 kg/ha, imazethapyr at 0.1 and 0.05 kg/ha, glyphosate at 0.05, 0.025 and 0.012 kg/ha, Oxyfluorfen at 0.2 kg/ha and trifluralin at 0.1 kg/ha treatments. Maximum yield was obtained with the application of fluchloralin at 1.0 kg/ha followed by pendimethalin at 1.0 kg/ha.

**Yadav** (2006) found highest grain yield of urdbean in weed free treatment and was accompanied by two hand weeding done at 20 and 40 DAS, pre-emergent alachlor at 1.5 kg/ha + HW at 30 DAS and pendimethalin at 0.75 kg/ha + HW at 30 DAS treatments. All these treatments were found statistically at par but significantly superior over weedy check treatment.

**Kumar** *et al.* (2006) from Hisar reported that pendimethalin at 0.75 kg/ha + HW at 30 DAS, two HW at 20 and 40 DAS, pendimethalin at 1.0 kg/ha, alachlor at 0.75 kg/ha+ HW at 30DAS and alachlor at 1.0 kg/ha remaining at par among themselves resulted remarkable increase in grain yield of mungbean to the extent of 35.1, 33.3, 31.3, 29.8 and 29.6 per cent, respectively over weedy check. However, the maximum yield was obtained with weed free treatment. Likewise, **Kumar** *et al.* (2006) at Palampur observed that pendimethalin 0.75 kg/ha + HW at 45 DAS produced 12.9, 28.4, 35.7, 47.0 and 92.3 per cent higher grain yield of blackgram than two hand weedings at 25 and45 DAS, alachlor at 0.75 kg/ha + HW at 45 DAS, pendimethalin at1.5 kg/ha, alachlor at 1.5 kg/ha and unweeded control, respectively.

A field experiment was conducted by **Rao and Rao** (2006) at Bapatla in Andra Pradesh. They found that post emergence application of imazethapyr at 0.063 kg/ha gave higher number of seed per plant, test weight and seed yield of blackgram as compared to post emergence cyhalofop - butyl at 0.088 kg/ha, imazethapyr at 0.050 kg/ha and weedy check. Maximum seed yield was obtained under one HW at 52 DAS treatment followed by cyhalofop-butyl at 0.112 and 0.10 kg/ha at 21 DAS.

Begum and Rao (2006) also studied the efficacy of herbicides in blackgram at Bapatla. They observed that imazethapyr at 63 g/ha applied as post-emergence gave higher number of pods per plant, number of seeds per pods, test weight, seed yield and incremental B: C ratio as compared to thiobencarb at 2.0 kg/ha, fenoxaprop-p-ethyl at 0.056 kg/ha, clodinafop-propargyl at 0.052 kg/ha, cyhalofop-butyl at 0.10 kg/ha and control. Two hand weedings done at 15 and 30 DAS registered the highest seed yield and was followed by imazethapyr 0.063 kg/ha.

**Mishra and Bhanu** (2006) studied the effect of different herbicides in summer blackgram at Jabalpur. They found that maximum grain yield and yield attributes viz. pods per plant, seed weight per plant and test weight were obtained under weed free treatment that was closely followed by imazethapyr at 0.10 kg/ha applied as PPI, pendimethalin at 1.0 kg/ha as pre emergence also showed promising results.

**Sardana** *et al.* (2006) conducted a field experiment at PAU, Ludhiana to study the efficacy and economics of different weed management practices in blackgram. They observed that pre emergence application of pendimethalin at 0.56 kg/ha + one HW at 30 DAS gave significantly higher number of pods per plant, test weight, seed yield, net return and B:C ratio as compared to pendimethalin at 0.56 and 0.75 kg/ha, trifluralin at 0.5 and 0.75 kg/ha,

one HW at 30 DAS and weedy check treatments. Maximum seed yield and net returns were obtained from trifluralin at 0.5 kg/ha followed by one HW at 30 DAS.

**Sharma and Yadav** (2006) reported that weed free, two HW done at 20 and 40 DAS, pre emergent alachlor at 1.5 kg/ha + HW and pendimethalin at 0.75 kg/ha + HW treatments were found equally effective but significantly superior in enhancing the yield attributes as well as seed yield of greengram in comparison to weedy check. These treatments witnessed 71.7, 61.3, 52.9 and 54.0 per cent higher seed yield in comparison to weedy check, respectively

**Dhaka and Yadav** (2011) compared different weed management practices in sesame. They noted that pre emergence application of imazethapyr at 0.15 kg/ha + HW at 20 DAS resulted in the highest values of yield attributes viz. capsules per plant, seeds per capsule and test weight. It also produced the highest grain and stalk yield and fetched the maximum net returns that were significantly higher than rest of the treatments except two HW done at 20 and 40 DAS. It was followed by alachlor at 1.5 kg/ha + HW at 30 DAS treatment.

Ali et al. (2011) conducted an experiment during rainy season in greengram at S.K.Nagar on sandy loam soil. They obtained the highest grain yield and net returns in weed free treatments that showed statistical equivalence with imazethapyr at 100 g/ha and quizalofop-p-ethyl at 100 g/ha both applied at 20 DAS.

**Mundra and Maliwal (2012)** observed that per cent increase in seed yield of blackgram due to two hand weeding at 20 and 30 DAS, quizalofop-p-ethyl 50 g/ha, pendimethalin 750 g/ha and quizalofop-ethyl 37.5 g/ha to the extent of 226.1, 188.6, 141.7 and 126.5, respectively compared to weedy check insandy loam soil of Rajasthan.

**Nandan** *et al.*(2011) reported that highest seed yield (0.74 t/ha) of blackgram with application of imazethapyr 10% SL @ 250 ml/ha at 15-20 days after sowing and was followed by hand weeding twice at 20 and 40 days after sowing (0.73 t/ha) at Shiwalik, Jammu and Kashmir.

Choudhary *et al.*(2012) reported that, integrated application of pendimethalin @ 1.5 lit/ha + hand weeding at 25 DAS recorded higher pods/plant (38.1) compared to fluchloralin @ 1.5 lit/ha (34.1) and was similar to pendimethalin @ 1.5 lit/ha (36.0) in black gram crop. Higher values of number of pods plant-1, number of seeds pods-1, test weight were recorded with hand weeding at 20 and 40 DAS and pendimethalin 30%EC + imazethapyr 2% EC @ 1.0 kg *a.i.* ha-1 as pre-emergence application + sodium acifluorfen 16.5% SL+ clodinafop-

propargyl 8% EC @ 165 + 80 g *a.i.* ha-1 at 2-3 leaf stage of weeds (W4), might be due to the reason that lower weed population had provided favorable environment to the crop and least crop weed competition, which resulted in higher photosynthetic accumulation rate and better translocation to the sink as compared to weedy check. Similar results were reported by **Kumar** *et al.* (2015) and Singh *et al.* (2016). Significantly higher seed yield and haulm yield recorded with hand weeding at 20 and 40 DAS (W8) and pendimethalin 30% EC + imazethapyr 2% EC @ 1.0 kg *a.i.* ha-1 as pre-emergence application + sodium acifluorfen 16.5% SL + clodinafop-propargyl 8% EC @ 165 + 80 g *a.i.* ha-1 at 2-3 leaf stage of weeds (W4) may be due to the lower crop weed competition, weed population and weed dry weight, enabling the crop to establish and to grow vigorously resulting in better growth and development of the crop.

Sushmitha *et al.* (2019) conducted a field experiment at College Farm, Agricultural College, Mahanandi on sandy loam soils to know the efficacy of different herbicides in kharif blackgram [*Vigna mungo* (L.)]. The field experiment was laid out in a Randomised Block Design with nine treatments in three replications. Among these treatments, the lower weed dry weight, high weed control efficiency, yield attributes, maximum seed yield (1995 kg ha-1), haulm yield (2687 kg ha-1) and harvest index (42.62 %) were recorded under hand weeding at 20 and 40 DAS, which was statistically similar with pendimethalin 30%EC + imazethapyr 2% EC @ 1.0 kg *a.i.* ha-1 as pre-emergence application + sodium acifluorfen 16.5% SL+ clodinafop-propargyl 8% EC @ 165 + 80 g *a.i.* ha-1 at 2-3 leaf stage of weeds.

Vaishya *et al.* (2003) reported that weed free treatment produced highest grain yield 10.32 g/ha followed by twice HW at 20 and 40 DAS in urdbean.

**Gupta** *et al.* (2013) reported that highest seed yield was obtained with two hand weedingat 20 and 40 DAS and the values were found statistically at par with post emergence application of imazethapyr 25g/ha at 20 DAS in urdbean.

**Veeruputhiram** (2003) reported that higher number of pods/plant and grain/pods were produced under HW fallowed by mechanical weeding. The highest grain yield was registered by HW twice in blackgram.

**Meena** *et al.* (2011) revealed that application of imazethapyr 150g/ha as post emergence application of imazethapyr significantly recorded the highest no of branches/plant, pod/plant, seeds/pod and seed yield.

**Venkatesha** *et al.* (2008) reported that post emergence application of imazethapyr at 75g/ha alone with HW was most effective in minimizing the weed growth and and enhancing the grain yield of soyabean (Glysine max).

**Kumar and Angiras (2005)** reported that pendimethalin at 1.50kg/ha in combination with raised seedbed planting was effecting in controlling the weeds and increasing the seed yield of urdbean.

**Gupta** *et al.* (2014) reported that application of pendimethalin aty 2.0kg/ha and fluchloralin at 1.5 kg/ha recorded the highest seed yield which were at par with that of weed free in urdbean crop.

Raman *et al.* (2005) reported that with the treatment consisted of weedy control and one HW 20 DAS and two HW 20 and 20 DAS, fluchloralin and pendimethalin at .5 and 1.00 kg /ha in urdbean resulted significantly increased the seed yield and its component (grains/pods and pods/plant and 1000seed weight which was reduced weed competition for nutrient, moisture light and space.

**Kavita** *et al.* (2014) in a study of chemical weed management in urdbean at PDKV, Akola found superiority of pendimethalin 1.0 kg/ha over imazethapyr @ 50 and 75 g/ha applied as pre emergence. Imazethypyr at 75g/ha PE recorded yield at par with 2 HW and pendimethalin(1.0 and 1.5 kg/ha) and fenoxaprop –p- ethyl POST at 125 g/ha.

Yadav et al. (2015) studied the weed management treatment in urdbean and found that highest pod length (4.42 and 4.41 cm), number of branches 16.9 and 16.9 /plant and number of pods (65.69 and 57.7/plant) and grain and straw yield recorded with the post emergence application of imazethapyr + imazamox (premix) at 0.05kg/ha and with preemergence application of pendimethalin + imazethapyr (pre mix) at 1.0 kg/ha respectively and were at par with weed free treatment.

**Sharma** *et al.*(2016) studied the effect of weed control on growth and productivity of soybean and reported that maximum no of pods/plants, no of grains /pod , 100 seed weight and pod length were observed with weed free treatment which was closely followed by pendimethalin 0.75kg/ha PE+HW 30 DAS and 2 HW at 15 and 30 DAS.

**Halvankar** *et al.*(2005) reported that two hand weeding at 30 and 45 DAS registered the highest weed control efficiency, pods/plant and grain yield/ha.

**Koshta** *et al.*(2011) reported that two hand weeding 20 and 40 DAS gave the excellent control of all weeds and recorded higher yield 2735 kg/ha than the herbicidal treatment and control.

**Chaubey** *et al.*(2012) in a field experiment of blackgram reported that highest no of pods/plant, number of seed /pod, number , seed yield , straw yield and harvesting index were obtained under hand weeding twice 20 and 40 DAS fallowed by imazethapyr @ 25 g/ha PE and minimum was obtained under unweeded check.

**Jha** *et al.*(2012) reported that weed free produced significantly higher plant dry weight of 17.46 kg/plant over weedy check 5.53g/plant and combined use of Acifluorfen sodium 8%EC+clodinafop proparygyl 16.5 SL@ 100+206.2 g a.i./ha recorded more significantly more plant dry weight in soybean crop.

#### 2.5. Effect of weed management treatment on weed indices

Weed indices provide a mathematical preview of the extent of efficacy of different weed management intervention and can be indication of success or failure of different methods applied.

Vaisha et al. (2003) reported that in summer urdbean WCE was highest 46.6% with the twice hand weedings at 20 and 40 DAS followed by pendimethalin + HW 35 DAS (44.7%).

**Nirala and Dewangan 2012** reported that the lowest weed growth, lowest relative weed density and highest weed control efficiency were recorded under hand weeding twice 20 and 40 DAS fallowed by imazethapyr at 25g/ha PE in urdbean.

**Gupta** *et al.* **(2013)** observed highest weed control efficiency with two hand weeding at 20 and 40 DAS fallowed by application of imazethapyr 25g/ha PE in urdbean.

**Veerupthiram (2003)** reported that highest weed control efficiency and lower weed index under HW twice fallowed by mechanical weeding in both greengram and urdbean.

**Kushwah and Vyas (2005)** also reported that application of imazethapyr @ 75g/ha at 25 DAS in soyabean was found most effective in weed biomass and resulted higher weed control efficiency (90.10%) over other pre and post emergence herbicide

**Upadhyay** *et al.* (2012) reported that weed control efficiency was highest at and at harvest 69.82% and 81.82 % with the application of odyssey+ adjuvant (87.5 g +1000ml/ha) in soybean.

**Jadhav and Gadale (2012)** evaluated the post emergence herbicides in soybean in Maharashtra and reported that the application of imazethapyr+ imazamox @ 30 g/ha recorded the maximum weed control efficiency at 30 and 60 DAS.

Komal *et al.* (2015) studied the effect of weed management treatment on growth yield and nutrient uptake of greengram and found that the highest weed control efficiency and lowest weed control index percentage were observed in weed free treatment. Besides weed free treatment pendimethalin @ 0.75kg/ha as PE + imazethapyr +imazamox 40 g/ha at 30 DAS as post emergence, imazethapyr + imazamox 60 g/ha at 20 DAS as post emergence + one hand weeding at 40 DAS and imazethapyr + imazamox 20 DAS as post emergence + one hand weeding at 40 DAS recorded lower weed index 4.79. 6.07 And 7.51 and higher weed control efficiency 99.9, 99.8, 99.6, 98.6 percent. Similarly Mishra *et al.* (2016) carried out an experiment to study the bio efficacy of pre and post emergence herbicides in sorghum reported that pre emergence application of pendimethalin + imazethapyr resulted in higher weed control efficiency.

Elankavi et al. (2019) observed the impact of new generation herbicides in irrigated black gram at Annamalai University, Annamalai Nagar and stated that among the different weed control treatments hand weeding twice at 20 and 35 DAS registered lowest weed population. They also stated that application of Sodium acifluorfen 16.5% + Clodinafop propargyl 8% EC @ 1250 ml ha-1 at 20 DAS these treatments registered lowest weed population, weed dry matter production, highest weed control efficiency, weed control index and registered maximum yield.

#### 2.7. Effect of weed management treatment on different micro flora

Microbial degradation and photo degradation have been suggested as major dissipation mechanism for imazethapyr ( **Arora and Sondhia, 2013**).

**Khairnar** *et al.* **(2014)** carried out an field experiment on pre and post emergence herbicides weed management in mung bean and observed that initially, after the herbicide treatment (15, 30 and at Harvest) microbial counts was slightly less in pre emergence application of pendimethalin and pendimethalin + imazethapyr reaching a maximum between 30 days after sowing and at harvest.

Radivojeric et al. (2004) observed that toxic effect the toxic effect of herbicides normally appears immediately after the application of when their concentration in the soil highest. Later on, microorganism take part in degradation and herbicide concentration and its toxic effect decreases. The total microbial population was highest with the cultural operations and lower with herbicides. The application of herbicides in the recommended dose did not affect the microbial population significantly. Among herbicides results showed that application of herbicide in combination resulted in reduced microbial population compare to soils treated with the single herbicide likewise, Balasubramanian and Sankaran (2004) also reported initial suppression of soil moicroflora but the herbicide application in different soil which covered later on.

#### 2.8. Effect of weed control treatment on relative economics

**Rao** *et al.* **(2010)** reported that the highest net monetary return Rs 22255/ha and B: C ratio of 1.33 was obtained with pre emergence sand mix application of pendimethalin 1000g/ha fb imazethapyr 50 g/ha with net monetary return of 18270 and B: C ratio of 1.13 which may be due to higher weed control efficiency and lower cost of treatment in relay crop of urdbean.

**Velayudham (2007)** also reported that pre emergence application of pendimethalin at 0.75kg/ha + HW at 40 DAS + normal seed rate had gross return of 16340/ha and Rs 13860/ha with higher absolute B: C ratio of 2.1 and 1.8 for the years. This might be due to higher grain yield on account of effective weed control in urdbean.

Rao et al. (2008) obtained the highest net monetary return Rs 21993/ha and B: C ratio of 1.95 in urdbean with post emergence application of fenoxaprop 68g/ha which was closely followed by post emergence application of fenoxaprop 56g/ha with the monetary returns Rs 21025/ha and B: C ratio of 1.89 which may be due to higher weed control efficiency and lower cost of treatment.

**Adpawar** *et al.* (2011) reported that in urdbean the maximum net monetary return was obtained with one hoeing at 15 DAS and one HW at 30 DAS Rs. 20777/ha with B: C ratio 2.60 fallowed by pendimethalin pre emergence + one hand weeding at 30 DAS, but in case of gross monetary return recorded at par with each other but both were significantly over other treatments.

Chaudhary et al.(2012) reported that pre emergence application of pendimethalin in urdbean at 1.5 l/ha followed by one hand weeding on 25 DAS registered the highest net returns per rupee investment followed by hand weeding twice.

**Meena** *et al.* **(2011)** reported that application of imazrthapyr 10 % SL at 1000g/ha recorded significantly higher net returns (Rs 14237) and B: C ratio 1.68 fb imazethapyr10 percent at 150 g/ha over weedy check and imazethapyr 10 percent at 50 g/ha in soybean.

**Mirjha** *et al.* **(2013)** reported that maximum net returns Rs 22448 and B:C ratio 1.52 corresponds to the application of fenoxaprop – p- ethyl @ 50 g/ha + quizalofop – ethyl @ 4 g/.ha though cost effectiveness was also seen withy quizalofop – p – ethyl @ 37.5 g/ha+ chlorimuran- ethyl @ 4.0 g/ha post emergence and pendimethalin @ 1000 g/ha pre emergence in urdbean.

**Upadhyay** *et al.* **(2012)** studied the efficacy of early post emergence herbicides against weeds and revealed that application of imazethapyr+ imazamox (odyssey + adjuvant @ (87.5g+1000ml/ha) in soybean as recorded the highest net return and and B: C ratio in soybean as compared to other treatments. The lowest net returns and B: C ratio were recorded under weedy check treatment.

**Chaudhary** *et al.* (2012) studied the integrated weed management in urdbean and reported that application of pendimethalin @ 1.5 l/ha fallowed by one hand weeding at 25 DAS registered the highest net return per rupee investment fallowed by hand weeding twice.

**Yadav** *et al.* (2015) studied the weed management treatment in urdbean and reported that highest net returns Rs 17135/ha and B: C ratio 2.35 were recorded with post emergence application of imazethapyr+ imazamox (pre mix) at 0.05kg/ha fallowed by pre emergence application of pendimethalin + imazethapyr (pre mix) at 1.0 kg /ha (Rs 16410/ha and 2.30).

**Kaur** *et al.* (2016) studied the imizolinone herbicides for weed control in greengram and reported that pre emergence application of imazrthapyr + pendimethalin (pre mix) 1000g/ha recorded the highest benefit cost ratio and it was followed by lower doses of 900, 800g/ha and two hand weeding at 20 and 40 DAS. Lower benefit obtained when pendimethalin were pre emergence and imazethapyr + imazamox as post emergence applied for weed control.

Tamang et al. (2015) was carried out a field experiment at Bidhan Chandra Krishi Viswavidylaya (Nadia, West Bengal) during 2012 and 2013 (during March-May) in upland situation to judge the efficacy of the herbicides against weed flora in green gram crop field

and concluded that Maximum benefit: cost ratio was obtained from Vellore 32 (pendimethalin 30 EC+ imazethapyr 2 EC)@1.00 kg *a.i.* ha-1.

**Mansoori** *et al.* **(2015)** found that imazethapyr + imazamox (pre-mix) at 50g/ha as post-emergence (20 DAS) registered highest net returns and B: C ratio followed by imazethapyr + pendimethalin (pre-mix) at 1000 g/ha as preemergence in black gram.

#### 2.9. Effect of weed management treatment on phytotoxicity in black gram

**Chandrakar** *et al.* (2014) reported that effectiveness of early post emergence application of imazethapyr15-20 DAS imazethapyr at 40 g/ha and pendimethalin + imazethapyr at 1.0 kg/ha as pre emergence against weed in urdbean in clay texture soils Raipur, Chhatisgarh and found thatno phytotoxic effect of these herbicides was observed on urdbean crop.

**Yadav** *et al.*(2015) reported that on the basis of visual observation 0-10 scale application of imazethapyr alone 0.050 kg/ha and 0.070 kg/ha (post emergence and its premix combination with imazamox @0.05 kg/ha (post emergence) and pendimethalin uto 1.0 kg/ha recorded no phytotoxicity on urdbean in terms of any abnormality during the crop growth period.

**Singh** *et al.* (2014) reported that on the basis of visual observation application of imazethapyr even at higher rate (200 g/ha) recorded no phytotoxicity symptoms appeared on the groundnut crop. On the other hand, **Mishra** *et al.* (2016) reported that visual injury on sorghum plant with pre emergence readymix application of pendimethalin + imazethapyr (750+100g/ha) and post emergence application of imazethapyr+ imazamox 70 g/ha recorded slight yellowing of leaves Which recovered at harvest.

**Punia** *et al.* **(2015)** reported that premix application of imazethapyr + imazamox @ 70 and 80 g/ha cause 18-35% toxicity to greengram which mitigated with the time and remained 5-7% up to 45 DAS.

# Chapter- 3



## **Materials and Methods**

The details of the materials used and methods adopted during the course of investigation have been described in this chapter under the following headings:

#### 3.1. Experimental site

The present experiment laid out in PG Research Block during *kharif* season of 2019 of Banda University of agriculture and technology, Banda (UP). The experimental area having fairly uniform topography, normal fertility status and soil homogeneity. The selected field was naturally infested with location specific weeds.

#### 3.2. Climate and weather

The city Banda is situated in the Bundelkhand region of Uttar Pradesh. Banda (U.P) is situated between latitudes 24° 53′ and 25° 55′ N and longitudes 80° 07′ and 81° 34′ E and having an altitude of 168m above sea level. The climate of this region is a typically semi-arid, characterized by extremes of temperatures during both summers and winters. During summers, the temperature may go as high as 48°C while in winters, it may fall as low as -1°C. During 2019-20, a total of 1026.02 mm annual rainfall was occurred at the station and however, 96.37% of the total rainfall received and during crop season and rest was received in other months of the year. Maximum, minimum and average relative humidity was recorded 86.67%, 12.50% and 62.77% respectively. At the station, total 826 mm evaporation was recorded while maximum (56.30 mm) evaporation was recorded in 27<sup>th</sup> standard week and the average evaporation was recorded 38.44 mm from July to October. Data in table- 3.1 shows that the average of maximum and minimum temperature from July to October was 32°C and 25°C respectively.

The mean weekly weather parameters for the crop season recorded at college meteorological observatory have been presented in table- 3.1 and depicted graphically in figure- 3.1.

#### 3.3. Soil characteristics

A composite soil sample to a depth of 0-15 cm was collected from the experimental field prior to sowing of the crop. The sample was analyzed for its chemical attributes and the values obtained are given in Table-3.2. The experimental soil was sandy loam in texture; low in organic carbon content, low in available nitrogen and medium in available P and K.

Table-3.2: Chemical properties of the experimental soil

S. No	Particulars	Value	Method employed
1	pH (1: 2.5 soil water suspension)	7.58	Glass electrode pH meter (Jackson, 1973)
2	Electrical conductivity (dSm <sup>-1</sup> )	0.16	Electrical conductivity meter (Jackson, 1973)
3	Organic carbon (%)	0.40	Modified Walkley and Black method
4	Available nitrogen (kg/ha)	182	Alkaline KMnO <sub>4</sub> method (Subbiah and Asija, 1956)
5	Available P <sub>2</sub> O <sub>5</sub> (kg/ha)	16.4	Olsen's method (Olsen <i>et al.</i> Jackson, 1973)
6.	Exchangeable potassium (kg/ha)	186.3	1 N neutral ammonium acetate method (Jackson, 1973)

### 3.4. Cropping history of the field

The details of the crop and cropping system fallowed on the experimental field for the last few years prior to start the experiment have been given in the table 3.3.

Table-3.3: Cropping history of the experimental field

Year	Crops taken			
i cai	Kharif	Rabi		
2016-17	Pigeon pea	_		
2017-18	Pigeon pea			
2018-19	Black gram	Mustard		

## 3.5. Experimental details

The experiment was laid out in randomised block design during *kharif* season with three replication recommended dose of herbicide applied in black gram.

## 3.5.1. Treatment details

Sl. No.	Treatments	Herbicide	Doses (g a.i.ha <sup>-1</sup> )	Time of application	
1.	$T_1$	Imazethapyr	70	PE	
2.	$T_2$	Imazethapyr	80	PE	
3.	T <sub>3</sub>	Imazethapyr	70	3-4 leaf stage	
4.	T <sub>4</sub>	Imazethapyr	80	3-4 leaf stage	
5.	$T_5$	Imazethapyr+ ImazamoxRM	70	PE	
6.	$T_6$	Imazethapyr+ imazamox RM	80	PE	
7.	$T_7$	Imazethypr +Imazamox RM	70	3-4 leaf stage	
8.	$T_8$	Imazethypr + imazamox RM	80	3-4 leaf stage	
9.	T <sub>9</sub>	Pendimethalin	1000 g	PE	
10.	$T_{10}$	Imezathypr + pendimathalin( RM)	1000 g	PE	
11.	T <sub>11</sub>	Sodium acifluerfen 16.5% + clodinafop proparygyl 8EC	1000ml	2-4 leaf stage	
12.	T <sub>12</sub>	Hand weeding twice		15 and 30 DAS	
13	T13	Weedy check			
14	T14	Weed free		up to45days	

#### Note - PE - Pre-emergence; POE - Post-emergence

## Technical program of work

1.	Location	Research farm at BUAT, Banda (UP)
2.	Crop	Black gram
3.	Season	kharif 2019
4.	Variety	Azad urd 3
5.	Design	RBD (Randomized Block Design)
6.	Treatments	14
7.	Replications	3
8.	Total no. of plots	42 (14 x 3)
9.	Plot size	3.60 m x 3.00 m
10.	Gross Plot size	$5X \ 3 = 15m^2$
11.	Net Plot Size	$4x2.5 = 10m^2$
12.	Spacing	45 cm x 10 cm
13.	Seed rate	20 kg/ha
14.	Date of sowing	29 July
15.	Date of harvesting	20-22 October

## 3.5.2. Experimental design and layout

The seeds of Black gram variety Azad urd 3 were sown at a row to row distance of 45cm and a plant to plant spacing of 10 cm in a Randomised Block Design (RBD) with three replications. The layout is represented by a Figure-3.2 given below.

	Plot Border	
T <sub>14</sub>	T <sub>13</sub>	T <sub>14</sub>
T <sub>6</sub>	T <sub>14</sub>	T <sub>11</sub>
T <sub>5</sub>	T <sub>12</sub>	$T_2$
T <sub>8</sub>	T <sub>10</sub>	T <sub>4</sub>
T <sub>3</sub>	T <sub>6</sub>	T <sub>3</sub>
T <sub>9</sub>	$T_2$	T <sub>5</sub>
T <sub>4</sub>	T <sub>4</sub>	T <sub>6</sub>
T <sub>2</sub>	T <sub>7</sub>	T <sub>10</sub>
T <sub>10</sub>	T <sub>9</sub>	T <sub>8</sub>
T <sub>11</sub>	T <sub>5</sub>	T <sub>1</sub>
$T_1$	T <sub>8</sub>	T <sub>7</sub>
T <sub>7</sub>	T <sub>3</sub>	T <sub>12</sub>
T <sub>12</sub>	T <sub>1</sub>	T <sub>9</sub>
T <sub>13</sub>	T <sub>11</sub>	T <sub>13</sub>
R1	R2	R3

**3.6. Herbicide description** 

3.6.1. Pendimethalin

Mode of action of pendimethalin

This herbicide is active in the surface layer of soil where it controls annual weed by

inhibiting seed germination and seedling development or shortly after emergence from the

soil. Pendimethalin inhibits both cell division and cell elongation in the roots and shoot

meristem of the susceptible weed species. The growth is inhibited directly following

absorption through hypocotyls and shoot region. Germination as such is not inhibited, the

plant die shortly after germination or emergence from the soil. In soybean plant

pendimethalin alter cell arrangement of leaves and internodes walls of pericylic fibres of stem

are abnormally thickened. Pendimethalin also induce irregular thickening of hypocotyls of

soybean. There is a little redistribution by translocation. Growth is inhibited directly

fallowing absorption through shoot and hypocotyls. Shoot absorption is the more important

phenomenon in influencing the control of broad leaved weeds. Weeds die shortly after

germination or fallowing emergence from the soil.

Group: Dinitroaniline

Common name: Pendimethalin

Trade name: Stomp

Active ingredient: 30% EC

IUPAC name: N-(1-ethylpropyl)-2, 6- dinitro-3,4-xylidine

Molecular weight: 281.31

Empirical formula: C<sub>13</sub>H<sub>19</sub>N<sub>3</sub>O<sub>4</sub>

Pendimethalin is mostly used as a pre-emergent herbicide for low land rice. Though

the main use of pendimethalin is for rice, it has proved useful for other crops as well wheat,

maize, sorghum, pearlmillet, chickpea, peas, groundnut, soybean, sunflower, mustard,

linseed, jute, cotton and vegetables. Pendimethalin is strongly absorbed on soil clay and

organic matter and is not subject to leaching. In contrast to the case with most other

dinitroaniline herbicides, soil microorganisms do not appear to play significant role in

degradation of pendimethalin.

#### Structural formula:

**Pendimethalin/penoxalin** [N-(1-ethylpropyl)-3, 4-dimethyl1-2, 6-dinitrobenzenamine]

#### 3.6.2 Imazethapyr

#### Mode of action of imazethapyr

It is absorbed by roots and foliage, trans-located throughout the xylem and phloem, and accumulated in the growing regions. Therefore, it controls the entire weeds, including root or rhizome. It control both emerged and multiple flushes of shallow germination weeds. It kills the weed by inhibition of aceto hydroxy acid. This causes a disruption in protein synthesis. It targets the plastid enzyme aceto lactate synthase (ALS) in plant, which catalyses the first step in the biosynthesis of initial branched chain amino acids (valine, leucine and isoleucine). The ALS inhibitors thus stop cell division and reduce carbohydrate translocation in the susceptible plants. The affected plant succumbs to this herbicide completely in 7-20 days. After pre-emergence or pre plant incorporation susceptible weeds may germinate and emerge; however, normal growth stops. After post-emergence application susceptible weeds stop growing and necrosis occur within 4-8 days and provide control over 30 -35 DAS

Group: Imidazolinone

Common name: Imazethapyr

Trade name: Pursuit/pursuit plus

Active ingredient: 10SL

IUPAC name: [2-{4, 5-dihydro-4-methyl1-4-(1-methylethyl)-5-oxo-1-H-imidazo-2-yl}-5-

ethyl-3-pyridine carboxylic acid]

Empirical formula: C<sub>15</sub>H<sub>19</sub>N<sub>3</sub>O<sub>3</sub>

Imazethapyr is a systemic pre-plant incorporated, pre-emergence, or post-emergence applied herbicide. Imazethapyr is mainly used in soybeans; however, it is also used in crops like corn, oil seed rape and vegetables for control of many major annual and perennial grass and broad-leaved weeds. It is absorbed by the roots and foliage, with translocation in the xylem and phloem, and accumulation in the meristematic regions and inhibits branched chain amino acid synthesis (ALS or AHAS.). Hence reduces levels of valine, leucine and isoleucine, leading to disruption of protein and DNA synthesis. Selectivity in soybean and peanuts is attributed to rapid detoxification via hydroxylation and glycosylation. Growth is inhibited within few hours after application, but injury symptoms usually appear after one to two weeks or more. Meristematic areas become chloratic, followed by slow general foliar chlorasis and necrosis. Generally absorbed rapidly into foliage although absorption varies from 20 -90 % in 24 hours, root absorption is slower, this inhibition cases distruption in protein synthesis. After post emergence application of susceptible weeds stop growing and competing with the soybean sown after treatment with death occurring within 4-8 weeks. Plant death result from events occurring in response to ALS inhibition but the actual sequence of phototoxic process is unclear.

#### Structural formula

$$C_{2}H_{5}$$
 $C_{2}H_{5}$ 
 $C_{2}H_{5}$ 
 $C_{3}H_{5}$ 
 $C_{2}H_{5}$ 
 $C_{3}H_{5}$ 
 $C_{4}C_{5}H_{5}$ 
 $C_{5}H_{5}$ 

#### 3.6.3. Mode of action of imazamox

It inhibits the enzyme aceto hydroxy acid synthaase (AHAS) in plant species, which is involve in the synthesis of three branched- chain aliphatic amino acids; isoleucine, leucine and valine. This inhibition disrupts protein synthesis and subsequently interferes with cell growth. Studies indicate that after application, imazamox is taken up by the foliage and trans- located throughout the plant. Susceptible weeds stop growing shortly after application and expire within 4-12 weeks.

Group: Imidazolinone

Common name: Imazamox

IUPAC name: (RS)-2-(4-isopropyl-4-methyl-5- oxo-2-imidazolin-2-yl)-5- methoxymethyl-nicotinic

acid

Empirical formula: C<sub>15</sub>H<sub>19</sub>N<sub>3</sub>O<sub>4</sub>

3.6.4. Imazethapyr + imazamox

Group: Imidazolinone

Common name: **Imazethapyr** + **imazamox** 

Trade name: Odyssey

Active ingredient: 70 WG

IUPAC name:

Molecular weight: 281.31

**Mode of Action** 

It is absorbed by the foliage and translocated through the xylem and phloem and

accumulated in the meristematic region. So it controls the entire weeds, including the root or

rhizome. It will not harm the succeeding crops because it has short soil persistence. Odyssey

controls both emerged and multiple flushes of shallow germinating weed.

3.7. Cultural operations

The details of pre and post planting operation carried out in experimental field are given in

Table - 3.4.

#### Calendar of different cultural operation carried out during experimentation

Operation	Date of operation	Remark			
Field preparation	20/7/2019and 21/7/2019	Primary tillage done with disc harrow while secondary tillage operations were done with the help of cultivar.			
Layout	22/7/2019	Field layout done manually with the help of rope and liner.			
Fertilizer application	29/7/2019	Placement of fertilizer made manually			
Date of sowing	29/7/2019	Line sowing was done manually			
Herbicide application	30/7/2019	Application of pre emergence herbicide			
	15/8/2019	Application of post emergence herbicide			
Thinning and gapfilling	15/8/2019 and 16/8/2019	For maintaining plant population thinning and gapfilling was done manually			
Hand weeding	14/8/2019, 30- 31/8/2019 and 17- 18/9/2019	Weeding in hand weeding and weed free plots, done manually with the help of khurpi			
Plant protection measures	14/9/2019 and 26/9/2019	Pesticides were applied to manage Blister Beetle at the time of flowering			
Harvesting	20-22/ 10/2019	Harvesting was done manually			
Threshing 23-25/10/2019		Threshing was also done manually			

#### 3.7.1. Field preparation

Initially the field was prepared with the help of tractor drawn implements. After giving one deep ploughing the experimental field was crossed harrowed and levelled properly to break the clods and bring the soil to the desired tilth. The plot was prepared manually for sowing the subsequent crops of the experimental study.

#### 3.7.2. Fertilizer Application

A uniform dose of 20 kg N and 40 kg  $P_2O_5$  /ha was drilled in furrows at a depth of 8-10 cm at the time of sowing. Urea and SSP were used as source of nutrients.

#### **3.7.3.** Sowing

Furrows were opened manually with the help of liners at a specified row to row distance of 45 cm and a plant to plant distance of 10 cm on 29<sup>th</sup> July 2019. The seeds were covered with soil. A seed rate @ 20kg/ha was used for black gram crop.

#### 3.7.4. Gap filling and thinning

In places where seeds failed to germinate, gap filling was done at 12 days after sowing. When more than one seedling was present in a hill, they were thinned out to maintain one seedling for proper spacing at 20 days after sowing.

#### 3.7.5. Harvesting, threshing and winnowing

The black gram crop was harvested during 20-22 October 2019, when the pods were fully ripened and turned black. At the time of harvesting the crop from gross plot size harvested, bundled separately and tagged. Harvested produce was left in the respected plots for 3 days to allow sun drying and weighing to record biological yield. Harvested produce was threshed by beating with sticks with the help of manual labour and finally seeds were winnowed by using *supas*. Threshed seeds were sundried for 2-3 days to reduce the moisture content and then the seed yield per plot was recorded and converted into q/ha. The straw yield was computed by subtracting the grain yield from the biological yield

#### 3.7.6. Plant protection

Prophylactic plant protection measures were undertaken to protect the crop from insects and diseases. Before sowing, the seed was treated with bavistin @ 2 g/kg to protect from seed borne diseases. Two spray of contact pesticide were done on September, 14<sup>th</sup> and 26<sup>th</sup>, 2019 to protect the crop from damage of Blister Beetle.

#### 3.7.7. Herbicide application

Herbicide were applied with the help of Knapsack sprayer fitted with flat fan T-jet nozzle using a spray volume of 500 l/ha. Pre-emergence application of imazethapyr @ 70g/ha, imazethapyr @ 80g/ha, imazethapyr + imazamox RM @ 70g/ha, imazethapyr + imazamox RM 80 g/ha, pendimethalin @ 1000 ml/ha and imazethapyr + pendimethalin RM @ 1000ml/ha. Whereas post emergence application of imazethapyr @ 70g/ha, imazethapyr 80g/ha, imazethapyr + imazamox RM @ 70g/ha, imazethapyr + imazamox RM 80 g/ha and and clodinafop proparygyl 8EC+ sodium aciflurfen16.5% was done 20 days after sowing as post emergence application. Two hand weeding was done 15 and 30 DAS whereas in weed free plots, weed were not allowed grow weeds and hand weeding was done as and when weeds were emerged.

#### 3.8. Observation recorded

#### 3.8.1. Growth parameter

For all the growth and development studies during the crop growth period three plants were selected randomly and were tagged in each plot except for that of leaf area index and dry matter accumulation where plants row from border rows selected for reading observations.

#### **3.8.1.1. Plant height (cm)**

Plant height was measured from the ground level to the tip of growing point and the average of three plants was expressed as plant height in centimetre at 30 DAS, 60 DAS and at harvest stage.

#### 3.8.1.2. Number of branches plant<sup>-1</sup>

The number of primary branches emerging directly from main stem was counted and the number of branches emerging from each primary branch was counted and the average of the three plants was expressed as number of primary and secondary branches plant<sup>-1</sup>, respectively.

#### 3.8.1.3. Number of nodules per plant

The total numbers of nodules per plant were counted at flowering stage. Three plants were randomly selected from sample rows of each plot and uprooted carefully. The soil mass

embodying the roots of the plant was washed off by water and total nodules were counted. The mean value was recorded as total number of nodules per plant.

#### **3.8.1.4.** Root length

Three plants were randomly selected from sample rows of each plot and uprooted carefully. The soil mass embodying the roots of the plant was washed off by water and total root length was recorded. The mean value was recorded as total length of root per plant.

#### 3.8.1.5. Number of leaves per plant

The number of leaves per plant was counted and the average of the three plants was expressed as leaves per plant.

#### 3.8.1.6. Dry matter production and its distribution (g plant<sup>-1</sup>)

Plant samples for dry matter studies were collected at 30, 60 days after sowing and at harvest. At each sampling three plants were uprooted at random in each treatment. These samples were first air dried and then oven dried at 65-70°C till a constant weight was obtained. Oven dry weight was recorded and the mean dry matter of whole plant sample was calculated by dividing the total dry matter of plant (g plant<sup>-1</sup>) from three. The total dry matter production plant<sup>-1</sup> was obtained with the summation of dry weight of all the plant parts and was expressed as g plant<sup>-1</sup>.

#### 3.8.1.7. Leaf area index

Three plants selected randomly from the border rows of the both crops from each plot and were close to the ground. All the leaves were removed from these plants, counted and categorized into three group of large medium and small sized. A representing leaf from each category was chosen and its leaf area meter (Model: LAMETRE-211, Systronic made) and the leaf area was worked out which was then multiplied with the total no of leaves obtained from all the three plants and average leaf area from /plant was worked out. Further the leaf area index was worked out by using the formula as given here under

Land area /plant = Row distance X plant distance

$$LAI = \frac{Leaf \text{ area/plant cm}^2}{Land \text{ area/plant cm}^2}$$

#### 3.8.2. Observation on yield attributes and yield

The plants selected for growth studies were utilized for recording the observations on the following yield components.

#### 3.8.2.1. Number of pods per plant

Fully developed pods were separated from three tagged sample plants in net plot and were counted and the average was taken as the number of pods per plant.

#### 3.8.2.2. Number of seeds per pod

The seeds from 5 representative pods were separated by hand threshing counted and the mean number of seed per pod was calculated by dividing the number of seeds by number of pods.

#### 3.8.2.3. Seed yield per plant (g)

The seeds from the pods of three plants were separated by hand threshing and their mean weight was taken as seed weight per plant and expressed in grams.

#### 3.8.2.4. 100 seed weight (g)

Seed samples from the produce of each treatment were taken at random and 100 seeds from these samples were counted and weighed and expressed in grams.

#### 3.8.2.5. Plant stand after germination and at harvest (Number ha<sup>-1</sup>)

Total number of plants from net plot size was counted and it was converted into hectare basis.

#### 3.8.2.6. Seed yield (q ha<sup>-1</sup>)

Pods from each net plot according to the treatment were threshed, cleaned and the seed weight was recorded and yield per hectare was computed and expressed in q ha<sup>-1</sup>.

#### 3.8.2.7. Straw yield (q ha<sup>-1</sup>)

Plants from the net plot after threshing were dried and their weight was recorded. From this straw yield per hectare was calculated and expressed in q ha<sup>-1</sup>. Straw yield (q/ha) was obtained by subtracting the grain yield from biological yield.

#### **3.8.2.8.** Biomass yield (q ha<sup>-1</sup>)

Above ground plant parts harvested from net plot area, were carefully bundled, tagged and taken to the threshing floor separately. The individual bundle was weighed after complete drying in the sun before threshing. After the threshing, grain yield was determined and converted in to q ha<sup>-1</sup>.

#### **3.8.2.9.** Harvest index (%)

Harvest index was estimated as per the formula suggested by Donald (1962).

Economic yield (kg ha<sup>-1</sup>)
$$HI = \frac{1}{\text{Biological yield (kg ha}^{-1})} \times 100$$

#### 3.9. Weed observations

#### 3.9.1. Weed density (Number m<sup>-2</sup>)

The determination of weed density was done by the standard quadrant method given by Mishra and Mishra (1997). The number of weeds were counted from an area of  $0.25 \text{ m}^2$  (quadrant size) randomly selected in each plot at two places 35 DAS and harvest and converted to per square meter (m<sup>-2</sup>) basis. Later the original values were transformed to square root values ( $\sqrt{X+0.5}$ ) and subjected to statistical analysis.

#### 3.9.2. Weed dry weight (g m<sup>-2</sup>)

The weeds present within the quadrant area were uprooted, and transferred to brown covers. After air drying, the weeds were dried in the hot air oven at 65-70°C till the constant weights obtained. The dry matter thus obtained was recorded at 35 DAS and harvest which was expressed in g/m2and the original data were subjected to square root transformation ( $\sqrt{X}$  + 0.5) and analyzed statistically.

#### 3.9.3. Weed control efficiency (%)

Weed control efficiency was calculated on dry weight basis by adopting the formula given by Mani *et al.* (1976).

WCE = 
$$\frac{\text{Dry matter of weeds in weedy check} - \text{Dry matter of weeds in treated plot}}{\text{Dry matter of weeds in weedy check}} \times 100$$

#### 3.9.4. Weed Index/ Weed competition index

Weed index is reduction in yield due to weed infestation. It is calculated by using the formula given by Gill and Kumar (1969).

$$X - Y$$

Where,

X- Yield of weed free plot

Y-Yield of treated plot

#### 3.10. Soil studies

Before sowing of crop individual soil samples taken from all the plots were taken from the surface 0-15cm for the determination of pH, EC, OC, available nitrogen, phosphorous and potassium. The samples were dried under shade, grounded and passed through 2mm sieve and were analyzed for nutrients.

#### 3.10.1. Available nitrogen

Available nitrogen was determined by modified alkaline permagnate method as described by Subbiah and Asija 1956 and expressed in kg/ha.

#### 3.10.2. Available phosphorous

Available phosphorous was determined by using method described by Olsen et al 1954. The intensity of the color developed by ascorbic acid (Watanable and Olsen, 1956) was measured at 880nm on spectrophotometer and was expressed in  $P_2O_5$  kg/ha.

#### 3.10.3. Available potassium

Available K was extracted with neutral normal ammonium acetate solution described by Piper 1956 and potassium was described by flame photometer and expressed in k kg/ha.

#### 3.11. Economics

The economics of treatments is the prime important consideration before making any recommendation to the farmers for its adoption. Hence, to evaluate the effectiveness and profitability of the treatments, comprehensive economics including Gross monetary return (GMR), net monetary returns (NMR) and B:C ratio was calculated so that the most effective and remunerative treatment could be recommended. The details of calculation with prevailing market rates of the inputs and produce are given in appendix.

#### 3.11.1. Cost of cultivation Rs/ha

Cost of different operations done during the crop growth was worked out separately for each item. The manual and mechanical labor power engaged for different operations was recorded on per hectare basis and the cost was calculated for different operation by multiplying with the existing market prices. Similarly, cost of all input was also calculated. The total cost of calculated by adding the expenditure involved in all kind of operation as per treatment on per ha basis in Rs/ha.

#### 3.11.2. Gross return

The gross return by calculated multiplying the total grain and straw yield with prevalent market price of the item. They were presented on per ha basis as per treatments.

#### **3.11.3.** Net return

The net Return was computed by deducting the total cost of cultivation from the gross return as per treatments.

#### 3.11.4. Benefit cost ratio

Benefit cost ratio was calculated by dividing the net return with the cost of cultivation for different treatment.

Benefit cost ratio = 
$$\frac{\text{Net return (Rs. ha}^{-1})}{\text{Total Cost of Cultivation (Rs. ha}^{-1})}$$

#### 3.12. Statistical analysis and interpretation of data

#### 3.12.1 Statistical analysis

The data were subjected to analysis of variance techniques (ANOVA) for randomized block design as prescribed by Cochran and Cox (1963). Critical difference of different treatments at 5% level of probability were calculated wherever F test will be significant.

#### 3.12.2. Standard error of mean

Standard error of mean was calculated by using the formula:

Standard error of mean 
$$=\frac{\sqrt{EMSS}}{r}$$

Where,

SEm  $\pm$  = Standard error of mean

EMSS= Error mean sum of square

r = Number of replications on which the observation is based

#### 3.12.3. Critical difference

The critical difference at 5 per cent level of probability will be worked out to compare treatments means wherever 'F' test was significant.

Critical difference = 
$$S Em \pm x \sqrt{2} x t$$
 (at error degree of freedom)

#### 3.12.4. Coefficient of Variation (%)

Coefficient of variation, the standard deviation expressed as percentage of mean, will be computed as follows:

$$C.V.(\%) = \frac{\sqrt{EMSS}}{Mean} \times 100$$

Where,

C.V. (%) = Coefficient of variation

EMSS= Error mean sum of square

Mean = Grand mean

#### **Analysis of Variance (ANOVA)**

Source of variation	Degree of Freedom
Replication	2
Treatments	13
Error	26
Total	

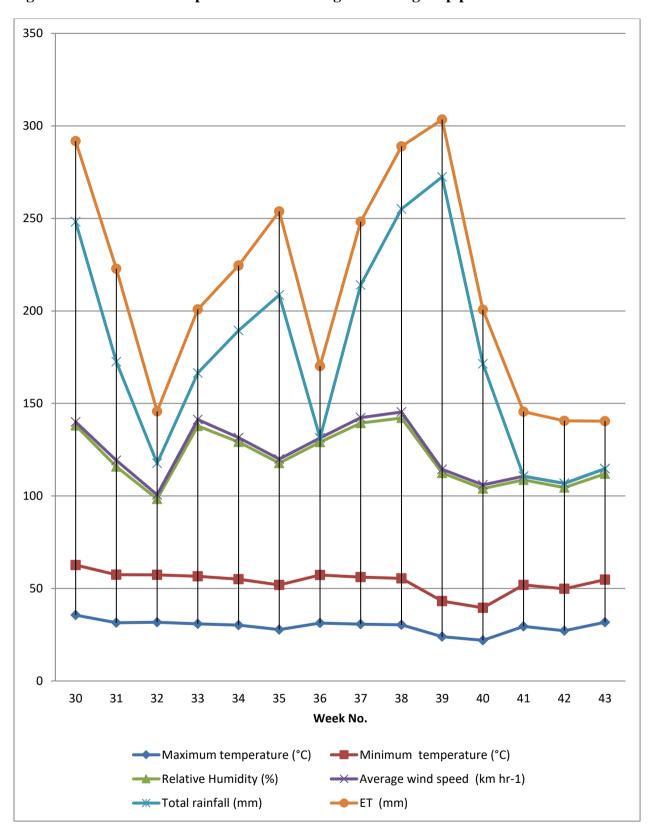
#### 3.12.5. Transformation of data

Data on weed count and weed dry weight showed high variation. To make the analysis of variance more valid, the data on weed count and weed dry weight was subjected to square root transformation by using formula  $\sqrt{x} + 0.5$  (Chandel, 1984).

Table 3.1 Weekly weather data record during crop period of kharif 2019.

Week No	From	То	Maximum temperature (°C)	Minimum temperature (°C)	Relative Humidity (%)	Average wind speed (km hr <sup>-1</sup> )	Total rainfall (mm)	ET (mm)
30	23- Jul-19	29- Jul-19	35.61	27.05	75.43	1.91	108.2	43.6
31	30- Jul-19	5- Aug- 19	31.5	25.92	58.43	3.38	53.3	50.3
32	6- Aug- 19	12- Aug- 19	31.75	25.63	41	2.23	17.1	28
33	13- Aug- 19	19- Aug- 19	30.9	25.7	81.2	3.46	25.2	34.4
34	19- Aug- 19	26- Aug- 19	30.2	24.8	74.2	2.32	57.9	35.1
35	27- Aug- 19	2- Sep- 19	27.75	24.21	65.83	2.15	88.68	45.2
36	3- Sep- 19	9- Sep- 19	31.33	25.92	71.83	2.28	0	38.8
37	10- Sep- 19	16- Sep- 19	30.75	25.38	83.25	3	71.6	34.3
38	17- Sep- 19	23- Sep- 19	30.38	25.08	86.67	3.23	109.7	33.9
39	24- Sep- 19	30- Sep- 19	24	19.14	69.29	2	158	31
40	1-Oct- 19	7-Oct- 19	22	17.57	64.43	2.04	65.4	29.2
41	8-Oct- 19	14- Oct- 19	29.5	22.43	56.71	2.06	0	34.8
42	15- Oct- 19	21- Oct- 19	27.14	22.71	54.71	2.26	0	33.8
43	22- Oct- 19	28- Oct- 19	31.8	23	57.2	2.74	0	25.7
			29.61	23.89	67.15	2.50	755.08	498.1

Fig. 3.1. Effect of weather parameter on black gram during crop period.



# Chapter- 4



## Chapter -4

## **Experimental results**

The results of the experiment entitled "Studies on herbicidal weed management in black gram [Vigna mungo (L.) Hepper]" conducted during kharif 2019 at research block, Banda University of Agriculture and Technology, Banda (UP) are being presented in this chapter. Data on growth of crop, yield and weed dynamics periodically recorded during the course of investigation were statistically analyzed to test their significance. The analyses of variance for all these components have been given in the annexure at the end. Results have been presented and illustrated graphically for better understanding of important trends, wherever felt necessary.

#### 4.1. Effect of weed management practices on growth parameters

#### 4.1.1. Plant population Lac/ha.

Data pertaining to the effect of weed management treatments on plant population at germination and at maturity presented in table 4.1. Data reveals that no weed management treatments could bring significant variation in plant population of black gram crop up to level of significance at germination stage.

At maturity, among the all treatments the highest population of black gram was recorded with weed free treatment followed by hand weeding twice 15 & 30 DAS. Among the herbicidal treatments the maximum plant population was observed in imazethapyr @ 80g a.i./ha PE which remains at par with pendimethalin @ 1000g and imazethapyr + imazamox RM @ 80g a.i./ha PE. However the minimum plant population was recorded in weedy check.

#### 4.1.2. Plant height (cm)

Plant height is an important parameter reflecting the vertical growth of a crop plant. Data pertaining to the effect of weed management treatments on plant height at 30 DAS, 60 DAS and harvest are presented in table 4.2. Data revealed that the treatments have significant higher plant height at all growth stages except 30 DAS as compared to weedy check.

The maximum plant height was recorded under weed free treatment followed by hand weeding twice 15 & 30 DAS at all growth stages. Among the herbicidal treatment the

maximum plant height was recorded with  $T_{10}(imazethapyr + pendimethalin RM @ 1000g$  PE) which was at par with  $T_1(imazethapyr @ 70g$  a.i/ha PE),  $T_{11}(sodium aciflurfen 16.5\% + clodinafop proparygyl 8EC 1000ml POE)$  and  $T_2(imazethapyr @ 80g$  a.i./ha PE),  $T_3(imazethapyr + imazamox RM @ 70g$  a.i./ha PE) and found significantly superior over  $T_8(imazethapyr + imazamox RM @ 80g$  a.i./ha 3-4 leaf stage),  $T_6(imazethapyr + imazamox RM @ 80g$  a.i./ha PE) and weedy check treatment at 60 DAS.

At harvest among the herbicidal treatments the maximum plant height was recorded in the treatment of imazethapyr + pendimethalin RM @ 1000g PE which was statistically at par with imazethapyr @ 70g a.i/ha PE, imazethapyr @ 80g a.i./ha PE, imazethapyr @ 70g a.i./ha at 3-4 leaf stage, imazethapyr + imazamox RM @ 70g a.i./ha PE and found significantly superior over imazethapyr + imazamox RM @ 80g a.i./ha PE and pendimethalin @ 1000g. However the minimum plant height was observed in weedy check.

#### 4.1.3. No. of leaves plant <sup>-1</sup>

Data pertaining to the effect of weed management treatments on number of leaves per plant at 30 DAS, 60 DAS and at harvest are presented in table 4.3. Data revealed that weed management options significantly affect the no of leaves per plant at all growth stages except 30 DAS. The maximum no of leaves per plant was recorded under weed free treatment fallowed by hand weeding twice 15 & 30 DAS at 30 DAS, 60 DAS and harvest.

Among the herbicidal treatments the maximum no of leaves per plant was found in imazethapyr + pendimethalin RM @ 1000g PE which remains at par with imazethapyr + imazamox RM @ 70g a.i./ha PE, imazethapyr @ 80g a.i./ha PE, sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE and rest of the treatment at 60 DAS, whereas lower number of leaves per plant was recorded in imazethapyr @ 70g a.i/ha PE at 60 DAS.

At harvest stage, among the herbicidal treatment the maximum number of leaves per plant was observed in imazethapyr + imazamox RM @ 70g a.i./ha PE which was at par with imazethapyr + pendimethalin RM @ 1000g PE, sodium aciflurfen 16.5%+clodinafop proparygyl 8EC 1000 ml POE and rest of the treatments. However the minimum number of leaves was observed in weedy check.

#### 4.1.4. Root length per plant (cm)

The data on the root length per plant at 45 DAS of crop growth were analyzed statistically and are presented in table 4.4. Data revealed that all the treatments gave significant effect on root length per plant.

A perusal of data presented in table 4.4 reveals that maximum root length was recorded in weed free treatment fallowed by hand weeding twice 15 & 30 DAS. Among the herbicidal treatments maximum root length 14.2 was recorded with imazethapyr + pendimethalin RM @ 1000g PE which was significantly superior over rest of the treatment. However the minimum root length was recorded in weedy check.

#### 4.1.5. Nodules per plant.

Data pertaining to the effect of weed management treatments on nodule per plant at 45 DAS of crop growth are presented in table 4.4. Data revealed that adoption of weed management practices recorded significantly higher no of nodules per plant at 45 DAS in comparison to weedy check. Maximum number of nodules 36.01 per plant recorded with weed free treatment followed by hand weeding twice at 15 & 30 DAS.

Among the herbicidal treatments maximum no of nodules per plant were recorded with application of Imazethapyr + pendimethalin RM @ 1000g PE which was at par with imazethapyr @ 80g a.i./ha PE, imazethapyr @ 80g a.i./ha at 3-4 leaf stage and rest of the treatments.

#### 4.1.6. Leaf area index

At peak flowering stage, scrutinizes of data pertaining to LAI presented in table 4.4 reveals that different weed management treatments significantly influenced LAI of black gram crop. Among the treatments the maximum (3.79) value of leaf area index was recorded under weed free treatment followed by hand weeding twice 15 & 30 DAS.

Among the herbicidal treatments the maximum value of leaf area index 3.40 was recorded in imazethapyr + pendimethalin RM @ 1000g PE which remains at par with imazethapyr @ 80g a.i./ha PE, imazethapyr @ 70g a.i./ha at 3-4 leaf stage and found significantly superior over imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage, imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage and pendimethalin @ 1000g.

#### 4.1.7. No of branches plant -1

Data pertaining to the effect of weed management treatments on number of branches per plant at 60 DAS and at harvest are presented in table 4.5. Results revealed that weed management practices significantly influenced the number of branches per plant at all the crop growth stages. The maximum number of branches/plant was found in weed free condition fallowed by hand weeding twice at 15 & 30 DAS at 60 DAS and at harvest.

At 60 DAS, among the herbicidal treatment the maximum 5.13 number of branches per plant was found in Imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage which was at par with Imazethapyr + pendimethalin RM @ 1000g PE, Imazethapyr @ 80g a.i./ha PE, Imazethapyr @ 80g a.i./ha at 3-4 leaf stage and significantly superior over Imazethapyr @ 70g a.i/ha PE, pendimethalin @ 1000g, sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE and weedy check.

At Harvest among the herbicidal treatments the maximum no of branches 5.17 per plant were recorded in imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage which was significantly superior over imazethapyr @ 70g a.i/ha PE and Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE and at par with rest of the treatment. However, the minimum 3.83 no of branches per plant was found in weedy check.

#### 4.1.8. Dry matter accumulation

Periodic dry matter accumulation per plant (g plant<sup>-1</sup>) owing to different weed management practices was significant at various stages of crop growth.

Dry matter accumulation per plant exhibited an increasing trend with advancement in crop growth irrespective of the treatment (Table- 4.6). The rate of dry matter accumulation was slow during initial stage. Practicing any of the weed control measure resulted in significant increase in dry matter accumulation per plant in comparison with weedy check.

At 30 DAS, among the various weed control treatments, higher dry matter accumulation per plant 13.1 was recorded in imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage which remains at par with imazethapyr + imazamox RM @ 80g a.i./ha PE, imazethapyr + Imazamox RM @ 70g a.i./ha PE, imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage and found significantly superior over rest of the treatments.

At 60 DAS, among the weed control treatments, significantly higher dry matter accumulation per plant was recorded in imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage (27.03) than imazethapyr + pendimethalin RM @ 1000g PE (20.40), sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE(20.17) and imazethapyr @ 80g a.i./ha at 3-4 leaf stage(21.20), while it was statistically at par with T<sub>8</sub>- imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage(26.97), imazethapyr @ 70g a.i/ha PE (26.17) and imazethapyr + imazamox RM @ 70g a.i./ha PE(T5) 25.37 treatments.

At harvest maximum dry matter accumulation was observed in imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage(48.50) which was significantly superior over all the herbicidal treatments except  $T_8$  and  $T_{11}$ .

# 4.2. Yield attributes of black gram as influenced by weed management practices

Crop yield is directly related with yield attributing characters like number of pods per plant, seeds per pod, 100 seed weight etc. The data pertaining to yield attributes is presented in Table-4.7

#### 4.2.1 No. of pods plant<sup>-1</sup>

The number of pods plant<sup>-1</sup> differed significantly among different treatments. Among the treatments the maximum (40.67) no of pod per plant was recorded in weed free treatments followed by hand weeding twice 15 & 30 DAS. However among the herbicidal treatments the maximum (38.60) number of pods per plant were observed in imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage Which was statistically at par with T<sub>8</sub>- Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage and Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE and found significantly superior over rest of the treatments including weedy check.

#### 4.2.2 Pod length (cm)

Data pertaining to the effect of weed management treatments on pod length (cm) are presented in table 4.7. Data reveals that maximum pod length was observed in weed free treatment followed by hand weeding twice 15 & 30 DAS.

Among the herbicidal treatments the maximum pod length was recorded in imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage which was significantly higher than imazethapyr @ 80g a.i./ha at 3-4 leaf stage while it remains at par with rest of the treatments. However the minimum pod length was recorded in weedy check.

#### 4.2.3. Number of seeds pod<sup>-1</sup>

A perusal of data presented in table 4.7 reveals that the number of seeds pod<sup>-1</sup> differed significantly due to different weed management practices. The maximum 6.33 no of seeds pod<sup>-1</sup> was recorded in weed free treatment followed by hand weeding twice 15 & 30 DAS among the treatments but among the herbicidal treatments the maximum 6.30 no of seeds pod<sup>-1</sup> were recorded in imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage which was statistically at par with imazethapyr + pendimethalin RM @ 1000g PE, imazethapyr + imazamox RM @ 70g a.i./ha PE and found significantly superior over rest of the treatments. However the minimum no of seeds pod<sup>-1</sup> were recorded in weedy check.

#### **4.2.4 100** seed weight

A critical examination of the data (Table 4.7) indicated that significantly highest 100 seed weight to the tune of 5.68 g recorded with treatment  $T_{14}$ (weed free) followed by  $T_{12}$ (hand weeding twice 15 & 30 DAS). Among herbicidal treatments the highest 100 seed weight (g) to the tune of 5.50 was recorded in  $T_7$  (imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage) which was significantly superior over  $T_1$ (imazethapyr @ 70g a.i/ha PE) while remains statistically at par with rest of the treatments. Whereas the lowest 100 seed weight was observed in weedy check with the corresponding value of 4.84 g.

#### 4.3. Effect of weed management practices on yield parameters

The data pertaining to yield parameters as influenced by different weed management practices are presented in Table-4.8.

#### **4.3.1** Seed yield (q ha<sup>-1</sup>)

A perusal of data presented in table 4.8 reveals that the seed yield of black gram significantly affected by different weed management treatments. Among the all treatments  $T_{14}$  (weed free) was recorded significantly highest seed yield to the tune of 12.4 q/ha fallowed by hand weeding twice 15 & 30 DAS. Among the herbicidal treatment  $T_7$  (imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage) was recorded highest seed yield to the tune of

11.34 q/ha which was significantly superior over rest of the treatments. Whereas the lowest seed yield was recorded  $T_{13}$  (weedy check) with corresponding value of 4.8 q/ha.

#### **4.3.2** Straw yield (q ha<sup>-1</sup>)

Perusal of data presented in table 4.8 indicated that straw yield of black gram was also improved to a considerable extent by all the weed management treatments (Table 4.8 and Fig. 4.3). The maximum straw yield of 36.80 q/ha was obtained with weed free treatment. It was followed by hand weeding twice 15 & 30 DAS. Among the herbicidal treatments the maximum 34.50 q/ha straw yield was recorded in  $T_6$  (imazethapyr + imazamox RM @ 70g a.i./ha PE) which remains at par with  $T_4$ (imazethapyr @ 80g a.i./ha at 3-4 leaf stage) and found significantly superior over rest of the treatments.

#### 4.3.3 Harvest index

Harvest index, the ratio of economic yield to biological yield, varied significantly under weed control measures led to better diversion of photosynthates towards seed and thereby high harvest index. The highest value of harvest index was observed in hand weeding twice 15 & 30 DAS to the corresponding value 25.77 followed by imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage to the corresponding value 25.40 which was significantly superior over rest of the treatments.

#### 4.4 Effect of weed management practices of weed dynamics

The important weed species that were found to infest the experimental field along with their taxonomical details have been mentioned in table 4.9. Survey of the experimental field revealed that weedy check plots were heavily invaded by annual dicot weeds chiefly *Amaranthus viridis*, *Amaranthus spinosus* and *Trianthema portulacastrum* immediately with the crop emergence. *Euphorbia hirta*, *Digera arvensis*, *Corchorus acutangulus*, *Phyllanthus niruri and Physalis minima* were the another dicot weeds found to infest the experimental field. Cyperus rotundus, Dactylactenium aegypticum, Cynodon dactylon, Digitaria sanguinalis and Cenchrus biflorus were found to be the prominent monocot weeds species though; the population of these weeds was comparatively lower.

#### 4.5. Effect of weed management practices on weed Density

The results of the weed population in terms of grassy weeds, BLWs, sedges and total weed density per m<sup>2</sup> as influenced by different weed control treatments recorded at 45 DAS and at harvest are presented in Table 4.10 to 4.13, respectively.

## 4.5.1. Weed density (m<sup>-2</sup>) of broad leaved weeds as influenced by weed management practices

A perusal of data on weed density of broad leaved weeds revealed that all the weed control measure led to significant reduction in its count at 45 DAS and at harvest in comparison with weedy check (Table-4.10).

Among the treatments the lowest weed density recorded in weed free condition  $(T_{14})$  at 45 DAS and at harvest followed by two hand weeding 15 and 30 DAS  $(T_{12})$  treatment and highest weed density of broad leaf weed recorded in weedy check.

Among the herbicidal treatments the lowest (2.41m²) density of BLW at 45 DAS was recorded with application of imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage (T<sub>8</sub>) which was statistically at par with the application of imazethapyr + pendimethalin RM @ 1000g (T<sub>10</sub>), imazethapyr + imazamox RM @ 70g a.i./ha PE (T<sub>5</sub>), Sodium aciflurfen 16.5% + clodinafop proparygyl 8 EC 1000ml(T11), imazethapyr @ 80g a.i./ha at 3-4 leaf stage( T<sub>4</sub>), imazethapyr + imazamox RM @ 70g a.i./ha PE (T<sub>5</sub>) and significantly superior over T<sub>1</sub> (imazethapyr @ 70g a.i/ha PE), T<sub>2</sub>( imazethapyr @ 80g a.i./ha PE), T<sub>3</sub>( imazethapyr @ 70g a.i./ha at 3-4 leaf stage) and pendimethalin @ 1000g (T<sub>9</sub>) applied plots.

At harvest perusal of data indicated that the lowest weed density of the BLW recorded with the application imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage ( $T_8$ ) which was statistically at par with the application of  $T_7$  (Imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage),  $T_{10}$  (imazethapyr + pendimethalin RM @ 1000g) and Sodium aciflurfen 16.5% + clodinafop proparygyl 8 EC 1000 ml ( $T_{11}$ ) and found significantly superior over  $T_2$  (imazethapyr @ 80g a.i./ha PE) and  $T_3$ (imazethapyr @ 70g a.i./ha at 3-4 leaf stage). However each and every weed control treatments significantly superior over weedy check.

#### 4.5.2. Weed density (m<sup>-2</sup>) of grassy weeds as influenced by weed management practices

The data pertaining to the density of grassy weeds recorded at 45 DAS & at harvest as influenced by different weed management practices are presented in Table-4.11. Adoption of weed control options significantly reduced the grassy weed population at different crop growth stages.

Data indicated that all the treatments adopted for weed management in blackgram recorded significantly lower density of grassy weeds at all the stages of observation in comparison to weedy check. Among the treatments the lowest population of grassy weeds at 45 DAS observed in weed free treatment (T<sub>14</sub>). However among the herbicidal treatment lowest density of grassy weeds observed with the application of imazethapyr @ 70g a.i./ha at 3-4 leaf stage 1.75 (T<sub>3</sub>) treatment which was significantly superior over hand weeding twice 15 & 30 DAS, while it remains statistically at par with the application of imazethapyr + imazamox RM @ 70g a.i./ha PE 1.88 (T<sub>5</sub>) treatment, imazethapyr + pendimethalin RM @ 1000g1.90 (T<sub>10</sub>) and the application of Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml 1.90 (T<sub>11</sub>) and rest of the treatments.

At harvest stage lowest density of grassy weeds among the herbicidal treatment again was observed with the application of imazethapyr @ 70 g a.i/ha at 3-4 leaf stage fallowed by  $T_5$  (imazethapyr + imazamox RM @ 70g a.i./ha PE) and  $T_7$  ( imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage) treatment which was statistically at par with the rest of treatments and least effective treatment  $T_{12}$  i.e. hand weeding twice 15 and 30 DAS. However, each treatment recorded significantly lower grassy weed population than weedy check.

#### 4.5.3. Weed density (m<sup>-2</sup>) of sedges

The weed density of sedge weeds presented in Table-4.12 revealed that density of sedges differed significantly due to different weed control treatments at all growth stages. Among the all treatments the lowest density of sedges were recorded with weed free treatment fallowed by hand weeding twice (4.07) at 45 DAS and at harvest.

At 45 DAS, lowest density of sedges (4.63 m<sup>-2</sup>) were observed with the application of imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage which was significantly superior over Pendimethalin @ 1000g(T<sub>9</sub>), imazethapyr + imazamox RM @ 70g a.i./ha PE (T<sub>5</sub>) and

Imazethapyr + imazamox RM @ 80g a.i./ha PE (T<sub>6</sub>) while it remains statistically at par with rest of the treatments. Least effective treatment to control over sedges is imazethapyr + imazamox RM @ 70ga.i./ha PE. However each treatment recorded significantly lower sedges weed population than weedy check.

At harvest stage the lowest density of sedges recorded with the application of sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml ( $T_{11}$ ) 4.41 which was significantly lowest over imazethapyr + imazamox RM @ 70g a.i./ha PE ( $T_5$ ), imazethapyr + imazamox RM @ 80g a.i./ha PE ( $T_6$ ) and pendimethalin @ 1000g( $T_9$ ) while it remains at par with rest of the herbicidal treatments. However each treatment recorded significantly lower density of sedges than weedy check.

#### 4.5.4 Total weed density (m<sup>-2</sup>)

It is evident from the Table-4.13 that total weed density differed significantly due to weed management practices at all growth stages.

The lowest density of total weed was observed in weed free treatment followed by hand weeding twice at 15 and 30 DAS at 45 DAS and at harvest. Among the herbicidal treatments lowest total weed density was observed with the application of imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage (T<sub>8</sub>) which was significantly superior over T<sub>9</sub> (pendimethalin @ 1000g), T<sub>5</sub>(Imazethapyr + Imazamox RM @ 70g a.i./ha PE) and T<sub>6</sub>(Imazethapyr + imazamox RM @ 80g a.i./ha PE) however it remains at par with rest of the treatments at 45 DAS and at harvest. However each treatment recorded significantly lower values of total weed density than weedy check.

#### 4.5.5 Weed dry weight (g)

Observations on weed dry biomass were taken at 45 DAS and at harvest in black gram crop. The data on weed dry weight as affected by different treatments have been summarized and presented in Table-4.13.

A perusal of data revealed that weed dry weight differed significantly at all the stages of growth due to adoption of various weed control measures. Weedy check plot recorded highest weed dry weight at both the crop growth stages, *i.e.*, 45 DAS and at harvest.

Weed free condition produces the lowest weed dry weight followed by hand weeding twice at 15 and 30 DAS at both stages of crop growth i.e. 45 DAS and at harvest.

Among the herbicidal treatments the lowest weed dry weight was recorded with the application of  $T_8$  (imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage) which was significantly lower over  $T_5$  (imazethapyr + imazamox RM @ 70g a.i./ha PE),  $T_6$  (imazethapyr + imazamox RM @ 80g a.i./ha PE) and  $T_9$  (pendimethalin @ 1000g) while it remains at par with rest of the treatments at 45 DAS.

At harvest, lowest dry weight recorded with T<sub>8</sub> (imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage) which was statistically at par with T<sub>3</sub> (imazethapyr @ 70g a.i./ha at 3-4 leaf stage), T<sub>4</sub> (imazethapyr @ 80g a.i./ha at 3-4 leaf stage) and T<sub>7</sub> (imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage) and found significantly superior over T<sub>5</sub> (imazethapyr + imazamox RM @ 70g a.i./ha PE), T<sub>6</sub> (imazethapyr + imazamox RM @ 80g a.i./ha PE) and T<sub>9</sub>(pendimethalin @ 1000g). However, all weed control measures proves their superiority over weedy check in terms of weed dry matter at both stages of crop growth.

#### 4.5.6. Weed control efficiency (%)

A perusal of data presented in table 4.15 reveals that among the different weed management practices, highest weed control efficiency (100%) was observed with the treatment T<sub>14</sub> (weed free) at 45 DAS and at harvest followed by T<sub>8</sub> (imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage) 78.31,75.31 which was highest in comparison to weed control efficiency achieved in T<sub>8</sub>(imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage) at 45 DAS & at harvest respectively which was statistically higher over T<sub>5</sub>(imazethapyr + imazamox RM @ 70g a.i./ha PE), imazethapyr + imazamox RM @ 80g a.i./ha PE and pendimethalin @ 1000g which was statistically at par with rest of the treatments at 45 DAS and at harvest respectively. However the lowest weed control efficiency was recorded with weedy check T<sub>13</sub> treatment (0.00%).

#### 4.5.7. Weed index (%)

The data presented in table 4.16 with respect to weed index reveals that amongst the weed management practices in black gram maximum yield loss in terms of weed index observed in weedy check with tune of 61.29% as compared to weed free plot which was observed no yield loss due to absence of weeds. Adoption of two hand weeding (15 & 30 DAS) corresponding value is 0.8 %. Amongst the different weed management options at

harvest numerically the lowest value of weed index to the tune of 8.51% was recorded with the application of  $T_7$ — imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage which was followed by treatment Sodium aciflurfen 16.5%+ clodinafop-proparygy 1.8 EC 1000 ml POE 10.24%,  $T_8$ - imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage 10.48%,  $T_8$ - imazethapyr + imazamox RM @ 80g a.i./ha PE 16.74%), imazethapyr + imazamox RM @ 70g a.i./ha PE 18.55% and rest of the treatments.

#### 4.6. Effect of weed management practices of relative economics.

The data pertaining to the cost of cultivation, gross returns, net returns and B: C ratio as influenced by different weed control treatments are presented in Table-4.17

#### 4.6.1. Cost of cultivation

The cost of cultivation differed due to different weed management practices. Higher cost of cultivation was involved in weed free plot (Rs. 31100ha<sup>-1</sup>) followed by two hand weeding 15 & 30 DAS (Rs.29080 ha<sup>-1</sup>). Weedy check recorded the minimum cost (Rs. 21000 ha<sup>-1</sup>) of cultivation. The next best treatments with respect to lower cost of cultivation were noticed with imazethapyr @ 70g a.i/ha PE (Rs. 22743 ha<sup>-1</sup>) and imazethapyr @ 70g a.i./ha at 3-4 leaf stage (Rs. 22743 ha<sup>-1</sup>).

#### 4.6.2. Gross returns

A perusal of data revealed that the gross returns differed due to different weed management practices. Higher gross returns (Rs. 78040  $ha^{-1}$ ) were recorded with weed free plot and lower gross returns were obtained in weedy check (Rs. 31840  $ha^{-1}$ ). Among the herbicidal treatments, post-emergence application imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage gave significantly higher gross return (Rs. 71298  $ha^{-1}$ ) fallowed by  $T_8$  - imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage (Rs.70090  $ha^{-1}$ ).

#### 4.6.3. Net returns and B: C ratio

The net returns differed among different weed management practices. Higher net returns (Rs. 47981 and Rs. 46496 ha<sup>-1</sup>) with higher benefit cost ratio (2.06 and1.97) were recorded with post-emergence application of imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage and T<sub>8</sub>- imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage respectively. Minimum net return (Rs10840 ha<sup>-1</sup>) and B: C ratio 0.52 obtained from weedy check plot.

Table no 4.1: Plant population of black gram as influenced by the weed management practices.

	Plant population		
Treatments	After germination	At Maturity	
Imazethapyr @ 70g a.i/ha PE	2.199	1.981	
Imazethapyr @ 80g a.i./ha PE	2.199	2.005	
Imazethapyr @ 70g a.i./ha at 3-4 leaf stage	2.199	1.995	
Imazethapyr @ 80g a.i./ha at 3-4 leaf stage	2.198	1.978	
Imazethapyr + Imazamox RM @ 70g a.i./ha PE	2.196	1.983	
Imazethapyr + imazamox RM @ 80g a.i./ha PE	2.195	1.998	
Imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage	2.200	1.983	
Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage	2.196	1.972	
Pendimethalin @ 1000g	2.200	2.002	
Imazethapyr + pendimethalin RM @ 1000g PE	2.196	1.998	
Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE	2.198	1.997	
Hand Weeding twice 15 and 30 DAS	2.200	1.998	
Weedy check ( control)	2.098	1.829	
Weed free up to 45 DAS	2.232	2.036	
SEm±	0.010	0.010	
CD (P=0.5)	NS	0.029	

Table-4.2: Plant height of black gram as influenced by weed management practices at different stages of crop growth.

	Plant height (cm)			
Treatment	30 DAS	60 DAS	At maturity	
Imazethapyr @ 70g a.i/ha PE	39.17	64.30	66.70	
Imazethapyr @ 80g a.i./ha PE	39.77	64.60	69.03	
Imazethapyr @ 70g a.i./ha at 3-4 leaf stage	34.23	60.30	65.73	
Imazethapyr @ 80g a.i./ha at 3-4 leaf stage	34.07	59.96	65.63	
Imazethapyr + Imazamox RM @ 70g a.i./ha PE	35.07	61.73	67.47	
Imazethapyr + imazamox RM @ 80g a.i./ha PE	33.97	56.30	60.40	
Imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage	31.40	59.60	65.53	
Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage	31.07	59.30	65.20	
Pendimethalin @ 1000g	33.77	60.10	63.37	
Imazethapyr + pendimethalin RM @ 1000g PE	40.07	67.43	70.00	
Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE	38.53	64.86	69.83	
Hand Weeding twice 15 and 30 DAS	40.07	68.46	71.50	
Weedy check (control)	33.10	55.36	62.23	
Weed free	40.23	68.46	72.00	
SEm±	2.09	2.73	1.77	
CD (P=0.5)	6.12	7.97	5.17	

Table no 4.3 No. of leaves of black gram as influenced by weed management practices at different stages of crop growth.

	No of leaves/plant		
Treatment	30 DAS	60 DAS	At maturity
Imazethapyr @ 70g a.i/ha PE	38.11	58.00	56.33
Imazethapyr @ 80g a.i./ha PE	38.56	62.33	60.67
Imazethapyr @ 70g a.i./ha at 3-4 leaf stage	38.12	60.67	59.00
Imazethapyr @ 80g a.i./ha at 3-4 leaf stage	36.89	59.33	57.67
Imazethapyr + Imazamox RM @ 70g a.i./ha PE	42.45	63.67	62.00
Imazethapyr + imazamox RM @ 80g a.i./ha PE	36.22	60.00	57.93
Imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage	36.56	60.33	58.67
Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage	35.22	59.00	57.33
Pendimethalin @ 1000g	36.89	60.67	59.00
Imazethapyr + pendimethalin RM @ 1000g PE	43.25	64.77	61.67
Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE	35.33	63.33	60.10
Hand Weeding twice 15 and 30 DAS	43.88	65.30	62.60
Weedy check ( control)	24.60	30.30	21.37
Weed free up to 45 DAS	44.03	65.67	63.67
SEm±	4.86	3.42	5.34
CD (P=0.5)	NS	9.99	15.61

Table no 4.4 No. of nodule/plant, root length and LAI of black gram as influenced by weed management practices.

Treatment	Root length (cm)	Nodules/ plant (45 DAS)	Leaf area index (at peak flowering stage)
Imazethapyr @ 70g a.i/ha PE	12.07	31.56	2.66
Imazethapyr @ 80g a.i./ha PE	12.37	32.47	3.15
Imazethapyr @ 70g a.i./ha at 3-4 leaf stage	12.65	31.76	2.91
Imazethapyr @ 80g a.i./ha at 3-4 leaf stage	12.77	32.33	2.71
Imazethapyr + Imazamox RM @ 70g a.i./ha PE	10.60	31.37	2.97
Imazethapyr + imazamox RM @ 80g a.i./ha PE	11.78	27.12	2.98
Imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage	10.60	27.52	2.04
Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage	11.20	31.18	1.95
Pendimethalin @ 1000g	10.77	29.77	1.81
Imazethapyr + pendimethalin RM @ 1000g PE	14.20	33.07	3.40
Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE	10.60	27.37	2.86
Hand Weeding twice 15 and 30 DAS	14.51	35.82	3.70
Weedy check (control)	8.67	23.52	1.40
Weed free up	15.07	36.01	3.79
SEm±	0.40	1.24	0.29
CD (P=0.5)	1.17	3.63	0.85

Table no.4.5: No. of branches/plant of black gram as influenced by weed management practices at different stages of crop growth.

Treatment	No of branches/plant		
	60 DAS	At maturity	
Imazethapyr @ 70g a.i/ha PE	3.90	4.07	
Imazethapyr @ 80g a.i./ha PE	4.70	4.90	
Imazethapyr @ 70g a.i./ha at 3-4 leaf stage	4.43	4.67	
Imazethapyr @ 80g a.i./ha at 3-4 leaf stage	4.50	4.93	
Imazethapyr + Imazamox RM @ 70g a.i./ha PE	4.70	5.03	
Imazethapyr + imazamox RM @ 80g a.i./ha PE	4.33	4.80	
Imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage	5.13	5.17	
Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage	4.63	4.70	
Pendimethalin @ 1000g	4.40	4.60	
Imazethapyr + pendimethalin RM @ 1000g PE	4.73	4.90	
Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE	4.13	4.33	
Hand Weeding twice 15 and 30 DAS	5.40	5.50	
Weedy check ( control)	3.80	3.83	
Weed free	5.73	5.80	
SEm±	0.23	0.20	
CD (P=0.5)	0.66	0.59	

Table no. 4.6. Dry matter accumulation of black gram as influenced by the weed management practices at different stages of crop growth.

	Dry weight of plant (g)			
Treatment	30 DAS	60DAS	At harvest	
Imazethapyr @ 70g a.i/ha PE	11.40	26.17	44.33	
Imazethapyr @ 80g a.i./ha PE	10.30	24.13	42.07	
Imazethapyr @ 70g a.i./ha at 3-4 leaf stage	11.40	23.27	37.17	
Imazethapyr @ 80g a.i./ha at 3-4 leaf stage	11.20	21.20	34.50	
Imazethapyr + Imazamox RM @ 70g a.i./ha PE	12.70	25.37	36.80	
Imazethapyr + imazamox RM @ 80g a.i./ha PE	12.70	24.63	36.10	
Imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage	13.10	27.03	48.50	
Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage	12.40	26.97	46.50	
Pendimethalin @ 1000g	11.50	23.33	44.83	
Imazethapyr + pendimethalin RM @ 1000g PE	10.40	20.40	42.33	
Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC				
1000ml POE	10.13	20.17	45.33	
Hand Weeding twice 15 and 30 DAS	13.80	29.27	49.50	
Weedy check ( control)	10.10	18.40	27.50	
Weed free up to 45 DAS	13.90	29.87	55.50	
SEm±	0.53	0.94	1.13	
CD (P=0.5)	1.55	2.75	3.29	

Table 4.7: Yield attributes of black gram as influenced by weed management practices

Treatment	No of pod/plant	Pod length (cm)	Number of seeds /pod	100 Seed weight
Imazethapyr @ 70g a.i/ha PE	34.07	4.10	5.86	5.13
Imazethapyr @ 80g a.i./ha PE	34.30	4.13	5.94	5.36
Imazethapyr @ 70g a.i./ha at 3-4 leaf stage	34.50	4.04	5.84	5.13
Imazethapyr @ 80g a.i./ha at 3-4 leaf stage	34.83	4.20	6.05	5.44
Imazethapyr + Imazamox RM @ 70g a.i./ha PE	34.67	4.14	6.16	5.47
Imazethapyr + imazamox RM @ 80g a.i./ha PE	34.57	4.10	6.07	5.44
Imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage	38.60	4.20	6.30	5.50
Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage	38.40	4.10	6.10	5.36
Pendimethalin @ 1000g	32.73	4.13	6.16	5.13
Imazethapyr + pendimethalin RM @ 1000g PE	36.03	4.11	6.22	5.47
Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE	37.90	4.10	6.13	5.35
Hand Weeding twice 15 and 30 DAS	40.13	4.10	6.20	5.44
Weedy check ( control)	29.40	3.90	5.50	4.84
Weed free up to 45 DAS	40.67	4.20	6.33	5.68
SEm±	0.31	0.05	0.05	0.06
CD (P=0.5)	0.90	0.15	0.16	0.18

Table No. 4.8 Yield and harvests index of black gram as influenced by weed management practices.

Treatment	Seed yield q/ha	Straw yield q/ha	Biological yield q/ha	Harvesting index (%)
Imazethapyr @ 70g a.i/ha PE	9.82	32.11	41.93	23.42
Imazethapyr @ 80g a.i./ha PE	9.87	33.60	43.47	22.70
Imazethapyr @ 70g a.i./ha at 3-4 leaf stage	9.50	33.80	43.30	21.94
Imazethapyr @ 80g a.i./ha at 3-4 leaf stage	9.56	34.30	43.86	21.79
Imazethapyr + Imazamox RM @ 70g a.i./ha PE	10.10	32.93	43.03	23.47
Imazethapyr + imazamox RM @ 80g a.i./ha PE	10.32	34.50	44.82	23.03
Imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage	11.34	33.30	44.64	25.40
Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage	11.10	34.10	45.20	24.56
Pendimethalin @ 1000g	8.55	32.50	41.05	20.84
Imazethapyr + pendimethalin RM @ 1000g PE	9.26	32.70	41.96	22.06
Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE	11.13	33.80	44.93	24.77
Hand Weeding twice 15 and 30 DAS	12.36	35.60	47.96	25.77
Weedy check (control)	4.80	22.40	27.20	17.65
Weed free up to 45 DAS	12.40	36.80	49.20	25.20
SEm±	0.03	0.08	0.10	0.07
CD (P=0.5)	0.09	0.23	0.28	0.19

Table no 4.9.Important weed flora of the experimental field.

S. No.	Botanical name	Common name	English name	Family
1.	A. viridis L.	Jangli Chaulai	Slender amaranthus	Amaranthaceae
2.	Amaranthus spinosus L.	Kataili chaulai	Spiny amarthus	Amaranthaceae
3.	Boerhavia diffusa L.	Bish khapra	Spiderling	Nyctaginaceae
4.	Caesulia axillaris	Kala Maka	Pink node flower	Asteraceae
5.	Commelina benghalensis L.	Moria bati	Dayflower	Commelinaceae
6.	Cynodon dactylon L.	Doob grass	Bermuda graass	Poaceae
7.	Cyperus rotundus L.	Motha	Purple nutsedge	Cyperaceae
8.	Dactyloctenium aegypticum	Makra grass	Crow footgrass	Poaceae
9.	Digera arvensis	Lahsua	Digera	Amaranthaceae
10.	Euphorbia hirta L.		Bari dudhi	Euphorbiaceae
11.	Leucas aspera	Gumma	Leucas	Labiatae
12.	Phyllanthus niruri	Bhuinanwla		Euphorbiaceae
13.	Sigitatia sanguinalis	Jhernia grass	Crab grass	Poaceae
14.	Trianthema portulacastrum L.	Patharchath	Horsepurslane, Carpet weed,	Aizoaceae
15.	Tribulus terrestris L.	Bhandri	Puncturevine	Zygophyllaceae

Table-4.10: Weed density (m<sup>-2</sup>) of broad leaved weeds as influenced by weed management practices.

Treatments	BLW weed	BLW weed density (m <sup>-2</sup> )		
	45 DAS	At harvest		
Instanthanus @ 70 a citha DE	3.29	3.13		
Imazethapyr @ 70g a.i/ha PE	(10.00)	(9.00)		
Imazathanya @ 20g a i /ha DE	3.62	3.40		
Imazethapyr @ 80g a.i./ha PE	(12.33)	(11.00)		
Imazethapyr @ 70g a.i./ha at 3-4 leaf stage	3.58	3.26		
mazemapyi @ 70g a.i./na at 3-4 lear stage	(12.00)	(9.67)		
Imazathanyr @ 80g a i /ha at 2 / laaf staga	2.88	2.70		
Imazethapyr @ 80g a.i./ha at 3-4 leaf stage	(7.33)	(6.33)		
Imazathanyr - Imazamov PM @ 70g a i /ha DE	2.93	2.74		
Imazethapyr + Imazamox RM @ 70g a.i./ha PE	(7.67)	(6.67)		
Imagathanya Limagamay DM @ 80g a i /ha DE	3.04	2.88		
Imazethapyr + imazamox RM @ 80g a.i./ha PE	(8.33)	(7.33)		
Imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf	2.56	2.41		
stage	(5.67)	(5.00)		
Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf	2.41	2.35		
stage	(5.00)	(4.67)		
Deading delin @ 1000	3.09	2.99		
Pendimethalin @ 1000g	(8.67)	(8.00)		
Insert the grown to good diseasthed in DM @ 1000 c DE	2.49	2.41		
Imazethapyr + pendimethalin RM @ 1000g PE	(5.33)	(5.00)		
Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC	2.81	2.68		
1000ml POE	(7.00)	(6.33)		
Hand Wooding twice 15 and 20 DAS	2.068	2.271		
Hand Weeding twice 15 and 30 DAS	(3.33)	(4.67)		
	3.71	3.58		
Weedy check (control)	(13.00)	(12.00)		
	1.00	1.00		
Weed free up to 45 DAS	(0.00)	(0.00)		
SEm±	0.23	0.27		
CD (P=0.5)	0.67	0.80		

Table-4.11: Weed density  $(m^{-2})$  of grassy weeds as influenced by weed management practices.

Treatments	Grassy weed density (m	
	45 DAS	At harvest
Imagethanya @ 70g a i/ha DE	2.00	1.91
Imazethapyr @ 70g a.i/ha PE	(3.00)	(2.67)
Imagathanya @ 80g a i /ha DE	1.91	1.82
Imazethapyr @ 80g a.i./ha PE	(2.67)	(2.33)
Imazethapyr @ 70g a.i./ha at 3-4 leaf stage	1.75	1.62
mazethapyi @ /og a.i./na at 5-4 lear stage	(2.33)	(2.00)
Imagethanyr @ 20g a i /ha at 3 4 loof stage	2.21	2.21
Imazethapyr @ 80g a.i./ha at 3-4 leaf stage	(4.00)	(4.00)
Imazethapyr + Imazamox RM @ 70g a.i./ha PE	1.88	1.74
miazemapyi + miazamox Kivi @ 70g a.i./na FE	(2.67)	(2.33)
Imagethory Limogemey DM @ 20g of the DE	2.29	2.22
Imazethapyr + imazamox RM @ 80g a.i./ha PE	(4.33)	(4.00)
Imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf	2.15	1.95
stage	(3.67)	(3.00)
Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf	1.98	1.79
stage	(3.00)	(2.33)
Pendimethalin @ 1000g	2.22	2.13
Tendimeniami @ 1000g	(4.0)	(3.67)
Imazethapyr + pendimethalin RM @ 1000g PE	1.90	1.79
miazethapyr + pendimethami Kivi @ 1000g FE	(2.67)	(2.33)
Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC	1.90	1.91
1000ml POE	(2.67)	(2.67)
Hand Wanding twice 15 and 20 DAS	2.41	2.33
Hand Weeding twice 15 and 30 DAS	(5.00)	(4.67)
Weedy check (control)	3.37	3.23
weedy check (control)	(10.67)	(9.67)
Weed free up to 45 DAS	1.00	1.00
weed free up to 45 DAS	(0.00)	(0.00)
SEm±	0.21	0.25
CD (P=0.5)	0.62	0.73

Table-4.12: Weed density (m<sup>-2</sup>) of sedges weeds as influenced by weed management practices

Treatments	ents Sedge weed density (m <sup>-2</sup> )	
	45 DAS	At harvest
Imagethanur @ 70g a i/ha DE	4.99	4.93
Imazethapyr @ 70g a.i/ha PE	(24.00)	(23.33)
Imazethapyr @ 80g a.i./ha PE	4.66	4.56
imazemapyi @ oog a.i./na FE	(21.00)	(20.00)
Imazethapyr @ 70g a.i./ha at 3-4 leaf stage	4.78	4.66
imazemapyi @ 70g a.i./na at 3-4 leaf stage	(22.00)	(21.00)
Imazethapyr @ 80g a.i./ha at 3-4 leaf stage	4.82	4.71
imazemapyi @ 80g a.i./iia at 3-4 lear stage	(22.33)	(21.33)
Imagethanyr - Imagemov PM @ 70g e i /he PE	5.87	5.79
Imazethapyr + Imazamox RM @ 70g a.i./ha PE	(33.67)	(32.67)
Imazethapyr + imazamox RM @ 80g a.i./ha PE	5.72	5.60
imazemapyi + imazamox Kwi @ 80g a.i./ila FE	(32.00)	(30.67)
Imagethanyr i imagemov PM @ 70g a i /ha 2 4 Loof stage	4.66	4.46
Imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage	(21.00)	(19.33)
Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage	4.63	4.45
imazemapyi + imazamox Rivi @ 80g a.i./iia 3-4 Leai stage	(20.67)	(19.33)
Pendimethalin @ 1000g	5.80	5.67
Tendimenianii @ 1000g	(32.67)	(31.33)
Imazethapyr + pendimethalin RM @ 1000g PE	5.10	4.96
mazemapyr + pendimemanii Kivi @ 1000g i E	(25.33)	(24.00)
Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC	4.82	4.41
1000ml POE	(22.33)	(18.67)
Hand Weeding twice 15 and 30 DAS	4.07	3.68
Trand weeding twice 13 and 30 DAS	(16.00)	(13.33)
Weedy check ( control)	7.68	7.68
weedy check (control)	(58.67)	(58.33)
Weed free up to 45 DAS	1.00	1.00
weed free up to 45 DAS	(0.00)	(0.00)
SEm±	0.30	0.36
CD (P=0.5)	0.89	1.05
	I	[

Table-4.13: Total weed density (m<sup>-2</sup>) of weeds as influenced by weed management practices at different stages of crop growth.

Treatments	Total weed density (m <sup>-2</sup> )	
	45 DAS	At harvest
L.,	6.15	5.99
Imazethapyr @ 70g a.i/ha PE	(37.00)	(35.00)
Importhance @ 200 at the DE	6.04	5.84
Imazethapyr @ 80g a.i./ha PE	(35.67)	(33.33)
1 1 0 70 11 12 11 1	6.09	5.77
Imazethapyr @ 70g a.i./ha at 3-4 leaf stage	(36.33)	(32.67)
Imagethorym @ 90g a i /ha at 2 4 lasf stage	5.88	5.71
Imazethapyr @ 80g a.i./ha at 3-4 leaf stage	(33.67)	(31.67)
Imagethory J. Imagemey P.M. @ 70g a idea DE	6.69	6.50
Imazethapyr + Imazamox RM @ 70g a.i./ha PE	(44.00)	(41.67)
Importhermal importance DM @ 90g at the DE	6.74	6.53
Imazethapyr + imazamox RM @ 80g a.i./ha PE	(44.67)	(42.00)
Imazethapyr + imazamox RM @ 70g a.i./ha 3-4	5.56	5.24
Leaf stage	(30.33)	(27.33)
Imazethapyr + imazamox RM @ 80g a.i./ha 3-4	5.43	5.16
Leaf stage	(29.00)	(26.00)
Destinated at 6 1000	6.80	6.62
Pendimethalin @ 1000g	(45.33)	(43.00)
Insert the ground and diseasthed in DM @ 1000s DE	5.56	5.18
Imazethapyr + pendimethalin RM @ 1000g PE	(30.00)	(26.67)
Sodium aciflurfen 16.5%+ clodinafop proparygyl	6.01	5.76
8EC 1000ml POE	(35.33)	(32.67)
Hand Wasding twice 15 and 20 DAC	5.15	4.79
Hand Weeding twice 15 and 30 DAS	(26.00)	(22.67)
Was decided ( as more)	9.15	8.99
Weedy check (control)	(83.00)	(80.00)
Wood from up to 15 DAG	1.00	1.00
Weed free up to 45 DAS	(0.00)	(0.00)
SEm±	0.32	0.40
CD (P=0.5)	0.92	1.18

Table-4.14: Weed dry weight of weeds as influenced by weed management practices at different stages of crop growth.

	Weed dry weight (g/m <sup>-2</sup> )		
Treatment	45 DAS	At harvest	
Imazethapyr @ 70g a.i/ha PE	5.14 (25.54)	5.31 (27.50)	
Imazethapyr @ 80g a.i./ha PE	4.96 (23.66)	5.16 (25.67)	
Imazethapyr @ 70g a.i./ha at 3-4 leaf stage	4.63 (20.74)	4.84 (22.67)	
Imazethapyr @ 80g a.i./ha at 3-4 leaf stage	4.62 (20.38)	4.83 (22.33)	
Imazethapyr + Imazamox RM @ 70g a.i./ha PE	5.59 (30.36)	5.71 (31.67)	
Imazethapyr + imazamox RM @ 80g a.i./ha PE	5.88 (33.90)	6.04 (35.83)	
Imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage	4.19 (17.33)	4.51 (19.33)	
Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage	4.11 (16.00)	4.42 (18.66)	
Pendimethalin @ 1000g	6.06 (35.74)	6.22 (37.67)	
Imazethapyr + pendimethalin RM @ 1000g PE	4.43 (19.32)	4.65 (21.33)	
Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE	4.59 (20.07)	4.80 (22.00)	
Hand Weeding twice 15 and 30 DAS	4.22 (17.35)	4.44 (19.33)	
Weedy check (control)	8.66 (74.09)	8.77 (76.00)	
Weed free up to 45 DAS	1.00 (0.00)	1.00 (0.00)	
SEm±	0.31	0.31	
CD (P=0.5)	0.91	0.90	

Table-4.15: Weed control efficiency (%) at different stages of crop growth as influenced by weed management practices

Treatments	WO	WCE %		
	45DAS	At harvest		
Imazethapyr @ 70g a.i/ha PE	65.57	63.53		
Imazethapyr @ 80g a.i./ha PE	68.07	66.19		
Imazethapyr @ 70g a.i./ha at 3-4 leaf stage	71.81	69.97		
Imazethapyr @ 80g a.i./ha at 3-4 leaf stage	72.41	70.53		
Imazethapyr + Imazamox RM @ 70g a.i./ha PE	58.99	58.27		
Imazethapyr + imazamox RM @ 80g a.i./ha PE	54.48	53.10		
Imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage	76.60	74.57		
Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage	78.31	75.31		
Pendimethalin @ 1000g	51.66	50.35		
Imazethapyr + pendimethalin RM @ 1000g PE	74.18	72.19		
Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml				
POE	72.92	71.02		
Hand Weeding twice 15 and 30 DAS	76.30	74.28		
Weedy check ( control)	0.00	0.00		
Weed free up to 45 DAS	100.00	100.00		
SEm±	3.82	3.93		
CD (P=0.5)	11.17	11.47		

Table-4.16: Weed index as influenced by weed management practices.

Treatments	Weed index (percentage)
T <sub>1</sub> -Imazethapyr @ 70g a.i/ha PE	20.80
T <sub>2</sub> -Imazethapyr @ 80g a.i./ha PE	20.43
T <sub>3</sub> -Imazethapyr @ 70g a.i./ha at 3-4 leaf stage	23.39
T <sub>4</sub> -Imazethapyr @ 80g a.i./ha at 3-4 leaf stage	22.93
T <sub>5</sub> -Imazethapyr + Imazamox RM @ 70g a.i./ha PE	18.55
T <sub>6</sub> -Imazethapyr + imazamox RM @ 80g a.i./ha PE	16.74
T <sub>7</sub> – Imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage	8.54
T <sub>8</sub> - Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage	10.48
T <sub>9</sub> -pendimethalin @ 1000g	31.02
T <sub>10</sub> - Imazethapyr + pendimethalin RM @ 1000g	25.35
T <sub>11</sub> – Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml	10.24
T <sub>12</sub> – Hand Weeding twice 15 and 30 DAS	0.32
T <sub>13</sub> - Weedy check	61.29
T <sub>14</sub> - Weed free up to 45 DAS	0.00
SEm±	0.24
CD (P=0.5)	0.70

Table No: 4.17. Relative economics of black gram as influenced by weed management practices

Treatment	Total cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net Return (Rs./ha)	B:C ratio
Imazethapyr @ 70g a.i/ha PE	22734	62317	39583	1.74
Imazethapyr @ 80g a.i./ha PE	22924	62999	40075	1.75
Imazethapyr @ 70g a.i./ha at 3-4 leaf stage	22734	60930	38196	1.68
Imazethapyr @ 80g a.i./ha at 3-4 leaf stage	22924	61332	38408	1.68
Imazethapyr + Imazamox RM @ 70g a.i./ha PE	23317	64170	40853	1.75
Imazethapyr + imazamox RM @ 80g a.i./ha PE	23594	65724	42130	1.79
Imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage	23317	71298	47981	2.06
Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage	23594	70090	46496	1.97
Pendimethalin @ 1000g	22904	55292	32388	1.41
Imazethapyr + pendimethalin RM @ 1000g PE	23204	59265	36061	1.55
Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE	23466	70201	46735	1.99
Hand Weeding twice 15 and 30 DAS	29080	77572	48492	1.67
Weedy check (control)	21000	31840	10840	0.52
Weed free	31100	78040	46940	1.51

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## **Discussion**

The results of the field experiment entitled "Studies on herbicidal weed management in black gram [Vigna mungo (L.) Hepper]" conducted in Research block of College of Agriculture, Banda University of Agriculture and Technology, Banda are discussed under the following headings.

- 5.1 Effect of weather conditions on crops and weeds
- 5.2 Effect of weed management practices on crop growth
- 5.3 Effect of weed management practices yield attributes and yield
- 5.4 Effect of weed management practices on weed studies
- 5.4 Effect of weed management practices on economics

#### 5.1 Effect of weather conditions on crops and weeds

Kharif pulses like black gram requires moderate rainfall for proper growth and development, however long dry spell and heavy rainfall may affect growth and development and finally yield. Similarly, temperature is also play very important role to exploit the potential yield of any *kharif* pulses like black gram. Higher range of temperature during initial and grain formation may adversely affect the growth and yield of crop. Similarly, humidity play a vital role in growth of any crop, however moderate to high humidity favours of good growth development but during grain filling stage, high humidity may affects the yield of black gram due to disease incidences and flower dropping in black gram.

In present study, monsoon commences in the month of end of June and retreats by the early of September. The mean annual precipitation of this region is 865 mm (Av. of last 32 years). The observations of the meteorological parameters for the year 2019 are presented in Table 3.1 The rainfall received during crop season was 755.08 mm. Due to moderate to good distribution of rainfall crop performed very well except some dry spell in initial stage and heavy rainfall in grain filling period. No serious diseases were noticed in crop but insects affected the floral buds. Due to different types of weed flora and more flushes affect the distribution of different weed species in different treatments. However, weed dynamics

depending upon the seed bank available in surface soil which capable to germinate in favourable conditions. The losses in crop yield may be higher when weather condition was not good due to higher crop weed competitions, poor efficacy of pre emergence herbicide and poor performance of hand weeding. Also crop damaged with the lodging of weeds and crops. Therefore, post emergence selective herbicides may be good option to control weeds and found better performance of two ready mixed herbicides used as post emergence in lower as well as higher dose.

#### 5.2 Effect of weed management properties on crop growth and yield

Plant height differed significantly with various weed control treatments. Higher plant height was recorded in weed free plots i.e. 40.2, 68.4 and 72.0 cm at 30, 60 days and at maturity, respectively. In weed free conditions, since no weeds were allowed to grow throughout the crop growth period which enabled zero crop-weed competition for resources throughout the crop growth period. Hand weeding at 15 and 30 days after sowing also equally effective to weed free in relation to plant height at all stages of crop growth. Weedy check recorded the lower plant height (33.0, 55.3 and 62.3 cm at 30, 60 days and at maturity. The main reason was due to the presence of more number of sedges weeds, broad leaved and grassy and associated with the crop which exhibited severe competition throughout the crop growth. Weed competition has the effect of progressively decreasing the plant height in black gram by 17.7 %, 19.1 % and 13.6 percent at respective stages. The main reason attributed to this was increased competition for nutrients, light and space between the crop and weeds especially in the initial stages. Severity of nut sedges competes with the crops for nutrient absorption and also affects root growth in rhizosphere.

The crop weed competition varied with various treatments, based on intensity of weeds. The higher weed competition was noticed in the treatment of weedy check. However all herbicidal treatments recorded significantly higher plant height over weedy check at all stages of crop growth. Among the herbicidal treatments the maximum plant height of 67.4 and 70.0cm was recorded with application of imazethapyr + pendimethalin RM @ 1000 at 60days and at maturity respectively. This might be due to the application of higher dose caused some phytotoxic effect on plants; however it recovered gradually with time.

Number of branches per plant influenced significantly with the adoption of weed management practices and found that weed free condition and used twice hand weeding recorded significantly higher number of branches as compared to imazethpyr @ 70g ai and

80 g ai/ha as pre emergence as well as post emergence. It might be due to less effectiveness of herbicide at pre emergence and post emergence of single herbicide of imazethpyr @ 70g a.i./ha and 80 g ai/ha. The combination of imazethpyr and imazamox RM 70g a.i./ha applied as pre emergence and as well as post emergence recorded significantly higher numbers of branches over weedy check and single application of imazethpyr @ 70g ai and 80 g ai/ha as pre emergence in black gram. While, higher dose of imazethpyr and imazamox RM 80 g a.i./ha applied as post-emergence recorded comparatively less values of branches/plant 4.63 and 4.7 at 60 days and at maturity, respectively compared to lower dose of imazethpyr and imazamox RM 80g ai applied as post-emergence. However, application of pendimethalin as pre emergence recorded lower values of branches plant (4.4 at 60 DAS and 4.60 at maturity), it might be due to less effectiveness against sedges and late germinated weeds. Similar finding was observed by of **Yadav** *et al.* (2015)

Number of leaves/plant varied significantly at 60 day stage and at maturity, while it had non- significant difference at 30 day stage. All weed control options recorded significantly higher number of leaves over weedy check. However, maximum number of leaves was recorded with weed free condition followed by hand weeding at 15 and 30 days stage. It might be due to higher weed control efficiency in all weed control measures caused better utilization of natural resources. It might be due better weed control in these treatments low pressure of weed and less weed crop compitions for natural resources. These results are conformity with the findings of **Yadav** *et al.* (2015)

The dry matter production per plant differed significantly with different treatments (Fig.4.6).At all the stages of crop growth, weedy check recorded significantly lower crop dry matter accumulation (10.10, 18.40 and 27.50 g plant<sup>-1</sup>). This might be attributed to severe competition of weeds with crop for growth factors which restricted the development of the crop. While, highest dry matter production per plant at different growth stages was observed in weed free plot (13.90, 29.87 and 55.50 g plant<sup>-1</sup>) as no weeds were allowed to grow throughout the crop growth period. As a result, the crop exhibited luxuriant growth and produced more number of branches and reproductive parts like flowers, green pods which in turn produced more dry matter accumulation per plant. Vivek *et al.* (2003) was of the opinion that weed free maintenance for initial 60 days of crop growth resulted in significant reduction in the dry matter accumulation of total weeds which in other words, means that this favoured

for higher dry accumulation in the crop. Among the herbicidal treatments the higher total dry matter production was recorded with post-emergence application imazethapyr + Imazamox @ 70 g a.i. ha<sup>-1</sup> at 30. 60 and at harvest, which was statistically at par with higher dose imazethapyr + Imazamox @ 80 g. a.i. ha<sup>-1</sup>. This might be due to higher dose of these herbicide suppressed the growth of plant. Higher dry matter accumulation per plant was observed in these treatments due to effective control of weeds after imposing the treatments at the early stages of crop growth. As a result, the crop had put forth luxuriant growth and produced more number of branches, and reproductive parts like flowers, pods which in turn produced more dry matter accumulation per plant. Pre emergence application of pendimethalin alone and with imazethapyr produced less dry matter as compared to other heribicides. This may be attributed due to less control of weed in this treatment. The herbicidal effect gradually decreases with time in case of pendimethalin which finally resulted in less control of weeds which germinate at different intervals with onset of rain. Similar results was reported by **Upadhyay** *et al.* (2012).

#### 5.3. Effect of weed management practices yield attributes and yield

The various yield components were significantly influenced by different weed control treatments. Weed free plot recorded maximum number of pods plant<sup>-1</sup> (40.6), higher pod length (4.2) and higher number of seed /pod (6.3), and hundred seed weight (5.68 g). The higher yield components in weed free plot was mainly due to the complete elimination of weeds throughout the crop growth, which enabled the better plant growth along with more branches and leaf area index, which resulted in higher yield attributing parameters. Whereas these yield components were adversely affected in weedy check. This is due to heavy weed infestation and more crop-weed competition. Among the herbicidal treatments, post-emergence application imazethapyr + imazamox @70 g a.i. ha<sup>-1</sup> the higher yield attributes were obtained in T<sub>7</sub> may be due to higher weed control efficiency and less phytotoxicity. Similar results was reported by **Sasode** *et al.* (2018).

Seed yield differed significantly owing to different weed control treatments (Fig.4.8.). Significantly higher seed yield was recorded in weed free plot (12.4 q ha<sup>-1</sup>). The higher yield in weed free plot was mainly due to the complete elimination of weeds throughout the crop growth which enabled minimum competition and causing better plant growth along with branches and yield attributes. Among the herbicidal treatments post-emergence application imazethapyr + imazamox @70 g a.i. ha<sup>-1</sup> recorded higher seed yield and was on par with

post-emergence application imazethapyr + imazamox @80 g a.i. ha<sup>-1</sup>. Further, the higher yields in these treatments could be attributed to higher dry matter accumulation per plant, plant height, higher DMA, and higher weed control efficiency and minimized crop-weed competition during crop growth.

Thus crop plants might have used available resources effectively throughout the crop growth stages resulting in higher seed yield. These results are in close conformation with the findings of **Padmaja** *et al.* (2013) who reported that application of imazethapyr recorded higher yield attributes and yield which was due to lower weed density and weed dry weight. Application of herbicides controlled the weeds effectively and made available nutrients to crop and consequently resulted in higher yield (**Channappagoudar and Biradar 2007** and **Vyas** *et al.* 2003). While, weedy check recorded lower yield due to heavy weed infestation and more crop weed competition throughout the crop growth resulting in low nutrient uptake by crop, while weeds removed more quantity of nutrients throughout the crop growth period. This shows that the reduction in yield was apparently due to reduction in growth and yield components caused by weed infestation.

Straw yield also differed significantly due to different weed management practices (Fig.4.8.). Significantly higher straw yield was recorded in weed free plot (36.8 q ha<sup>-1</sup>). The increased straw yield in weed free treatment was mainly due to complete elimination of weeds throughout the crop growth which enabled better crop growth with more numbers branches plant<sup>-1</sup>, resulting in higher stem dry matter accumulation, which ultimately led to higher straw yield. Among the herbicidal treatments, maximum straw yield of black gram recorded with application of imazethapyr + Imazamox @ 80 g a.i. ha<sup>-1</sup> as pre emergence (34.5q ha<sup>-1</sup>), which was at par with post-emergence application of imazethapyr + imazamox @80 g a.i. ha<sup>-1</sup> (34.1 q ha<sup>-1</sup>) and imazethapyr @ 80 g a.i. ha<sup>-1</sup> as pre emergence 34.3q ha<sup>-1</sup>) and significantly higher than rest of treatments. The increased straw yield in these treatments could be attributed to better plant growth, as evidenced by increased numbers of leaves and branches which made the plants to utilize the resources more efficiently resulting in higher dry matter production of the crop. The lower straw yield was recorded in weedy check (22.4) q ha<sup>-1</sup>). The lower straw yield in this treatment was mainly because of severe infestation of weeds, which were competing for the available resources. Singh and Sekhon (2013) also reported that reduction in grain yield in different years due to weeds in pigeon pea to the tune of 31-52.8 % at Ludhiana.

Harvest index is indication of diversion of phosynthates into economic yield. The harvest index was significantly affected by different weed management practices, maximum harvest index was recorded with hand weeding twice at 15 and 30 days stage which was at par with post-emergence application imazethapyr + imazamox @70 g a.i. ha<sup>-1</sup> as pre emergence. Minimum value of harvest index (17.6 %) was recorded with weedy conditions.

#### 5.4 Effect of weed management practices on weed studies

Weed population (grasses, broad leaved, sedges and total) at different stages of crop growth (*viz*; 45 and at harvest) differed significantly among the various weed management practices.

A total 14 weed species found in experimental field research block, the relative percentage of sedges was 72.9%, grassy 12.1 and broad leaved weeds 15% in weedy conditions.

Weed density declined from 50 DAS to maturity stage due to compactions among weed species. Among the herbicidal treatments, all applied herbicide had remarkable impact caused reduction in weed population due to effective control of weeds at early stage of crop growth and also due to its residual impact in soil. Reddy *et al.* (2008) and Ram *et al.* (2012) also reported the prominent effect of imazethapyr in many kharif pulses. Imazethapyr alone and with imazamox effectively controls the germinated weeds either by direct killing or suppression.

Generally, at all the stages (45 DAS and at maturity) the higher grassy weed population (10.6 to 9.6 per m<sup>2</sup>) was observed in weedy check due to unchecked weed growth throughout the crop growth period (Fig.4.11.). **Dhonde** *et al.* (2009) also reported the maximum weed in weedy check plot at each growth stages in pigeonpea. The mode of action of imazethapyr inhibit ALS or AHAS enzymes responsible for the synthesis of three branches chain amino acids such as leusine, isoleusine and valine.

The lowest weed population of BLW was drastically reduced afterimposed any herbicide under investigation. This might be due to its broad spectrum control. These treatment of imazethapyr either alone and combined with imazamox resulted in more reduction of weed in comparison with pre-emergence application of pendimethalin. Pendimethalin application control the weed for inhibited germination and uptake by growing shoots. The residual effect of pendimethalin does not remain in soil for long time. *Digera* 

*arvensis* is a major broad leaved weed and some large seed weeds cannot control due to depth protection in soil, which is usually not controlled by pre-emergence application of pendimethalin.

Similarly, pre emergence herbicide also ineffective against sedges, the population of sedges weeds differed significantly due to different weed management practices. Imazethapyr containing treatments effectively control the population of sedges either ides as pre emergence and used as post emergence. This might be due to its persistence and long half life period. Total weed population also control effectively with application of combined application imazethapyr and imazamox as compared to another herbicidal treatment. All the weed control treatments resulted in significant reduction in weed population as compared to weedy check at different growth stages. The maximum weed control efficiency (78.31 %) and (75.31 %) was noticed in imazethapyr+ Imazamox @ 80 g a.i. ha<sup>-1</sup> applied as post emergence (T<sub>8</sub>) at 45 and at maturity, respectively; as this treatment recoded lowest weed population and weed dry weight. Similar findings was reported by **Upadhyay** *et al.* (2012)

The weed competition index results indicated that reduction in yield due to weed infestation, all the treatments recorded lower values of weed index when comparison to weedy check. Uncontrolled weeds reduced the yield of blackgram by 61.2 per cent. However the lowest weed index values was recorded with post emergence herbicidal treatments either alone or combined form. The least effective herbicide of weed control was pre emergence application of pendimetalin which obtained 31.2 per cent yield reduction due to poor efficacy for weed control in blackgram under investigation. Application of sodium aceflurfen 16.5% + clodinofop proparygyl 18 EC @100 g/ha performed excellent methods of weed control and obtained minimum value of weed index (10.24%) after imazethapyr + imazamox RM @ 70 g ai /ha applied (8.54 %). This is due eliminations of all types of weeds with these treatments, However, hand weeding twice at 15 and 30 days stages also eliminated all types of weeds and recorded very less value of yield reduction (0.32%). Similar results was also obtained by **Komal et. al., (2015)** 

#### 5.4 Effect of weed management practices on economics

Cost of cultivation, grain yield and benefit ratio were varied due to different weed management practices. However, in weed free plot the cost of cultivation was maximum and minimum in weedy check. Higher gross return (Rs. 78040 ha<sup>-1</sup>) was recorded with weed free plot. While among the different herbicidal treatments, maximum gross return was recorded

with imazethapyr + imazamox RM @ 70 g ai /ha (Rs.71298 ha<sup>-1</sup>) followed by sodium aceflurfen 16.5% + clodinofop proparygyl 18 EC @100 g/ha (Rs 70201 ha<sup>-1</sup>) and imazethapyr+ imazamox @ 80 g a.i. ha<sup>-1</sup> (Rs. 70090 ha<sup>-1</sup>). The higher gross returns were mainly attributed by higher seed yield obtained due to higher weed control efficiency. The lower gross returns (Rs.31840 ha<sup>-1</sup>) was recorded with weedy check, which was mainly owing to less seed yield (4.8 g ha<sup>-1</sup>) obtained due to uncontrolled weeds throughout the crop duration. Significantly higher net returns (Rs.47981 and Rs.46735 ha<sup>-1</sup>) with higher benefit cost ratio (2.06 and 1.99) were recorded with imazethapyr + imazamox RM @ 70 g ai /ha and sodium aceflurfen 16.5% + clodinofop proparygyl 18 EC @100 g/ha, respectively (Fig.-5.11). This was mainly due to higher gross returns along with lesser cost of cultivation, particularly less weed management cost. Significantly lower net returns were recorded with weedy check, however application of imazethapyr alone as pre emergence performed better as compared to post emergence in relation to benefit cost ratio. The higher values of gross return and BC ratio is due to higher grain and straw yield than weedy check. Hand weeding and weed free condition was not economical due higher cost involved in cost of production and resulted lower comparatively low value of B: C ratio. However hand weeding at 15 and 30 day obtained maximum gross return (Rs 48492). This was mainly due to higher seed and straw yield but due to higher cost of production it is less economical in comparison imazethapyr + imazamox RM @ 70 g ai /ha and sodium aceflurfen 16.5% + clodinofop proparygyl 18 EC @100 g/ha. Padmaja et al. (2013) observed similar results with least net return and B: C ratio under weedy check.

Relative population of grassy, broad leaved and sedges in weedy conditions

Weeds	45 DAS	At Harvest	Relative percentage
Grassy	10.67	9.67	
			12.1
BLW	13.0	12.1	
			15.0
Sedges	58.6	58.3	
			72.9
Total	82.2	79.9	



## **Summary and Conclusion**

A field experiment entitled "Studies on herbicidal weed management in black gram [Vigna mungo (L.) Hepper]" conducted during kharif 2019 at research block, Banda University of Agriculture and Technology, Banda (UP) are being presented in this chapter to find out the cost-effective herbicide for controlling weeds and to fine tune the dose of herbicide with the impact of weed management practices on growth and yield of black gram.

The experiment was laid out in Randomized Complete Block Design with three replications. The weed control treatments were: T1-imazethapyr @ 70g a.i/ha PE,T2-imazethapyr @ 80g a.i./ha PE ,T3-imazethapyr @ 70g a.i./ha at 3-4 leaf stage,T4-imazethapyr @ 80g a.i./ha at 3-4 leaf stage, T5-imazethapyr + imazamox RM @ 70g a.i./ha PE,T6-imazethapyr + imazamox RM @ 80g a.i./ha PE,T7-imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage,T9- Pendimethalin @ 1000g,T10- Imazethapyr + pendimethalin RM @ 1000g PE,T11-Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE, T12- Hand Weeding twice 15 and 30 DAS, T13-Weedy check (control), T14- Weed free.

The salient features of the results are summarized in this chapter.

- 1. The maximum plant height was recorded under weed free conditions followed by hand weeding twice 15 & 30 DAS at all growth stages. Among the herbicidal treatment the maximum plant height was recorded with T<sub>10</sub> (Imazethapyr + pendimethalin RM @ 1000g PE) which remains at par with T<sub>1</sub> (Imazethapyr @ 70g a.i/ha PE), T<sub>11</sub> (Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE) and T2 (Imazethapyr @ 80g a.i./ha PE),T<sub>3</sub> (Imazethapyr + Imazamox RM @ 70g a.i./ha PE) and found significantly superior over T8 (Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage), T<sub>6</sub> (Imazethapyr + imazamox RM @ 80g a.i./ha PE) and weedy check treatment at 60 DAS.
- 2. The maximum number of branches/plant was found in weed free conditions followed by (hand weeding twice at 15 & 30 DAS at 60 DAS and at harvest. Among the herbicidal treatment the maximum number of branches per plant (5.1) was found in imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage which remains at par with

- imazethapyr + pendimethalin RM @ 1000g PE, imazethapyr @ 80g a.i./ha PE, imazethapyr @ 80g a.i./ha at 3-4 leaf stage and significantly superior over imazethapyr @ 70g a.i/ha PE, pendimethalin @ 1000g and sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE .However, the minimum 3.83 no of braches per plant was found in weedy check treatment.
- 3. Weed free conditions followed by hand weeding twice recorded maximum no of leaves per plant at 30 DAS, 60 DAS and harvest. Among the herbicidal treatments the maximum no of leaves per plant was found in imazethapyr + pendimethalin RM @ 1000g PE which remains at par with imazethapyr + imazamox RM @ 70g a.i./ha PE, imazethapyr @ 80g a.i./ha PE, sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE and rest of the treatment at 60 DAS. Lowest no of leaves per plant was recorded in imazethapyr @ 70g a.i/ha PE at 60DAS. At harvest stage, among the herbicidal treatment the maximum no of leaves per plant was observed in imazethapyr + imazamox RM @ 70g a.i./ha PE which remains at par with imazethapyr + pendimethalin RM @ 1000g PE, sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE and rest of the treatments. However the minimum no of leaves was observed in weedy check treatment.
- 4. The maximum root length and number of nodules was recorded in weed free treatment followed by hand weeding twice 15 & 30 DAS. Among the herbicidal treatment maximum root length and number of nodules (14.2 and 33.0) were recorded with imazethapyr + pendimethalin RM @ 1000g PE and lowest root length was recorded with imazethapyr + imazamox used as pre emergence. However the minimum root length was recorded in weedy check treatment.
- 5. Among the all treatments the maximum (3.79) value of leaf area index was recorded under weed free treatment fallowed by hand weeding twice 15 & 30 DAS. Among the herbicidal treatments the maximum 3.40 value of leaf area index was recorded in imazethapyr + pendimethalin RM @ 1000g PE which remains at par with imazethapyr @ 80g a.i./ha PE, imazethapyr @ 70g a.i./ha at 3-4 leaf stage and found significantly superior over imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage, imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage and pendimethalin @ 1000g.
- 6. The highest plant population of black gram was recorded with weed free treatment followed by hand weeding twice 15 & 30 DAS. Among the herbicidal treatments the maximum plant population per m<sup>2</sup> was observed in imazethapyr @ 80g a.i./ha PE

- which remains at par with pendimethalin @ 1000g and imazethapyr + imazamox RM @ 80g a.i./ha PE. However the minimum plant population per m<sup>2</sup> was recorded in weedy check.
- 7. Among the various weed control practices adopted in investigation, the maximum value of dry matter accumulation per plant (13.1 g/plant) was recorded in imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage which remains at par with imazethapyr + imazamox RM @ 80g a.i./ha PE, imazethapyr + imazamox RM @ 70g a.i./ha PE, imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage and found significantly superior over rest of the treatments. At 60 DAS, significantly higher dry matter accumulation per plant was also recorded in imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage (27.03) than imazethapyr + pendimethalin RM @ 1000g PE(20.40), sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE(20.17) and imazethapyr @ 80g a.i./ha at 3-4 leaf stage(21.20), while it was statistically at par with T<sub>8</sub>- imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage(26.97), imazethapyr @ 70g a.i/ha PE (26.17) and imazethapyr + imazamox RM @ 70g a.i./ha PE (T<sub>5</sub>) 25.37 treatments. At harvest maximum dry matter accumulation was observed in imazethapyr + imazamox RM @ 70g a.i/ha 3-4 leaf stage (48.50) which was significantly superior over all the herbicidal treatments except T8 and T11.
- 8. The number of pods plant<sup>-1</sup> pod length grains/pod and 100 seed weight were differed significantly among different treatments. Among the treatments the maximum values of yield attributing characters was recorded in weed free treatments followed by hand weeding twice 15 &30 DAS. However among the herbicidal treatments the maximum values of yield attributes were observed in imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage Which was statistically at par with imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage and sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE and found significantly superior over rest of the treatments including weedy check.
- 9. Seed yield of black gram influenced significantly by adoption of different weed management practices. Among the all treatments, weed free conditions was recorded significantly higher seed yield to the tune of 12.4 q/ha followed by hand weeding twice 15 & 30 DAS. Among the herbicidal treatment, application of imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage was recorded highest seed yield to the tune of 11.34 q/ha which was significantly superior over rest of the treatments.

- Whereas the lowest seed yield was recorded  $T_{13}$  (weedy check) with corresponding value of 4.8 q/ha.
- 10. The maximum straw yield of 36.80 q/ha was obtained with weed free treatment. It was followed in by hand weeding twice 15 & 30 DAS. Among the herbicidal treatment the maximum 34.50 q/ha straw yield was recorded in T<sub>6</sub> (Imazethapyr + imazamox RM @ 70g a.i./ha PE) which remains at par with T<sub>4</sub> (Imazethapyr @ 80g a.i./ha at 3-4 leaf stage) and found significantly superior over rest of the treatments.
- 11. Harvest index, the ratio of economic yield to biological yield, varied significantly under weed control measures led to better diversion of photosynthates towards seed and thereby high harvest index. The highest value of harvest index was observed in hand weeding twice 15 & 30 DAS to the corresponding value 25.7 followed by imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage to the corresponding value 25.4 which was significantly superior over rest of the treatments..
- 12. The lowest density of BLW (2.41m²) at 45 DAS was recorded with application of imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage which was statistically at par with the application of imazethapyr + pendimethalin RM @ 1000g (T10), imazethapyr + imazamox RM @ 70g a.i./ha PE (T₅), sodium aciflurfen 16.5% + clodinafop proparygyl 8 EC 1000ml(T₁₁), Imazethapyr @ 80g a.i./ha at 3-4 leaf stage(T₄), Imazethapyr + Imazamox RM @ 70g a.i./ha PE (T₅) and significantly superior over T₁ -Imazethapyr @ 70g a.i./ha PE, T₂ -Imazethapyr @ 80g a.i./ha PE, T₃ -Imazethapyr @ 70g a.i./ha at 3-4 leaf stage and pendimethalin @ 1000 g (T໑). However each and every weed control treatments significantly superior over weedy check at both the stages.
- 13. Adoption of weed control options significantly reduced the population of grassy weed at both the stages. All the treatments adopted for weed management in black gram recorded significantly reduced the density of grassy weeds at both the stages of observation in comparison to weedy check. Among the treatment the lowest population of grassy weeds at 45 DAS and at harvest were observed in application of imazethapyr @ 70g a.i./ha at 3-4 leaf stage and at harvest, which was significantly superior over hand weeding twice 15 & 30 DAS, while it remains statistically at par with the application of imazethapyr + imazamox RM @ 70g a.i./ha PE, imazethapyr + pendimethalin RM @ 1000g and the application of sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml.

- 14. Among the herbicidal treatments lowest density of sedges (4.63 m<sup>-2</sup>) were observed with the application of imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage which was significantly superior over pendimethalin @ 1000g , imazethapyr + imazamox RM @ 70g a.i./ha PE and imazethapyr + imazamox RM @ 80g a.i./ha PE, while it remains statistically at par with rest of the treatments. At harvest stage the lowest density of sedges was recorded with the application of sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml (4.41) which was significantly lowest over imazethapyr + imazamox RM @ 70g a.i./ha PE, imazethapyr + imazamox RM @ 80g a.i./ha PE and pendimethalin @ 1000g applied plots. However each treatment recorded significantly lower density of sedges than weedy check.
- 15. The density of total weed was lowest in hand weeding twice at 15 and 30 DAS at 45 DAS and at harvest. Among the herbicidal treatment lowest total weed density was observed with the application of imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage which was significantly superior over T9(pendimethalin @ 1000g), T5(Imazethapyr + Imazamox RM @ 70g a.i./ha PE) and T6 (Imazethapyr + imazamox RM @ 80 g a.i./ha PE) however it remains at par with rest of the treatments at 45 DAS and at harvest.
- 16. Weedy check plots recorded highest weed dry weight at both crop growth stages, *i.e.*, 45 DAS and at harvest. Among the herbicidal treatment the lowest weed dry weight was recorded with the application of imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage) which was significantly lower over imazethapyr + imazamox RM @ 70g a.i./ha PE), imazethapyr + imazamox RM @ 80g a.i./ha PE) and pendimethalin @ 1000g while it remains at par with rest of the treatments at 45 DAS. At harvest, lowest dry weight also recorded with imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage) which was statistically at par with imazethapyr @ 70g a.i./ha at 3-4 leaf stage, imazethapyr @ 80g a.i./ha at 3-4 leaf stage and imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage and found significantly superior over imazethapyr + imazamox RM @ 70g a.i./ha PE), imazethapyr + imazamox RM @ 80g a.i./ha PE) and pendimethalin @ 1000g used as pre emergence. However, all control measure proves their superiority over weedy check in terms of weed dry matter at both stages of crop growth.
- 17. The highest weed control efficiency was observed with imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage (78.3 and 75.3) at 45 days and at harvest respectively. It was at par with imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage, imazethpyr used as post emergence either 70 or 80 g ai /ha, imazethpyr + pendimetalin RM 1000g a.i. /ha and sodium aciflurfen 16.5% + clodinofop proparygyl 18 EC applied plots in black gram.

- 18. Uncontrolled weeds reduced the grain yield of black gram is 61.29% while adoption of two hand weeding (15 & 30 DAS) corresponding value of weed index is 0.8 %. Amongst the different herbicidal treatment the lowest value of weed index to the tune of 8.51% which was recorded with the application of imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage fallowed by treatment sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000 ml POE (10.24%), Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage (10.48%), imazethapyr + imazamox RM @ 80g a.i./ha PE (16.74%) and imazethapyr + imazamox RM @ 70g a.i./ha PE (18.55%).
- 19. The maximum cost of cultivation was involved in weed free plot (Rs. 31100 ha<sup>-1</sup>) followed by two hand weeding 15 & 30 DAS (Rs. 29080 ha<sup>-1</sup>). Weedy check recorded the minimum cost (Rs. 21000 ha<sup>-1</sup>) of cultivation. However maximum gross returns (Rs.78040 ha<sup>-1</sup>) was recorded with weed free plot and lower gross returns were obtained in weedy check (Rs. 31840 ha<sup>-1</sup>). Among the herbicidal treatments, postemergence application imazethapyr + imazamox RM @ 70g a.i./ha 3-4 leaf stage gave higher gross return (Rs. 71298 ha<sup>-1</sup>) fallowed by Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 leaf stage. (Rs.70090 ha<sup>-1</sup>).
- 20. Higher net returns (Rs. 47981 and Rs. 46735 ha<sup>-1</sup>) with higher benefit cost ratio (2.06 and1.99) were recorded with post-emergence application of imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage and sodium aciflurfen 16.5% + clodinofop 18EC 1000ml /ha POE, respectively. Minimum net return (Rs10840 ha<sup>-1</sup>) and B: C ratio 0.52 obtained from weedy check.

#### **CONCLUSION**

Based on the results of the present study it can be concluded that application of imazethapyr + imazamox @ 70 g a.i. ha<sup>-1</sup> applied at 3-4 leaf stage was observed most effective, cost effective and profitable option of weed management in black gram. However, for draw a valid conclusion it may be tested for one more year.

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# 

# **APPENDICES**

# Appendix A

Appendix I. Common cost of cultivation of Black gram Rs/ha)

	Particulars	Quantity	Rate	Amount
				(in ₹)
1.	Field preparation			
	(One ploughing by cultivator, twice disc	05	Rs 600hr	3000/-
	harrowing and one ploughing by cultivator			
	followed by planking			
2.	Seed and sowing	I	,	
	Cost of seed	20 kg	Rs 100 /kg	1600/-
	Seed treatment (Chemical & manpower)		Rs 200+202	404/-
				4004
3	Irrigation	L	<u>ı</u>	
		Nil	-	0/-
4.	Fertilizer application			
	20:50:0 :: NPK kg/ha			
	DAP	100 kg	₹ 26 /kg	2600
	Labour used for fertilizer application	1 man	₹	202
		days	202/day/labour	
5.	Plant protection measures (Chemical+	1	202 + 400	602
	manpower)	mandays		
6.	Harvesting Threshing, winnowing, cleaning	40 man	₹ 202	8080
		days	/day/labour	
7.	Drying & bagging(Cost of bag+ man days)			1000
8.	Rental value of land for crop season	For 6	₹ 4000	2000
		month	/ha/year	
			Total	18488
	Total cost			18488
	Interest on working capital @ 12.0 % per year			2218
	Miscellaneous			294
	Grand total			21000

Appendix.II. Cost of cultivation in different weed control treatments

				total	13920
T $_{14}$ - Weed free up to 45 DAS	50	mandays	202		10100
T <sub>13</sub> - Weedy check	0	0	0	0	0
T <sub>12</sub> - Hand Weeding twice 15 and 30 DAS	40	mandays	202		8080
					2466
	2	Mandays			404
T <sub>11</sub> – Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml	1000	ml	825/400ml		2062
				total	2204
@ 1000g	2	mandays			404
$T_{10}$ - Imazethapyr + pendimethalin RM	3125	ml	1800		1800
				total	1904
T <sub>9</sub> -pendimethalin @ 1000g	2	mandays	174		404
	3030	ml	247.5/500ml		1500
	2020		0.47 5/500	total	2594
oog a.i./iia 3-4 Leai stage		mandays	202	tota1	
T <sub>8</sub> - Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage	2	mandays	202		404
70g a.i./ha 3-4 Leaf stage	114.28	gm	756/40gm		2190
		-		total	2317
T <sub>7</sub> - Imazethapyr + imazamox RM @	2	mandays	202		404
	100	gm	765/40gm		1913
				total	2594
80g a.i./ha 3-4 Leaf stage	2	mandays	202		404
T <sub>6</sub> – Imazethapyr + imazamox RM @	114.28	gm	765/40gm		2190
				total	2317
70g a.i./ha PE	2	mandays	202		404
T <sub>5</sub> -Imazethapyr + Imazamox RM @	100	ml	1900Rs/lit		1913
ioni singo	100	4	10005 711	total	1924
T <sub>4</sub> -Imazethapyr @ 80g a.i./ha at 3-4 leaf stage	2	mandays	202		404
T. I	800	ml	1900Rs/lit	totai	1520
leaf stage	2	Mandays	202	total	404 1734
T <sub>3</sub> -Imazethapyr @ 70g a.i./ha at 3-4	700	ml	1900Rs/lit		1330
		•		total	1924
T <sub>2</sub> -Imazethapyr @ 80g a.i./ha PE	2	Mandays	202		404
	800	ml	1900Rs/lit	wai	1520
T <sub>1</sub> -Imazethapyr @ 70g a.i/ha PE	2	Mandays	202	total	404 1734
	700	ml	1900Rs/lit		1330
	QTY	UNIT			
Treatments	Particulars		Rate (RS./Unit)		Total cost Rs./h

Appendix. III. Treatment wise cost of cultivation (Rs/ha)

S.N.	Treatments	Fixed cost	Variable	Total cost
		(Rs/ha)	cost(Rs/ha)	(Rs/ha)
T <sub>1</sub>	Imazethapyr @ 70g a.i/ha PE	21000	1734	22734
T <sub>2</sub>	Imazethapyr @ 80g a.i./ha PE	21000	1924	22924
T <sub>3</sub>	Imazethapyr @ 70g a.i./ha at 3-4 leaf stage	21000	1734	22734
T <sub>4</sub>	Imazethapyr @ 80g a.i./ha at 3-4 leaf stage	21000	1924	22924
T <sub>5</sub>	Imazethapyr + Imazamox RM @ 70g a.i./ha PE	21000	2317	23317
T <sub>6</sub>	Imazethapyr + imazamox RM @ 80g a.i./ha PE	21000	2594	23594
T <sub>7</sub>	Imazethapyr + imazamox RM @ 70g a.i./ha 3-4 Leaf stage	21000	2317	23317
T <sub>8</sub>	T <sub>8</sub> - Imazethapyr + imazamox RM @ 80g a.i./ha 3-4 Leaf stage	21000	2594	23594
T <sub>9</sub>	Pendimethalin @ 1000g	21000	1904	22904
T <sub>10</sub>	Imazethapyr + pendimethalin RM @ 1000g PE	21000	2062	23062
T <sub>11</sub>	Sodium aciflurfen 16.5%+ clodinafop proparygyl 8EC 1000ml POE	21000	2204	23204
T <sub>12</sub>	Hand Weeding twice 15 and 30 DAS	21000	2466	23466
T <sub>13</sub>	Weedy check (control)	21000	8080	29080
T <sub>14</sub>	Weed free	21000	10100	31100

#### Appendix B

#### Appendix: I plant population Lac/ha at germination

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.017			
Treatment	13	0.003	0.000	0.829	0.62788
Error	26	0.008	0.000		
Total	41	0.028			
CV	0.797				

#### Appendix: II plant population (Lac/ha) at maturity

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.017			
Treatment	13	0.022	0.002	5.464	0.00012
Error	26	0.008	0.000		
Total	41	0.047			
CV	0.876				

#### Appendix: III Plant height (in cm) at 30 DAS

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	146.052			
Treatment	13	457.107	35.162	2.677	0.01575
Error	26	341.469	13.133		
Total	41	944.628			
CV	10.05				

#### Appendix: IV plant height 60 DAS

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	128.140			
Treatment	13	699.250	53.788	2.406	0.02746
Error	26	581.251	22.356		
Total	41	1,408.641			
CV	7.602				

#### Appendix: V Plant height (in cm) at maturity

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	11.589			

Treatment	13	462.821	35.602	3.801	0.00183
Error	26	243.517	9.366		
Total	41	717.927			
CV	4.584				

### Appendix: VI No of leaves per plant at 30 das

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	87.790			
Treatment	13	961.158	73.935	1.045	0.44254
Error	26	1,839.431	70.747		
Total	41	2,888.380			
CV	22.214				

#### Appendix: VII. No of leaves per plant at 60 das

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	105.296			
Treatment	13	2,994.956	230.381	6.581	0.00002
Error	26	910.246	35.009		
Total	41	4,010.498			
CV	9.940				

### Appendix: VIII No. of leaves per plant at maturity

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	1.296			
Treatment	13	4,284.059	329.543	3.851	0.00167
Error	26	2,224.825	85.570		
Total	41	6,510.180			
CV	16.229				

#### **Appendix: IX. Root length (cm)**

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.689			
Treatment	13	122.657	9.435	19.553	0.00000
Error	26	12.546	0.483		
Total	41	135.892			
CV	5.794				

# Appendix: X No of nodules per plant

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	3.017			
Treatment	13	464.334	35.718	7.713	0.00001
Error	26	120.400	4.631		
Total	41	587.751			
CV	6.992				

# Appendix: XI. LAI of plant at peak flowering stage

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.071			
Treatment	13	19.681	1.514	5.981	0.00006
Error	26	6.581	0.253		
Total	41	26.333			
CV	18.383				

### Appendix: XII. No of Branches/ Plant 60 DAS

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.018			
Treatment	13	11.229	0.864	5.659	0.00009
Error	26	3.969	0.153		
Total	41	15.216			
CV	8.476				

### **Appendix: XIII No of Branches/ Plant at maturity**

ource	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.602			
Treatment	13	10.423	0.802	6.587	0.00002
Error	26	3.165	0.122		
Total	41	14.190			
CV	7.265				

# **Appendix: XIV Dry matter of plant at 30 DAS**

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	3.399			
Treatment	13	68.166	5.244	6.182	0.00004
Error	26	22.054	0.848		
Total	41	93.619			
CV	7.813				

### Appendix: XV. Dry matter of plant at 60 DAS

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	2.366			
Treatment	13	461.145	35.473	13.350	0.00000
Error	26	69.087	2.657		
Total	41	532.598			
CV	6.708				

#### Appendix: XVI. Dry matter of plant at maturity

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	105.312			
Treatment	13	2,030.332	156.179	40.997	0.00000
Error	26	99.048	3.810		
Total	41	2,234.692			
CV	4.624				

### Appendix: XVII. No. of pods/plant

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.921			
Treatment	13	367.681	28.283	98.928	0.00000
Error	26	7.433	0.286		
Total	41	376.035			
CV	1.495				

#### Appendix: XIX. No. of pod length (cm)

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.012			
Treatment	13	0.231	0.018	2.262	0.03705
Error	26	0.204	0.008		
Total	41	0.448			
CV	2.157				

#### Appendix: XX. No. of seeds/pod

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.006			
Treatment	13	1.874	0.144	16.180	0.00000
Error	26	0.232	0.009		
Total	41	2.111			
CV	1.557				

#### Appendix: XXI. 100 seed weight

<del></del>	_				
Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	1.769	0.136	12.002	0.00000
Treatment	13	0.295	0.011		
Error	26	2.092			
Total	41				
CV	1.995				

#### Appendix: XXII seed yield (q/ha)

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.023			
Treatment	13	137.724	10.594	3,417.457	0.00000

Error	26	0.081	0.003
Total	41	137.828	
CV	0.556		

# Appendix: XXIII straw yield (q/ha)

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.033			
Treatment	13	424.689	32.668	1,837.297	0.00000
Error	26	0.462	0.018		
Total	41	425.184			
CV	0.404				

# Appendix: XXIV Biological yield (q/ha)

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.099			
Treatment	13	1,002.925	77.148	2,772.598	0.00000
Error	26	0.723	0.028		
Total	41	1,003.748			
CV	0.388				

# Appendix: XXV Harvest index %

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.042			
Treatment	13	183.451	14.112	1,127.825	0.00000
Error	26	0.325	0.013		
Total	41	183.819			
CV	0.485				

### Appendix: XXVI. BLW density (g/m²) at 45 DAS

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.091			
Treatment	13	19.891	1.530	9.666	0.00000
Error	26	4.116	0.158		
Total	41	24.098			
CV	14.090				

#### Appendix: XXVII BLW density (g/m²) at harvest

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.225			
Treatment	13	15.804	1.216	5.380	0.00013
Error	26	5.876	0.226		
Total	41	21.905			
CV	17.581				

#### Appendix: XXVIII. Grassy weed density (g/m²) at 45 DAS

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.123			
Treatment	13	9.878	0.760	5.535	0.00011
Error	26	3.570	0.137		
Total	41	13.572			
CV	17.877				

#### Appendix: XXIX. Grassy weed density (g/m²) at harvest

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.305			
Treatment	13	9.299	0.715	3.800	0.00183
Error	26	4.895	0.188		
Total	41	14.499			
CV					
	21.923				

#### Appendix: XXX. Weed dry weight of plant 45 DAS

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.012			

Treatment	13	102.578	7.891	27.158	0.00000
Error	26	7.554	0.291		
Total	41	110.144			
CV	11.073				

### Appendix: XXI weed dry weight at harvest

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.130			
Treatment	13	103.546	7.965	28.340	0.00000
Error	26	7.307	0.281		
Total	41	110.984			
CV	10.498				

#### Appendix: XXXII Sedges weed density (g/m²) at 45 DAS

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.283			
Treatment	13	78.989	6.076	21.784	0.00000
Error	26	7.252	0.279		
Total	41	86.525			
CV	10.767				

# Appendix: XXXIII. Sedges weed density (g/m²) at harvest

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.173			
Treatment	13	80.702	6.208	15.886	0.00000
Error	26	10.160	0.391		
Total	41	91.036			
CV	13.137				

### Appendix: XXXIV. Total weed density (g/m²) at 45 DAS

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.285			
Treatment	13	113.685	8.745	29.439	0.00000
Error	26	7.723	0.297		
Total	41	121.693			
CV	9.272				

#### Appendix: XXXV total weed density at harvest

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.309			
Treatment	13	110.533	8.503	17.337	0.00000
Error	26	12.751	0.490		
Total	41	123.593			
CV					
	12.387				

### Appendix: XXXVI. Dry weight of weed at 45 DAS

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.012			
Treatment	13	102.578	7.891	27.158	0.00000
Error	26	7.554	0.291		
Total	41	110.144			
CV	11.073				

### Appendix: XXXVII. Dry weight of weed at harvest

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	0.130			
Treatment	13	103.546	7.965	28.340	0.00000
Error	26	7.307	0.281		
Total	41	110.984			
CV	10.498				

# Appendix: XXXVIII. weed index(%)

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	5.057			
Treatment	13	8,956.697	688.977	3,982.537	0.00000
Error	26	4.498	0.173		
Total	41	8,966.252			
CV	2.156				

### Appendix: XXXIX Weed control efficiency (%) at 45 DAS

Source	DF	S.S	M.S.S	F ratio	significance
Replication	2	14.709			
Treatment	13	19,389.067	1,491.467	34.065	0.00000
Error	26	1,138.340	43.782		
Total	41	20,542.116			
CV	10.055				

S.No.	Particular	Detail
1	Auther Name	Shikha Dubey
2	Father's Name	Santosh Kumar
3	Sex	Female
4	Date of Birth	12/04/1995
5	Place of Birth	Rasulabad
6	Village	Rasulabad
7	District	Kanpur Dehat
8	Nationality	Indian
9	Email add.	Shikhad674@gmail.com
10	Contact Number	9198767201
Acade	 emic and Professional qualific	cation
S.No.	Qualification Profile	Institute Name Passing year %

U.P Board

U.P Board

BUA&T Banda

CSJM University Kanpur

2010

2012

2016

2020

82.33

84.8

82.55

High School

Intermediate

4-year B.Sc. (Ag.)

M.Sc. (Ag.) Agronomy

2

3

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