

**HERBICIDAL EFFICACY OF CERTAIN
HERBICIDES AND INFLUENCE ON SOIL
MICROFLORA IN *rabi*
BLACKGRAM (*Vigna mungo* L.)**

**BY
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DECLARATION

I, **SHAIK RAZIA**, hereby declare that the thesis entitled “**HERBICIDAL EFFICACY OF CERTAIN HERBICIDES AND INFLUENCE ON SOIL MICROFLORA IN *rabi* BLACKGRAM (*vigna mungo* L.)**” submitted to **Acharya N.G. Ranga Agricultural University** for the degree of **Master of Science in Agriculture** in the major field of **Agronomy** is the result of original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

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CERTIFICATE

This is to certify that thesis entitled “**HERBICIDAL EFFICACY OF CERTAIN HERBICIDES AND INFLUENCE ON SOIL MICROFLORA IN *rabi* BLACKGRAM (*vigna mungo* L.)**” submitted in partial fulfillment of the requirements for the degree of ‘Master of science in Agriculture’ in the major field of **Agronomy** of the Acharya N. G. Ranga Agricultural University, Guntur, is a record of the bonafide original research work carried out by **Ms. SHAIK RAZIA** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance received during the course of the investigation have been duly acknowledged by the author of the thesis.

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Ms. SHAIK RAZIA has satisfactorily prosecuted the course of research and that thesis entitled “**HERBICIDAL EFFICACY OF CERTAIN HERBICIDES AND INFLUENCE ON SOIL MICROFLORA IN *rabi* BLACKGRAM (*vigna mungo* L.)**” submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by him for a degree of any university.

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Place -

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(RAZIA SHAIK)

Chapter I

INTRODUCTION

Blackgram is an important pulse crop grown in India and was grown in an area of 24.85 and 7.61 lakh hectares, respectively during *Kharif* and *rabi* seasons during the year, 2014-15. Blackgram considered as a priced pulse crop of Andhra Pradesh is cultivated in 3.15 lakh hectares with a production of 2.98 lakh tons and an average yield of 946 kg ha⁻¹. (www.indiastat.com), 2014-2015). Even though the production potential of blackgram is up to 3000 kg ha⁻¹, the average yields recorded are around 30 percent of the potential. Cultivation under poor and marginal soils with low input management, abiotic stresses and biotic stresses which include severe weed competition are the important reasons for the low yields in blackgram in spite of the high yield potential of the crop. Farmers are able to overcome pest and disease problems in cultivation of blackgram satisfactorily by cultivation of resistant varieties, use of insecticides and fungicides.

Weed competition is also one of the main reasons that comes in the way of successful cultivation and realisation of satisfactory yields in blackgram in addition to pests and diseases. The yield losses in blackgram due to uncontrolled weeds could be upto 63.8 % (Mishra and Bhanu, 2006). Blackgram is grown at a row spacing of 30 cm and the crop takes 35-40 days for covering the inter row space, which makes the crop highly prone to weed competition upto 30- 45 days after sowing which is considered to be critical for weed control (Vivek *et al.*, 2008). Traditionally farmers used to manage the weeds in blackgram through mechanical and manual measures. Due to decrease in availability and high cost of human labour for manual weeding, non availability of draught animals for mechanical weed control operations, over the last decade or so, farmers are gradually shifting to herbicidal usage for weed management in blackgram, as location specific

and effective pre and post emergence herbicides recommendations were made available from the researchers. Most of the recommendations were found effective in controlling weeds in blackgram at farmer's field level. Because of the acceptance and increased use of herbicides year by year by farmers, new herbicide molecules are regularly developed and released in to market. Newly released molecules are to be evaluated for their efficacy and suitability in a given agro climatic situation, before they are recommended to farmers. Some of the pre and post emergence herbicides molecules are regularly used by the farmers for weed management in blackgram over the last 10-15 years. This regular use of the same group of herbicides may lead to weed shifts and environmental hazards, which necessitates the use of new herbicides molecules. Newer herbicides alone or in combination with popular herbicides are to be tested for their weed control efficiency and their influence on soil micro flora population dynamics and performance. Keeping all these points in view, a field experiment was conducted during *rabi*, 2016 on blackgram with following objectives

1. To study the efficacy of new generation herbicides in *rabi* blackgram.
2. To investigate the effect of herbicides on soil microbial populations.
3. To calculate economics of weed management in blackgram.

Chapter II

REVIEW OF LITERATURE

The literature available on weed control in blackgram, grown in *rabi* is reviewed under different heads for “Herbicidal efficacy of certain herbicides and influence on soil microflora in *rabi* blackgram (*Vigna mungo* L.)”. Due to paucity of literature on the efficacy of some new post-emergence herbicides on *rabi* blackgram, literature available on blackgram grown in *kharif*, rice fallow situation and on other legume crops is also reviewed.

2.1 WEED FLORA

Weed flora associated with crops mostly depends upon the agro-ecological conditions, soil type, season and competing ability of crop and crop management practices. Knowledge of weed flora, their time of emergence, density and growth duration is essential for formulating sound weed control measures.

Shweta and Singh (2005) reported that the major weed flora in *kharif* blackgram were *Echinochloa colona*, *Cynodon dactylon*, *Eleusine indica* among grasses, *Cyperus rotundus* among sedges and *Trianthema monogyna*, *Commelina benghalensis* among broad leaved weeds on silty clay loam soils of Pantnagar, Uttarakhand.

Tuti *et al.* (2005) observed *Echinochloa colona*, *Cynodon dactylon* among grasses, *Cyperus rotundus* among sedges and *Grangea maderaspatana*, *Xanthium strumarium* and *Eclipta alba* among broad leaved weeds as the major weeds of rice-fallow blackgram on sandy clay soils of Bapatla, Andhra Pradesh.

The major weeds found in blackgram were *Echinochloa colona*, *Cyperus iria*, *Digitaria sanguinalis*, *Panicum dichotomiflorum*, *Commelina benghalensis*, *Polygonum alatum* and *Ageratum conyzoides* on silty clay loam soils of Palampur, Himachal Pradesh (Kumar and Angiras, 2005).

The dominant weeds in blackgram under rainfed conditions were *Eleusine aegyptiaca* (23%), *Cyperus rotundus* (15%) and *Cynodon dactylon* (4%) among grasses and *Digera arvensis* (40%) and *Commelina benghalensis* (10%) among broad leaved weeds on sandy loam soils of Nawanshahr, Punjab. (Sardana *et al.*, 2006).

Singh *et al.* (2006) found the major weed species in *kharif* blackgram as *Echinochloa* spp., *Cyperus* spp., *Trianthema portulacastrum* (L) and *Eclipta alba* on loamy soils of Pantnagar, Uttarakhand.

Sharma and Yadava (2006) summarized that *Trianthema monogyna* and *Cyperus rotundus* were the major weeds which contributed to the total weed dry weight to an extent of 45.4 and 59.6% at 60 DAS and 47.7 and 39.3% at harvest, respectively in *kharif* blackgram on sandy loam soils of Pantnagar, Uttaranchal.

Rao and Rao (2006) reported that among different weed flora of rice-fallow blackgram, *Echinochloa colona* constituted 80% of the total weed population. Other weeds like *Cyperus rotundus*, *Chrozophora rotleri*, *Xanthium strumarium*, *Gnaphalium polycaulon*, *Cleome chelidoni*, *Nasturitium indicum* and *Euphorbia virgatus* were also present but their population was negligible on clay loam soils at Lam, Andhra Pradesh.

Malliswari *et al.* (2008) reported weeds like *Dactyloctenium aegyptium*, *Digitaria sanguinalis*, *Cynodon dactylon*, *Panicum repens*, *Cyperus rotundus*, *Celosia argentea*, *Cleome viscosa*, *Digera arvensis*, *Euphorbia hirta*, *Phyllanthus niruri*, *Portulaca oleracea* and *Trianthema portulacastrum* on sandyloam soils of blackgram at Tirupathi.

Rao, (2008a) reported the important weed flora in rice-fallow blackgram as *Echinochloa colona*, *Panicum xylopodium*, *Dinebra retroflexa*, *Leptochloa chinensis*, *Cyperus rotundus*, *Cyperus kyllinga*, *Grangea maderaspatana*, *Ammannia baccifera*, *Cardanthera uliginosa*, *Gnaphalium polycaulon* and *Eclipta alba* on sandy clay loam soils at Bapatla, Andhra Pradesh .

Veeraputhiran and Chinnusamy (2008) reported that *Echinochloa colona*, *Echinochloa crusgalli*, *Oryza sativa*, *Cyperus rotundus*, *Cynodon dactylon* and *Cleome viscosa* were the major weed flora in relay cropped blackgram on clay loam soils of Killikulam, Tamil Nadu.

Vivek *et al.* (2008) revealed that *Trianthema portulacastrum*, *Digera arvensis*, *Echinochloa crusgalli*, *Parthenium hysterophorus*, *Phyllanthus niruri* and *Cynodon dactylon* were the dominant weed flora in blackgram on sandy loam soils of Meerut, Uttar Pradesh.

Venkateswarlu (2011) reported *Echinochloa colona* as the major weed species (more than 80%) and weeds like *Echinochloa crusgalli* and *Leptochloa chinensis*, *Panicum xylopodium* at negligible level on heavy black soils of Krishna western delta of Guntur, Andhra Pradesh.

Infestation of *Echinochloa colona* which consisted of 80% of the total weed population was reported in blackgram on clayloam soils of Lam, Guntur (Rao, 2011a).

Tomar (2011) indicated the domination of grassy weed flora viz., *Digitaria sanguinalis*, *Echinochloa colona*, *Echinochloa crus-galli*, *Eleusine indica* and the sedge *Cyperus rotundus* in *kharif* blackgram at Gurgoan.

Khot *et al.* (2012) reported that the weed flora in summer blackgram on clay soils of Junagadh, Gujarat, prominently comprised of *Panicum colonum*, *Brachiaria* spp., *Eluopus villosus*, *Commelina benghalensis*, *Eragrostis* spp., *Digera arvensis*, *Indigofera glandulosa*, *Corchorus acutangulus*, *Amaranthus viridis*, *Leucas aspera*, *Portulaca oleracea* and *Cyperus rotundus*.

Mundra and Maliwal (2012) revealed that the mean percent contribution of narrow leaved weeds consisted of *Echinochloa* spp. (58.6%) and *Cynodon dactylon* (0.9%), sedge *Cyperus rotundus* (6.9%) and broad leaved weeds, *Parthenium hysterophorus* (15.8%), *Amaranthus viridis* (10.1%), *Trianthema portulacastrum* (4.2%) and others (3.5%) in blackgram on sandy clay loam soils of Udaipur, Rajasthan.

Naidu *et al.* (2012) indicated that *Vicia sativa* was the dominant weed constituting around 70% of the total weed population in rice-fallow blackgram on sandy clay loam soils of Naira, Andhra Pradesh.

Rao (2013) reported the important weed flora of the rainy and winter season blackgram included *Echinochloa colonum*, *Dinebra retroflexa*, *Panicum repens* and *Cynodon dactylon*, which occupied more than 90% of the total weed population on clay loam soils at Lam, Guntur.

In summer blackgram infestation of *Parthenium hysterophorus*, *Cyperus rotundus*, *Trianthema monogyna*, *Digera arvensis* and *Leptochloa chinensis* was reported at 60 DAS and maximum population of *Cyperus rotundus* and highest drymatter of *Digera arvensis* was observed in summer blackgram on sandy loam soils of Kanpur, Uttar Pradesh (Chaudhry *et al.*, 2014).

Das *et al.* (2016) stated that in pre *kharif* blackgram on sandy loam soils of Nadia, West Bengal, the weed flora mainly consisted of broad leaved weeds viz., *Ageratum conyzoides*, *Borreria hispida*, *Commelina benghalensis*; grasses viz., *Echinochloa colona*, *Cynodon dactylon*, *Paspalum scrobiculatum*, *Digitaria sanguinalis* and sedges viz., *Cyperus rotundus*. Among them the maximum relative percentage was with *Ageratum conyzoides* (43.25%) followed by *Borreria hispida* (27.8%) and *Cynodon dactylon* (17.3%).

Sasikala *et al.* (2014) reported that in zero till sown rice fallow blackgram on sandy clay loam soils of Madurai, Tamil Nadu among grassy weed, *Echinochloa colonum* was the dominant species. Other major weeds were *Echinochloa crusgalli* and *Panicum repens* among grasses, *Cyperus rotundus* and *Cyperus difformis* among sedges and *Sphaeranthus indicus*, *Eclipta alba* and *Cleome viscosa* among broad leaved weeds.

Kumar *et al.* (2015) reported from Hisar that *Trianthema portulacastrum* was the dominant weed at 30 DAS with a relative density of 83%, but at 60 DAS, *Cyperus rotundus* was dominant with a relative density of 72% in *kharif* and *rabi* blackgram on sandy loam soils.

Pal *et al.* (2015) observed *Cleome viscosa*, *Corchorus aestuans*, *Croton bonplandianum*, *Cyperus rotundus*, *Merremia emarginata*, *Phyllanthus niruri*, *Trianthema portulacastrum* and *Urocloua panicoides* as dominant weeds on sandy loam soils in *kharif* blackgram at Meerut, Uttar Pradesh.

Patel *et al.* (2015) reported *Cyperus iria*, *Digera arvensis*, *Commelina benghalensis*, *Eleusine indica*, *Digitaria sanguinalis*, *Dactyloctenium aegyptium*, *Phyllanthus niruri* and *Ergrostis major* to be the predominant weed flora in *kharif* blackgram sandy loam soils of Anand, Gujarat.

Yadav *et al.* (2015) found that *Cyperus rotundus*, *Echinochloa crusgalli*, *Commelina benghalensis*, *Phyllanthus niruri* and *Digera arvensis* were predominant weed flora in *kharif* blackgram on sandy loam soils of Gwalior, Madhya Pradesh.

Balyan *et al.* (2016) found that *Cynodon dactylon*, *Commelina benghalensis*, *Cyperus rotundus*, *Ageratum conyzoides*, *Setaria glauca*, *Euphorbia hirta*, *Echinochloa colonum*, *Echinochloa crusgalli*, *Tribulus terrestris*, *Trianthema monogyna*, *Ipomoea pestigridis*, *Fimbristylis penera* were predominant in *Kharif* blackgram on sandy clay loam soils of Bhilwara, Rajasthan.

In *kharif* blackgram weed flora viz., *Echinochloa colonum*, *Eleusine indica*, *Dactyloctenium aegyptium*, *Digitaria sanguinalis*, *Panicum maximum* among grasses, *Digera arvensis*, *Cleome viscosa*, *Celosia argentea*, *Malugo stricta*, *Trianthema monogyna* among broad-leaf weeds and *Cyperus rotundus* among sedges was reported from Pantnagar, Uttarakhand by Singh *et al.*, 2016.

2.2 YIELD LOSSES CAUSED BY WEEDS

Weed infestation reduces grain yield directly and indirectly. The weeds cause maximum damage initially at 25 to 35 days after sowing. The degree of damage caused by weeds is related to the type, species and density of weeds growing in the community. Persistence of weeds in a location is largely influenced by climatic, edaphic and biotic factors which effect their occurrence, abundance, range and distribution. Competition occurs when one of the resources (nutrients, light, moisture and space) fall short of total requirement of blackgram and weeds.

Kumar and Tewari (2004) reported that higher yield was obtained when blackgram crop was sown in absence of weed competition (974 kg ha⁻¹) and closely followed by weedy condition till 10 days after sowing (963 kg ha⁻¹). Weed competition throughout the crop period caused a reduction of 40.1% in grain yield.

Mishra and Bhanu (2006) found that infestation of weeds throughout the season caused 63.8% reduction in grain yield over weed-free in summer blackgram on clay loam soils of Jabalpur, Madhya Pradesh.

Rao and Rao (2006) concluded that unchecked weed growth during the crop season reduced the grain yield to the extent of 43% compared to handweeding at 25 DAS in blackgram.

Rao (2008b) reported that the uncontrolled weed growth during the crop season reduced the grain yield to the extent of 30% in relay crop of blackgram on clay soils of Guntur, Andhra Pradesh.

Rao (2010) indicated that uncontrolled *Cuscuta* infestation in rice fallow blackgram caused 79% reduction in grain yield of blackgram compared to imazethapyr 63 g ha⁻¹ at 15 DAS on sandy loam soils of Bapatla, Andhra Pradesh.

Singh (2011) concluded that as compared to two hand weedings at 25 and 40 DAS, the unchecked weeds caused on an average of 41.2 and 41.6% reduction in grain yield during summer and *khariif* seasons, respectively in blackgram grown on sandy loam soils of Ludhiana, Punjab.

Rao (2011b) revealed that the uncontrolled weed growth during crop growing period resulted in a yield loss of 55% compared to fenoxaprop ethyl 56 g ha⁻¹ which recorded the highest yield in rice fallow blackgram grown on sandy clay loam soils of Guntur, Andhra Pradesh. .

The uncontrolled weed growth caused 32% reduction in grain yield compared to clodinafop-propargyl @ 52.50 g ha⁻¹ which recorded the highest grain yield of 922 kg ha⁻¹ in rice fallow blackgram on heavy black soils of Guntur, Andhra Pradesh (Venkateswarlu, 2011).

Sasikala *et al.* (2014) recorded that weed infestation in zero till sown rice fallow blackgram may reduce yield upto an extent of 45 to 60% on sandy clay loam soils of Madurai, Tamil Nadu.

Shruthi and Salakinkop (2015) reported that unweeded check registered 57.4% reduction in seed yield as compared to weed free check owing to severe competition offered by uncontrolled weeds for nutrients, soil moisture, space and light in *khariif* greengram on clay loam soils of Dharwad, Karnataka.

2.3 CRITICAL PERIOD OF CROP-WEED COMPETITION

Kumar and Tewari (2004) observed that weed infestation throughout crop period caused a reduction of 40.1% in grain yield and the overall contribution of weed-free period provided only till 10, 20, 30 and 40 DAS was found to be 31.79, 19.3, 9.8 and 2.87% over weed-free throughout crop period and thus inferred that the critical period of weed competition lies between 10 and 40 days after sowing in summer sown blackgram on sandy loam soils of Kanpur, Uttar Pradesh.

Vivek *et al.* (2008) noted that crop-weed competition during 30-45 DAS was critical in blackgram on sandy loam soils of Meerut, Uttar Pradesh.

Rao (2008a) indicated that reduction in seed yield due to weed competition throughout the cropping period was 75 per cent and yield obtained with weed free up to 30 DAS (833 kg ha⁻¹) was on par with weed free upto harvest (920 kg ha⁻¹) and weed free up to 30 DAS appears to be the critical period of crop weed competition in rice fallow blackgram on sandy clay loam soils of Bapatla, Andhra Pradesh.

2.4 WEED CONTROL

A review on weed control in blackgram through manual weeding, mechanical weeding and pre-emergence and post-emergence herbicides and their effects on blackgram and associated weeds is presented here under.

2.4.1 Manual Weeding

According to Sharma and Yadava (2006) two hand weedings at 20 and 40 DAS caused the lowest drymatter of *Cyperus rotundus*, *Trianthema monogyna* and other weeds at 60 DAS, which might be due to the complete removal of weeds by hand weeding in *kharif* blackgram on sandy loam soils at Pantnagar, Uttaranchal.

Raman, 2006 revealed that among the weed control treatments, hand weeding on 20 and 40 DAS recorded the lowest population and dry weight of weeds and the highest value of weed control efficiency in blackgram on clay loam soils of Annamalainagar, Tamil Nadu.

Rao and Rao (2006) opined that hand weeding on 25 DAS recorded the highest seed yield of 755 kg ha⁻¹ in blackgram grown as pure crop on clay loam soils of Guntur, Andhra Pradesh.

Shete *et al.* (2007) observed that significantly the highest weed control efficiency of monocot (87.93%) and dicot (96.29%) weeds with one hoeing (20 DAS) + two hand weedings at 30 and 60 DAS on sandy loam soils of Rahuri, Ahmednagar.

Malliswari *et al.* (2008) declared that significantly higher grain yield, weed control efficiency and net returns were recorded with hand weeding twice at branching and flowering stages because of reduced weed density and lesser weed biomass production in blackgram on sandy loam soils of Tirupati, Andhra Pradesh.

Naidu (2010) reported that highest crop dry weight, number of pods per plant and grain yield (579 kg ha⁻¹) with hand weeding.

Naidu *et al.* (2011) revealed that hand weeding at 15 and 30 DAS recorded the highest weed control efficiency of *Vicia sativa* in rice-fallow blackgram on sandy clay loam soils of Naira, Andhra Pradesh.

According to Rao (2011a) hand weeding at 15 and 30 DAS recorded the highest seed yield (1928 kg ha⁻¹) in rice fallow blackgram on clay loam soils of Guntur, Andhra Pradesh.

Two hand weedings, at 25 and 40 DAS recorded the highest grain yield (11.95 and 11.76 q ha⁻¹) in summer and kharif seasons in blackgram on sandy loam soils of Ludhiana, Punjab (Singh, 2011).

Khot *et al.* (2012) reported that two hand weedings at 20 and 40 DAS were more effective in blackgram against sedges and was at par with pendimethalin 1.0 kg ha⁻¹ pre-emergence + one hand weeding + intercultivation at 40 DAS and oxyfluorfen 0.18 kg ha⁻¹ pre-emergence + one hand weeding + intercultivation at 40 DAS on black clayey soils of Junagadh, Gujarat.

Pyare *et al.* (2013) reported highest grain yield of 8.50 and 10.67 q ha⁻¹, respectively, during two years study in *kharif* 2009 and 2010 with two hand weedings in blackgram on sandy loam soils at Kanpur.

Khot *et al.* (2015) recorded higher grain yield (1050 kg/ha) and stover yield (1364 kg/ha) in blackgram with two hand weedings at 20 and 40 DAS on clayey soils of Junagadh, Gujarat.

Patel *et al.* (2015) observed that significantly higher grain yield (1.74 t ha⁻¹) and haulm yield (3.65 t ha⁻¹) of blackgram was obtained with hand weeding at 20 and 40 DAS and was at par with the pre emergence or post emergence herbicide coupled with inter cultivation and one hand weeding at 30 DAS on sandy loam soils at Anand, Gujarat.

Hemlata *et al.* (2016) reported higher grain yield of blackgram with hand weeding at 20 and 40 DAS (695 kg ha⁻¹) because of higher number of pods per plant, number of seeds per pod, 100-seed weight at Raipur, Chhattisgarh.

2.4.2 Mechanical Methods

Chhodavadia *et al.* (2014) opined that two hand weedings and two intercultivations at 20 and 40 DAS registered the least loss of nutrients due to weeds and significantly increased protein content (22.15%) in greengram on black soils of Junagadh, Gujarat.

Kumar *et al.* (2015) reported maximum grain yield (0.90 t ha⁻¹) of blackgram with two hoeings at 20 and 40 DAS which was at par with imazethapyr + pendimethalin at 1.0 kg ha⁻¹ and pendimethalin at 1.0 kg ha⁻¹ applied as pre-emergence in sandy loam soils at Hisar, Haryana.

Choudhary *et al.* (2016) reported that effective weed control and highest yield in summer greengram can be achieved by hand hoeing at 20 and 30 DAS during crop growth period as compared with application of pendimethalin 1.0 kg ha⁻¹ as pre-emergence, on clayey soils of Gujarat.

2.4.3 Chemical Weed Control

The effect of different herbicides on blackgram and associated weeds is reviewed hereunder.

2.4.3.1 Pendimethalin

Pendimethalin inhibits both cell division and cell elongation in root and shoot meristems of the susceptible plants. The growth is inhibited directly following absorption through hypocotyl and shoot region. The plants die shortly after germination or emergence from the soil.

Kumar and Tewari (2004) concluded that the increase in seed yield of blackgram was 45.2% with pendimethalin (1.25 kg ha^{-1}) as compared with unweeded check.

Pendimethalin @ 1.0 kg ha^{-1} was found better than fluchloralin, with an increased yield of 128 kg ha^{-1} in blackgram on clay loam soils of Annamalaiagar, Tamilnadu (Raman, 2006).

Weed control efficiency recorded with pre-emergence application of pendimethalin 0.45 kg ha^{-1} + one hand weeding at 25 DAS (84.81 and 78.28%) was found on par with two hand weedings done at 25 and 40 DAS (85.01 and 84.89%) in summer and *khariif* blackgram on sandy loam soils of Ludhiana, Punjab (Singh, 2011).

Pendimethalin @ 1.0 kg ha^{-1} pre-emergence + one hand weeding + intercultivation at 40 DAS recorded on par grain and stover yield weed free treatment in blackgram (Khot *et al.*, 2012).

Pre emergence application of pendimethalin alone @ 1.0 kg ha^{-1} was found effective recording significantly higher seed yield (1.03 t ha^{-1}) in blackgram on sandy loam soils of Mushidabad, West Bengal. (Bhowmick *et al.*, 2015)

Pre emergence application of pendimethalin 1.0 kg ha^{-1} + one hand weeding + intercultivation at 40 DAS recorded higher protein content, chlorophyll content, yield (1323 kg ha^{-1}) and net income per unit area on clayey soils in summer blackgram under south Saurashtra region of Gujarat. (Khot *et al.*, 2015).

Singh *et al.* (2016) stated that application of pendimethalin @ 1.0 kg ha^{-1} alone recorded higher seed yield (1.15 t ha^{-1}) which showed 56.1% increment over the weedy check in blackgram on clayloam soils of Pantnagar, Uttarpradesh.

Hemalata *et al.* (2016) reported, highest seed yield of 580 kg ha⁻¹ with application of pendimethalin @ 1.0 kg ha⁻¹ *fb* fenoxaprop-p-ethyl @ 60 g ha⁻¹ + chlorimuron-ethyl @ 4.0 g ha⁻¹.

2.4.3.1.1 Effect on weed species

The results of a field experiment conducted by Mishra *et al.* (2004) in blackgram on clay loam soils of Jabalpur, Madhya Pradesh revealed that the pre-emergence application of pendimethalin @ 1.0 kg ha⁻¹ was at par with fluchloralin @ 1.0 kg ha⁻¹ in significantly reducing the emergence of *Cuscuta*.

Sharma and Yadava (2006) asserted that when pendimethalin (0.75 and 0.5 kg ha⁻¹) was applied in combination with hand weeding at 30 DAS, it caused lower dry matter of *Trianthema monogyna* as compared to pendimethalin alone (1.0 kg ha⁻¹) in *khari* blackgram on sandy loam soils of Pantnagar, Uttarpradesh.

Suresh kumar *et al.* (2006) stated that among different weed control methods, integration of one handing (45 DAS) with pendimethalin @ 0.75 kg ha⁻¹ resulted in significantly lower total weed density and total drymatter in blackgram on silty clay loam soils of Palampur, Himachal Pradesh.

Malliswari *et al.* (2008) declared that application of pendimethalin @ 1.5 kg ha⁻¹ registered the lowest weed density compared to other weed management practices and was more effective against broad leaved weeds followed by metalachlor in blackgram on sandy loam soils of Tirupati, Andhra Pradesh.

Kaur *et al.* (2010) noticed effective control of *Trianthema portulacastrum* with pre-emergence application of pendimethalin both @ 0.45 and 0.75 kg ha⁻¹ in summer greengram on sandy loam soils of Ludhiana, Punjab.

Ali *et al.* (2011) noted that pre-emergence of pendimethalin @ 1.0 kg ha⁻¹ was found to be most effective in reducing broad leaved weeds at 40 DAS in greengram on sandy loam soils of Sardarkrushinagar, Gujarat.

Sasikala *et al.* (2014) reported lower grassy and broad leaved weed densities with application of pendimethalin @ 1.0 kg ha⁻¹ by dibbling the blackgram seeds after harvest of rice on clay loam soils of Madhurai, Tamilnadu

Kumar *et al.* (2015) observed excellent control (90%) of *Trianthema portulacastrum* upto 30 DAS with the pre emergence application of imazethapyr + pendimethalin @ 1.0 kg ha⁻¹.

Verma *et al.* (2016) indicated lowest density (15.56 m⁻²) and dry weight (2.04 g m⁻²) of *Cyperus* with sequential application of pendimethalin (1.0 kg ha⁻¹, pre-emergence) followed by imazethapyr (100 g ha⁻¹, post-emergence) as compared to alone application of the two herbicides in greengram on sandy clay loam soils of Varanasi, Uttar Pradesh.

2.4.3.1.2 Effect on weed dry weight

Patel *et al.* (2015) observed that at 50 DAS, significantly lower dry weight of monocot and dicot weeds in hand weedings carried out at 20 and 40 DAS, which was at par with pre-emergence application of pendimethalin @ 500 g ha⁻¹ *fb* inter cultivation + hand weeding at 30 DAS in blackgram on sandy loam soils of Anand, Gujarat.

Application of pendimethalin @ 1.0 kg ha⁻¹ as pre-emergence reduced the weed dry matter to a notable level of 9.98g m² and 5.18 g m⁻² at 30 and 60 DAS in blackgram (Balyan *et al.*, 2016)

2.4.3.2 Alachlor

Alachlor is absorbed by germinating shoots and by roots. Its mode of action is elongase inhibition and inhibition of geranyl geranyl pyro phosphate (GGPP) cyclisation enzymes, part of the gibberellin pathway. It interferes with a plant's ability to produce protein and inhibits root growth.

Sharma and Yadava (2006) reported effective control of *Cyperus rotundus* when alachlor @ 1.5 and 1.0 kg ha⁻¹ was applied in combination with hand weeding at 30 DAS recording lower dry matter of *Cyperus rotundus*).

Talnikar *et al.* (2008) reported that pre-emergence application of alachlor @ 2.0 kg ha⁻¹ with hand weeding and hoeing at 6 weeks after sowing proved most effective and economical in controlling weeds and enhancing the grain yield in pigeon pea + soybean intercropping system .

Pre emergence application of alachlor @ 1.5 kg ha⁻¹ along with hand weeding at 40 DAS recorded lowest dry weight of weeds at harvest of blackgram and produced maximum grain yield (602 kg ha⁻¹) and production efficiency (7.6) over unweeded control (253 and 3.28 kg ha⁻¹, respectively) under maize + blackgram cropping system (Dwivedi *et al.* 2011).

Shweta and Malik (2013) reported maximum yield of blackgram with pre-emergence application of alachlor @ 1.5 kg ha⁻¹ along with one hand weeding at 40 DAS, which was 80 per cent higher than the unweeded control.

2.4.3.3 Imazethapyr

Application of imazethapyr, inhibits Aceto lactate synthase (ALS) enzyme responsible for the synthesis of three branched chain amino acid like isoleucine, leucine and valine.

Sasikala *et al.* (2014) reported that application of post emergence herbicides provided a weed free situation by timely control of weeds during the critical period of crop weed competition in rice fallow blackgram, application of imazethapyr @ 100 g ha⁻¹ increased the crop yield next to fenoxaprop-p-ethyl and cyhalofop butyl.

Kumar *et al.* (2015) reported maximum seed yield of (0.9 t ha⁻¹) in blackgram with two hoeings at 20 and 40 DAS which was at par with pre emergence imazethapyr + pendimethalin @ 1.0 kg ha⁻¹ on Shivalik foot hilly region of Panchkula, Haryana.

Patel *et al.* (2015) indicated that application of imazethapyr @ 50 g ha⁻¹ as PoE *fb* inter cultivation + hand weeding at 30 DAS in blackgram recorded on par seed and haulm yield as compared with hand weeding carried out at 20 and 40 DAS on sandy loam soils of Anand, Gujarat.

The maximum seed yield was obtained in weed free treatment followed by hand weedings at 20 and 40 DAS and pendimethalin 30 EC+imazethapyr 2 EC @ 1.0 kg ha⁻¹ in greengram on alluvial soils of Nadia, West Bengal (Tamang *et al.*, 2015).

Singh *et al.* (2016) reported higher number of pods per plant of blackgram with pre-mix combination of imazethapyr + pendimethalin @ 1.0 kg ha⁻¹ which was at par with alone application of pendimethalin applied @ 1.0 kg ha⁻¹ and pre-mix combination of imazethapyr + pendimethalin @ 800 and 900 g ha⁻¹ on clayloam soils of Pantnagar, Uttarkhand.

2.4.3.3.1 Effect on weed species

Rao (2010) stated that post-emergence application of imazethapyr 63 g ha⁻¹ applied at 15 DAS recorded significantly higher control of *Cuscuta* (75%) over its application at 25 DAS (53%) and observations recorded at 40 days after treatment indicated that imazethapyr 63 g ha⁻¹ applied at 15 and 25 DAS were on par in controlling *Cuscuta* (90%) in rice fallow blackgram on sandy loam soils of Bapatla, Andhra Pradesh

Ali *et al.* (2011) observed that application of imazethapyr @ 100 g ha⁻¹ at 15-20 DAS recorded the lowest grassy weeds and sedges at 40 DAS which was followed by quizalofop-p-ethyl @ 100 g ha⁻¹ at 15-20 DAS in greengram on sandy loam soils of Sardarkrushinagar, Gujarat.

Kundu *et al.* (2011) reported that twice hand weeding done at 20 and 40 DAS showed the maximum reduction of *Echinochloa colona* and *Echinochloa crusgalli* at all the stages and it was closely followed by imazethapyr @ 125 g ha⁻¹ at 10 DAS and imazethapyr @ 150 g ha⁻¹ at 10 DAS in soybean on sandy loam soils of Nadia, West Bengal.

Sasikala *et al.* (2014) reported the effect of imazethapyr @ 100 g ha⁻¹ on reduction of grassy weeds was next to fenoxaprop-p-ethyl and cyhalofop butyl, it reduced density and dry matter production of broad leaved weeds in clay loam soils of Madurai, Tamilnadu.

Khairnair *et al.* (2014) stated that imazethapyr was effective against annual broad-leaved weeds like *Commelina diffusa*, *Amaranthus viridis*, *Digera arvensis*, *Parthenium hysterophorus* and grassy weeds like *Bracharia* spp., *Echinochloa colona*, sedge like *Cyperus rotundus* in greengram on clay soils of Akola, Maharashtra

Singh *et al.* (2016) opined that imazethapyr @ 75 g ha⁻¹ was found to be effective for controlling sedges, grassy and broad leaved weeds as well as in improving grain yield of greengram with high weed control efficiency (72.2%) and harvest index (28.5%) on sandy loam soils of Ludhiana, Punjab.

Verma *et al.* (2016) concluded that pre-emergence application of pendimethalin (1000 g ha⁻¹) followed by post emergence application of imazethapyr (100 g ha⁻¹) recorded the lowest density (14.2 m⁻²) and dry weight (1.36 g m⁻²) of *Echinochloa* as

compared to alone application of pendimethalin (1.0 kg ha⁻¹, pre-emergence) and imazethapyr (100 g ha⁻¹, post-emergence), in greengram on sandy clay loam soils of Varanasi, Uttar Pradesh.

2.4.3.3.2 Time and method of application

Tewari *et al.* (2004) found that imazethapyr @ 100 g ha⁻¹ as pre-emergence excelled all the herbicide treatments with respect to effective weed control (64.4% WCE) and increased grain yield at par to manual weeding twice in greengram on sandy loam soils of Kanpur, Uttar Pradesh.

Among the post-emergence herbicides, imazethapyr @ 50-100 g ha⁻¹ and glyphosate @ 12-50 g ha⁻¹ significantly checked the *Cuscuta* infestation as compared to control in blackgram on clay loam soils of Jabalpur, Madhya Pradesh (Mishra *et al.*, 2004).

Gousia and Rao (2006 b) summarized that post-emergence application of imazethapyr @ 63 g ha⁻¹ applied at 15 DAS can keep an effective check on nutrient depletion by weeds in rice fallow blackgram on sandy clay loam soils of Bapatla, Andhra Pradesh.

The highest grain yield was recorded with weed-free check (1263 kg ha⁻¹) closely followed by pre-plant incorporation of imazethapyr (1190 kg ha⁻¹) and pre-emergence application of pendimethalin (973 kg ha⁻¹). Pre-plant incorporation of imazethapyr was superior to its post-emergence application in increasing grain yield in summer blackgram on clay loam soils of Jabalpur, Madhya Pradesh (Mishra and Bhanu, 2006).

Veeraputhiran and chinnuswamy (2008) concluded that the yield attributing characters of blackgram viz., number of pods plant⁻¹ and number of grains pod⁻¹ were higher under imazethapyr applied at 21 DAS, which was significantly superior to other times of application in blackgram on clay loam soils of Killikulam, Tamil Nadu.

Nandan *et al.* (2011) observed that the number of pods plant⁻¹ were found to be the highest during two years to the tune of 24.5 in 2006 and 23.5 in 2007 respectively with imazethapyr @ 250 ml ha⁻¹ at 15-20 DAS which was at par with that of hand weeding twice at 20 and 40 DAS in blackgram on sandy loam soils of SKUAST, Jammu and Kashmir.

Aggarwal *et al.* (2014) reported that application of imazethapyr @ 100 g ha⁻¹ at 15 DAS and two hand weedings gave the highest grain yield of blackgram which was at par with imazethapyr @ 75 g ha⁻¹ applied at 15 DAS and Imazethapyr @ 100 g ha⁻¹ applied at 25 DAS but significantly higher than all other weed-control treatments in blackgram on sandy loam soils of Ludhiana, Punjab.

After weed free, application of imazethapyr @ 0.1 kg ha⁻¹+ hand weeding at 30 DAS recorded the highest grain (1403 kg ha⁻¹), straw (2575 kg ha⁻¹) and biological yield (3978 kg ha⁻¹) of blackgram on loamy sandy soils of Bikaner, Rajasthan (Jakhar *et al.*, 2015).

Kumar *et al.* (2015) considered that pre-emergence application of imazethapyr+ pendimethalin at 1.0 kg ha⁻¹ provided excellent control (90%) of *Trianthema portulacastrum* upto 30 DAS. At 60 DAS, per cent control with this treatment decreased to 73% which was at par with two hoeings employed at 20 and 40 DAS and pendimethalin @ 1.0 kg ha⁻¹ as pre-emergence in blackgram on sandy loam soils of Hisar, Haryana.

2.4.3.4 Sodium salt of Acifluorfen+Clodinafop-p-propargyl

It was a premix selective post emergence herbicide with systemic action. Clodinafop absorbed by the leaves is rapidly translocated to the growing point of leaves and stem which interferes with production of fatty acids needed for plant growth in the seceptable grassy weeds. Leaves and growing point turn yellow with in one to three weeks after application, further colour changes and loss of vigour will be observed followed by a browning and control with in three to five weeks after application. It has no persistence in soil. Weeds that emerge after application of this herbicide will not be controlled.

Bera *et al.* (2012), reported lowest weed index value (7.81) with UPH-203 (clodinafop-propargyl @ 100 g ha⁻¹+Na-acifluorfen 10% SL @ 206.2 g ha⁻¹ and highest (52.16) with unweeded control in soybean on sandy loam soils of Nadia, West Bengal.

Clodinafop-propargyl 8% EC @ 80 g a.i. ha⁻¹ gave significantly more grain yield of 69.8% over weedy check and was at par to its 100 and 160 g a.i. ha⁻¹ doses and combined use of clodinafop-p-propargyl 8% EC+sodium salt of acifluorfen 16.5% SL @ 80+165 g a.i. ha⁻¹ and 100 + 206.2 g a.i. ha⁻¹ in soybean on sandy loam soils of Pantnagar, Uttar Pradesh (Jha *et al.*, 2014).

2.4.3.4.1 Effect on weed species

Singh *et al.* (2004) found that bentazon, Blazer (acifluorfen) and ready mix formulation of bentazon and Blazer were not effective in controlling *Echinochloa colona*, *Cyperus rotundus*. However, *Celosia argentia*, *Trianthema monogyna* and *Cleome viscosa* were effectively controlled by bentazon applied alone or as ready mix formulation with Blazer in soybean on loamy soils of Pantnagar, Uttaranchal.

According to Venkateswarlu (2011) clodinafop-p-propargyl @ 52.50 g ha⁻¹ recorded the highest grain yield increase of 47% due to effective control of *Echinochloa* and recorded higher weed control efficiency and more number of pods per plant and more number of seeds per pod in rice fallow blackgram on heavy black soils of Guntur, Andhra Pradesh.

Rao (2015) while reviewing the weed management in rice fallow blackgram, indicated that post emergence application (25-30 DAS) of ready mix of acifluorfen+clodinafop propargyl was effective in controlling *Vicia sativa* along with grasses and broad leaved weeds but was found to be ineffective against *Cuscuta*.

2.4.3.4.2 Time and method of application

The highest value (45.02%) of harvest index was recorded with the treatment UPH-20 (clodinafop-propargyl) 100 g ha⁻¹+Na-acifluorfen 10% SL 206.2 g ha⁻¹ sprayed at 23 DAS and lowest (35.94%) with weedy check in soybean on sandy loam soils of Nadia, West Bengal (Bera *et al.*, 2012).

Pal *et al.* (2013) summarized that the treatments UPH-203 (clodinafop-propargyl) 100 g ha⁻¹+Na-acifluorfen 10% SL 206.2 g ha⁻¹ sprayed at 23 DAS and imazethapyr 10% SL 1.0 kg ha⁻¹ sprayed at 10 DAS gave significantly higher seed yield of soybean and were statistically at par with each other on sandy loam soils of Nadia, West Bengal.

2.4.3.5 Quizalofop ethyl

Inhibition of acetyl CoA carboxylase (ACC ase) was caused by application of quizalofop ethyl. Leaves of effected plants turn purplish or red within 5-8 days after application and within 10-15 days completely killed. It is quickly absorbeb by the weeds and translocated and kills the weeds. The affected weeds could not regenerate.

Naidu *et al.* (2012) reported lower seed yield with application of quizalofop-p-ethyl @ 50 g ha⁻¹ and 75 g ha⁻¹ as compared with other herbicides on sandy clay loam soils of Naira, Andhra Pradesh.

Kumar *et al.* (2015) reported that number of seeds pod⁻¹ recorded with application of quizalofop ethyl @ 50 g ha⁻¹ to be lower than with treatment receiving two hand weedings. However, application of quizalofop ethyl alone recorded 37.7% increase in grain weight as compared with weedy check.

Balyan *et al.* (2016) stated that among post-emergence herbicides, quizalofop ethyl @ 50 g ha⁻¹ at 30 DAS was significantly superior in reducing weed density and increased the yield both at 30 and 60 DAS while it remained at par with the treatments of interculture 15 DAS *fb* imazethapyr @ 100 g ha⁻¹ at 30 DAS, interculture at 15 DAS *fb* quizalofop-ethyl @ 50 g ha⁻¹ at 30 DAS and imazethapyr @ 100 g ha⁻¹ 20 DAS on sandy clay loam soils of Udaipur, Rajasthan.

Marimuthu *et al.* (2016) reported that the increased seed yield of 1431 and 1493 kg ha⁻¹ were registered with the application of pendimethalin (0.75 kg ha⁻¹) as pre emergence at 3 DAS *fb* mixture of imazethapyr (50 g ha⁻¹) + quizalofop ethyl (50 g ha⁻¹) at 20 DAS during *rabi* and summer season respectively, on sandy clay loam soils of Madurai, Tamilnadu.

2.4.3.5.1 Effect on weed species

Naidu *et al.* (2012) reported that quizalofop-p-ethyl @ 50g and 75g ha⁻¹ was found ineffective in controlling weeds both at 30DAS and 60DAS. The poor performance of quizalofop-p-ethyl might be due to absence of grassy weeds in crop-weed ecosystem on sandy clay loam soils of Naira, Andhra Pradesh.

Pyare *et al.*(2013) reported lowest weed population (2.31 and 1.97 m⁻²) under two hand weedings followed by quizalofop-ethyl 5% EC @ 50g ha⁻¹ (2.67 and 2.11 m⁻²). Among the weedicides used the lowest weed population of *Digera arvensis* was recorded in quizalofop- ethyl 5% EC @ 50 g ha⁻¹ on sandy loam soils at Kanpur, Uttarpradesh.

Marimuthu *et al.* (2016) inferred that among the treatments, pre- emergence application of pendimethalin (0.75 kg ha⁻¹) at 3 DAS fb mixture of imazethapyr (50 g ha⁻¹) + quizalofop ethyl (50 g ha⁻¹) as post emergence on 20 DAS recorded higher weed control efficiency of 78 per cent *Trianthema portulacastrum*, *Cleome viscosa* in *rabi* and 77.94 per cent in summer on sandy clay loam soils of Madurai, Tamilnadu.

2.4.3.5.2 Time and method of application

Balyan *et al.* (2016) reported the highest values for plant height (64.6 cm), branches plant⁻¹(4.67), pods plant⁻¹ (48.67), grains pod⁻¹ (8.07), pod length (5.48 cm) and 1000- seed weight (45.90 g) under interculture at 15 DAS *fb* quizalofop-ethyl 50 g ha⁻¹ at 30 DAS due to reduced crop-weed competition on sandy clay loam soils of Udaipur, Rajasthan.

Marimuthu *et al.* (2016) reported that application of pendimethalin @ 0.75 kg ha⁻¹ as pre emergence *fb* application of mixture of imazethapyr and quizalofop ethyl each @ 25 g or 50 g ha⁻¹ at 20 DAS for effective and economic weed management as well as higher crop productivity in irrigated blackgram during both *rabi* and summer season on sandy clay loam soils of Madhuri, Tamilnadu.

2.5 Effect on Micro - organisms

Rodriguez *et al.* (2004) evaluated the effects of pendimethalin (600 and 1200 g ha⁻¹) on the biological activity in a greenhouse experiment. The results revealed that higher doses of pendimethalin had inhibitory effect on soils microorganisms through reduction of soil respiration and microbial biomass during the first seven days of incubation.

Rupela *et al.* (2005) confirmed that the effects of organics on microbial biomass under soil respiration were higher in the organic plots as compared to conventional as well as chemical farming in low-input farming system, at ICRISAT, Hyderabad.

According to Latha and Gopal (2010) butachlor, was more inhibitory to microbial population (7.85 to 34.20 % reduction over control) when compared to 2, 4- DEE, pretilachlor and pyrazosulfuron ethyl. Among the various concentrations tested, the 100 FR treatment recorded a reduction of 11.57 to 47.96% over control treatment for soil microbial population at Coimbatore, Tamilnadu.

Suresh and Qureshi (2010) revealed that application of lower doses of pendimethalin @ 1.0 kg ha⁻¹ followed by either inter cultivation at 20 to 25 days after sowing or hand weeding maintained favourably higher activity of soil enzymes and microbial activity in sunflower.

Baboo *et al.* (2013) concluded that herbicide treatments resulted in variation of enzyme activities, while highest activity was recorded for control soil. The gradual increase in microbial counts may be attributed to their ability to temporarily mineralize and use herbicides as energy source. The study suggested that the herbicides cause transient impact on microbial populations and enzyme activities associated with the type of herbicides at recommended field application rate at Sambalpur, Orissa.

Khuntia *et al.* (2013) reported that all the herbicides exhibited detrimental influence on soil microflora upto 15 days after application but recovered later on. oxadiargyl @ 0.1 kg ha⁻¹ showed minimum bacterial population at 15 days after planting which may be attributed to phytotoxic effect of this chemical on rice plant at Bhadrak, Odisha.

Jaya *et al.* (2015) concluded that in farmers fields in tropical vertisols of peninsular India, “high” fertilizer and pesticide usage at about 2.3 times the recommended rates in black gram (*Vigna mungo*) did not have a deleterious effect on the abundance of culturable microorganisms, associative nitrogen fixers, nitrifiers.

Shruthi and Salakinkop (2015) reported that pre-emergence herbicides significantly decreased the microbial load including root nodules in the soil at initial stages of application in greengram. But at later stages they recovered due to rapid degradation of herbicides due to production of soil enzymes on clay loam soils at Dharward, Karnataka.

According to Trimurthulu *et al.* (2015) the yield increase by application of oxyfluorfen is not only because of its chemical nature of suppressing weeds but also its synergistic influence of enhancing soil microbial populations and their activities which are the major contributing factors for obtaining significantly higher yields over control on vertisols of Amaravathi, Andhra Pradesh.

2.6 WEED CONTROL EFFICIENCY

Application of imazethapyr @ 0.1 kg ha⁻¹ controlled the weeds most effectively than other herbicides in summer irrigated blackgram on clay loam soils of Jabalpur, Madhya Pradesh (Mishra and Bhanu, 2006).

Kumar *et al.* (2006) reported that the highest weed control efficiency of 92% was recorded with pendimethalin @ 0.75 kg ha⁻¹ + one hand weeding (45 DAS) in blackgram on silty clay loam soils of Palampur, Himachal Pradesh.

Pre-emergence sand mix application of pendimethalin @ 1.0 kg ha⁻¹ followed by sequential application of imazethapyr @ 50 g ha⁻¹ at 20 DAS recorded higher weed control efficiency (WCE) of 70 % at 60 DAS and was at par with other sequential treatments and also with hand weeding at 15 and 30 DAS in rice fallow blackgram on clay soils of Guntur, Andhra Pradesh (Rao 2010).

Adpawar *et al.* (2011) found that the highest weed control efficiency was observed in treatment with one hoeing+one hand weeding (74.50%), followed by pendimethalin @ 1.0 kg ha⁻¹ as pre-emergence *fb* one hoeing at 30 DAS in blackgram on clay loam soils of Akola, Maharashtra.

Khan *et al.* (2011) found that hand weeding controlled the weeds by 76% over control which was at par with that of pendimethalin (75%) applied @ 2.0 and 3.0 L ha⁻¹ (85%) in greengram on clay soils of Pakistan.

Nandan *et al.* (2011) registered that the highest weed control efficiency of 90.48% was obtained with application of imazethapyr @ 250 ml ha⁻¹ at 15-20 DAS in blackgram on sandy loam soils of Samba, Jammu and Kashmir.

Bera *et al.* (2012) reviewed that combined chemical treatment of UPH-203 (clodinafop-propargyl) +Na-acifluorfen 10% SL, @ 100 g ha⁻¹ + 206.2 g ha⁻¹, 80 g ha⁻¹+ 165.0 g ha⁻¹ and 60 g ha⁻¹+ 123.7 g ha⁻¹ gave less weed dry weight and more weed control efficiency as compared to their sole applied chemical treatments.

Choudhary *et al.* (2012) stated that weed free plot recorded 100% weed control efficiency followed by hand weeding twice (86.2%) and pendimethalin @ 1.5 l ha⁻¹ followed by one hand weeding (78.8%) over weedy check in blackgram on silty loam soils of Basar, Arunachal Pradesh.

The highest value of weed control efficiency was recorded under weed free (83 and 82%), followed by two hand weedings at 20 and 40 DAS (80 and 79%), imazethapyr as post emergence @ 40 g ha⁻¹ at 20 DAS (78 and 76%) and Imazethapyr @ 25 g ha⁻¹ at 20 DAS (75 and 73%) at 60 DAS and harvest, respectively in blackgram on sandy loam soils of Jammu and Kashmir (Gupta *et al.*, 2014).

Balyan *et al.* (2016) reported highest weed control efficiency with alachlor @ 1.0 kg ha⁻¹ (PE) *fb* imazethapyr @ 100 g ha⁻¹ at 30 DAS, in blackgram on sandy clay loam soils of Udaipur, Rajasthan.

Singh *et al.* (2016) reported that pre emergence application of imazethapyr + pendimethalin (pre-mix) @ 1.0 kg ha⁻¹ resulted in 70.1% WCE which was followed by imazethapyr + imazamox (pre-mix) applied @ 70 g ha⁻¹ (63.3%) in Pantnagar, Uttarakhand.

2.7 GROWTH PARAMETERS

Veeraputhiran and Chinnusamy (2008) asserted that among the doses, the effect of imazethapyr @ 90 and 75 g ha⁻¹ on plant height was almost same, however, imazethapyr @ 90 g ha⁻¹ recorded significantly higher leaf area index (3.79) and dry matter production (2546 kg ha⁻¹) than @ 75 g ha⁻¹. Post emergence application of imazethapyr @ 60 g ha⁻¹ recorded significantly the shortest plants, lowest leaf area index and drymatter production in relay crop of blackgram on clay loam soils of Killikulam, Tamil Nadu.

Naidu *et al.* (2011) indicated that among the herbicides, the highest crop drymatter accumulation at harvest was obtained with imazethapyr @ 150 g ha⁻¹, which was on par with the rest of the herbicides except, imazethapyr @ 200 g ha⁻¹, quizalofop-p-butyl @ 50 g a.i ha⁻¹ and quizalofop-p-butyl @ 75 g a.i ha⁻¹ in rice-fallow blackgram on sandy clay loam soils of Naira, Andhra Pradesh.

Aggarwal *et al.* (2014) reported that imazethapyr @ 100 g ha⁻¹ at 15 DAS resulted in the highest plant height, being statistically at par with all other weed-control treatments except imazethapyr @ 50 g ha⁻¹ at 15 and 25 DAS and unweeded control in blackgram on sandy loam soils of Ludhiana, Punjab.

The maximum plant height and drymatter accumulation was recorded under weed free treatment at all the growth stages followed by pre emergence application of imazethapyr @ 0.10 kg ha⁻¹ fb hand weeding at 30 DAS (46.15 and 50.85 cm) and maximum drymatter accumulation of 108.88 and 159.31 g m⁻¹ row length at 50 DAS and at harvest stages in blackgram, on sandy loam soils of Bikaner, Rajasthan (Jakhar *et al.*, 2015).

According to Yadav *et al.* (2015), the weed free plot was significantly superior in respect of growth and yield attributes as compared to all other treatments and among the herbicidal treatments, the highest plant height (96.6 and 96.2 cm), number of leaves (35.7 and 35.2), pod length (4.42 and 4.41 cm), number of branches (16.9 and 16.9 plant⁻¹) and number of pods (65.69 and 57.7 plant⁻¹) were recorded with imazethapyr+imazamox (pre-mix) @ 0.05 kg ha⁻¹ and pendimethalin+ imazethapyr (pre-mix) @ 1.0 kg ha⁻¹, respectively in blackgram on sandy loam soils of Gwalior, Madhya Pradesh

2.8 YIELD ATTRIBUTES AND YIELD

2.8.1 Yield Attributes

Asaduzzaman *et al.* (2010) indicated that two weedings recorded the highest number of pods plant⁻¹ (14.40), seeds pod⁻¹ (7.47), 1000-seed weight (42.09 g), seed yield (1.39 t ha⁻¹), biological yield (3.025 t ha⁻¹) and harvest index (45.59) followed by one hand weeding in blackgram on shallow red brown terrace soils of Dhaka, Bangladesh.

Mundra and Maliwal (2012) reported that in blackgram on sandy clay loam soils of Udaipur, Rajasthan, the highest number of branches plant⁻¹, pods plant⁻¹ and seeds pod⁻¹ were recorded in treatment receiving two hand weedings at 20 and 35 DAS with values of 4.99, 37.48 and 6.93, respectively.

Aggarwal *et al.* (2014) declared that imazethapyr @ 100 g ha⁻¹ at 15 DAS resulted in maximum pods plant⁻¹ which were statistically at par with two hand-weedings and was significantly higher than all other weed-control treatments in blackgram on sandy loam soils of Ludhiana, Punjab.

Gupta *et al.* (2014) observed that two hand weedings at 20 and 40 DAS and imazethapyr (post emergence) @ 40 and 25 g ha⁻¹ at 20 DAS recorded on par pods plant⁻¹ (14.6), grains pod⁻¹ (3.53), grain and stover yield (392 and 863 kg ha⁻¹) as compared with weed free treatment in blackgram on sandy loam soils of Jammu and Kashmir.

Kumar *et al.* (2015) reported that an increase in grain weight per plant by 83.3%, 76.4% and 73.1% with treatments receiving two hand weedings, pendimethalin as pre emergence + hand weeding at 40 DAS and oxyfluorfen as pre emergence + hand weeding at 40 DAS, respectively when compared to weedy check on sandy loam soils of Meerut, Uttar Pradesh.

2.8.2 Seed Yield

Gousia and Rao (2006a) reported highest grain yield (930 kg ha⁻¹) with imazethapyr closely followed by thiobencarb (922 kg ha⁻¹), cyhalofop-butyl (876 kg ha⁻¹), fenoxaprop-ethyl (832 kg ha⁻¹) and clodinafop-propargyl (827 kg ha⁻¹) due to lower weed dry weight and better weed control in relay crop of blackgram on sandy clay loam soils of Bapatla, Andhra Pradesh.

Application of imazethapyr at 21 DAS @ 90 g a.i. ha⁻¹ was found to be superior as compared with other times and rates of application in blackgram under rice fallow situation on clay loam soils of Killikulam, Tamil Nadu (Veeraputhiran *et al.*, 2008).

Rao *et al.* (2010) reported that among the treatments, pre emergence sand mix application of pendimethalin @ 1.0 kg ha⁻¹ followed by imazethapyr 50 g ha⁻¹ at 20 DAS recorded significantly highest seed yield (1113 kg ha⁻¹) over all other treatments, except with the treatments, oxyfluorfen @ 120 g ha⁻¹ followed by imazethapyr (50 g ha⁻¹) and hand weeding at 15 and 30 DAS (1201 kg ha⁻¹) in rice fallow blackgram on clay soils of Guntur, Andhra Pradesh.

In summer blackgram Khot *et al.* (2015) reported higher grain (1050 kg ha⁻¹) and stover yield (1364 kg ha⁻¹) in weed free treatment throughout crop season which was statistically at par with treatments, pendimethalin @ 1.0 kg ha⁻¹ pre-emergence *fb* hand weeding *fb* inter cultivation at 40 DAS, two hand weedings at 20 and 40 DAS and oxyfluorfen @ 0.18 kg ha⁻¹ pre-emergence *fb* hand weeding *fb* inter cultivation at 40 DAS on clay soils of Junagadh, Gujarat.

Hemlata *et al.* (2016) reported significantly higher seed yield with hand weeding twice at 20 and 40 DAS (0.695 t ha^{-1}) than the other treatments tested and the lowest yield with unweeded check (0.343 t ha^{-1}) in blackgram on sandy loam soils of Raipur, Chhattisgarh.

2.8.2.1 WEED INDEX

Kundu *et al.* (2011) recorded the lowest harvest index (22.37%) as well as maximum weed index (43.34%) with weedy check treatment and the treatments imazethapyr @ 125 g , 150 g , 100 g ha^{-1} at 10 DAS could not make far difference with each other and showed minimum weed index (8.86, 11.15 and 12.26%, respectively) in soybean on sandy loam soils of Nadia, West Bengal.

Gupta *et al.* (2014) indicated the lowest value of weed index in two hand weedings at 20 and 40 DAS to the tune of 2.5 and was followed by imazethapyr (post emergence) @ 40 g ha^{-1} at 20 DAS, 25 g ha^{-1} at 20 DAS and pendimethalin (pre-emergence) @ 1.0 kg ha^{-1} (5.8, 9.9 and 15.4), respectively and the highest weed index (35.2) was recorded under weedy check in blackgram on sandy loam soils of Jammu and Kashmir.

Komal *et al.* (2015) noticed that besides weed free treatments pendimethalin @ 0.75 kg ha^{-1} as pre-emergence followed by imazethapyr+imazamox @ 40 g ha^{-1} at 30 DAS, imazethapyr+imazamox @ 60 g ha^{-1} at 20 DAS *fb* one hand weeding at 40 DAS and imazethapyr+imazamox @ 40 g ha^{-1} at 20 DAS as post-emergence *fb* one hand weeding at 40 DAS recorded lower weed index 4.79%, 6.07% and 7.51% and higher weed control efficiency 99.8%, 99.8%, 99.6% and 98.6% in greengram on sandy loam soils at Bikaner, Rajasthan.

According to Balyan *et al.* (2016) lowest weed index was found in manual weeding at 15 and 30 DAS (55.45%) and the highest weed index (98.8%) was recorded with interculture at 15 DAS *fb* quizalofop-ethyl @ 50 g ha^{-1} at 30 DAS, which was at par with pendimethalin @ 1.0 kg ha^{-1} PE *fb* imazethapyr @ 100 g ha^{-1} at 30 DAS, pendimethalin @ 1.0 kg ha^{-1} PE *fb* quizalofop-ethyl @ 50 g ha^{-1} at 30 DAS, alachlor @ 1.0 kg ha^{-1} PE *fb* imazethapyr @ 100 g/ha at 30 DAS, alachlor 1.0 kg ha^{-1} PE *fb* quizalofop-ethyl @ 50 g ha^{-1} at 30 DAS, interculture 15 DAS *fb* imazethapyr @ 100 g ha^{-1} at 30 DAS, imazethapyr 100 g ha^{-1} at 20 DAS, and quizalofop ethyl @ 50 g ha^{-1} at 30 DAS on sandy clay loam soils of Udaipur, Rajasthan.

2.9 ECONOMICS

Sumachandrika *et al.* (2002) noticed that the maximum net income of Rs. 10,997 was obtained with early post-emergence application of imazethapyr @ 0.1 kg a.i. ha⁻¹ among the herbicidal treatments over no weeding in *kharif* blackgram on clay soils of Bapatla, Andhra Pradesh.

Veeraputhiran *et al.* (2008) reported that in blackgram under rice fallow situation on clay loam soils of Killikulam, Tamil Nadu revealed that post emergence application of imazethapyr at 21 DAS was found more remunerative as it fetched maximum gross income of Rs. 18985 ha⁻¹, net income of Rs. 11845 ha⁻¹ and benefit cost ratio of 2.66. Regarding doses @ 90 g ha⁻¹ recorded higher gross income (Rs. 18775 ha⁻¹), net income (Rs. 11365 ha⁻¹) and benefit cost ratio (2.53).

The highest net monetary return (Rs. 22,255 ha⁻¹) and benefit cost ratio of 1.33 was obtained with pre-emergence sand mix application of pendimethalin @ 1.0 kg ha⁻¹ followed by imazethapyr 50 g ha⁻¹ at 20 DAS in rice fallow blackgram on clay soils of Guntur, Andhra Pradesh (Rao *et al.*, 2010).

The highest net monetary returns, gross monetary returns and B:C ratio were observed in treatment with one hoeing+one hand weeding i.e., (Rs. 12,777 ha⁻¹, 20782 ha⁻¹ and 2.60) followed by pendimethalin 100 kg a.i. ha⁻¹ as pre-emergence+one hoeing at 30 DAS (Rs. 11909 ha⁻¹, 20124 ha⁻¹ and 2.45, respectively) in blackgram on clay loam soils of Akola, Maharashtra (Adpawar *et al.*, 2011).

Naidu *et al.* (2011) reported that the highest B:C ratio (2.75) was with pendimethalin @ 1.0 kg a.i ha⁻¹, which might be due to higher seed yield coupled with lower cost of chemical (Rs. 300 l⁻¹) and it is the cost effective method of controlling *Vicia sativa* in rice-fallow blackgram on sandy clay loam soils of Naira, Andhra Pradesh.

Pal *et al.* (2013) reported that the highest net present value (NPV) was obtained with the treatment UPH-203 (clodinafop-propargyl) @ 100 g ha⁻¹+Na-acifluorfen 10 % SL @ 206.2 g ha⁻¹ (1.15) which was closely followed by twice hand weeding at 15 and 30 DAS (1.10) and imazethapyr 10 % SL @ 1.0 kg ha⁻¹ (0.99) in soybean on sandy loam soils of Nadia, West Bengal

Pre-emergence application of imazethapyr @ 0.10 kg ha⁻¹ *fb* hand weeding at 30 DAS provided the maximum net returns of Rs. 34815 ha⁻¹ with B:C ratio of 2.09 thereby, increasing the net returns by margin of Rs. 27883 ha⁻¹ over weedy check in blackgram on loamy sandy soils of Bikaner, Rajasthan (Jakhar *et al.*, 2015).

Balyan *et al.* (2016) reported highest value of net returns (Rs.42803/-) and B:C ratio (5.92) with application of quizalofop ethyl @ 50 g ha⁻¹ at 30 DAS, followed by imazethapyr @ 100 g ha⁻¹ 20 DAS with net returns (Rs. 41976/-) and B:C ratio (5.83) in blackgram on sandy clay loam soils of Udaipur, Rajasthan.

From the above review, it can be summarized that weed flora in *rabi* blackgram is dynamic and varies with location and growing conditions. Weeds effectively compete with blackgram up to 30-45 DAS and reduce grain yield. Though hand weeding along with intercultivation is very effective in controlling weeds, but it is difficult to practice in *rabi* blackgram due to non availability of labour in time and increased labour wages. Among chemical weed control measures sequential use of pre and post emergence herbicide combinations is gaining popularity. The present study was carried out to evaluate the combination herbicides for the control the important weeds which adversely effect the yields of *rabi* blackgram and also for broad spectrum weed control to realize the economic yields in *rabi* blackgram.

Chapter- III

MATERIAL AND METHODS

Field experiment was conducted at Regional Agricultural Research Station, Lam, during *rabi*, 2016 to study the “Herbicidal efficacy of certain herbicides and influence on soil microflora in *rabi* blackgram (*Vigna mungo* (L.) ”. The details of materials used and methods followed in the investigation are described in this chapter.

3.1 LOCATION

The experiment was laid out in field No. 2A at Regional Agricultural Research Station, Lam. The experimental site was situated at an altitude of 35.1 m above mean sea level, 16° 18^I N latitude, 80° 29^I E longitude and about 7 km away from the Guntur railway station junction in the Krishna Agro Climatic Zone of Andhra Pradesh, India.

3.2. WEATHER

The weather data recorded during crop growth period are presented in table 3.1 and depicted in Fig. 3.1 and 3.2.

The weekly mean maximum temperature ranged from 30.4°C to 35.1°C with an average of 33.2°C and the weekly mean minimum temperature ranged from 15.4°C to 23.4°C with an average of 19.3°C during the crop growth period (29.09.2016 to 15.12.2016). The weekly mean relative humidity varied from 64.9 to 80.6 percent with an average of 71.4 percent. A total rainfall of 176.8 mm was received in 9 rainy days during the crop growing period.

Table 3.1: Weekly weather data recorded at Regional Agricultural Research Station, Lam, during the crop growth period (29-09-2016 to 15-12-2016)

Standard meteorological week	Date and month	Weekly temperature (°C)			Mean relative humidity (%)	Rainfall (mm)	No. of rainy days
		Maximum	Minimum	Mean			
39	24 Sept. – 30 Sept.	32.0	23.4	27.7	79.6	13.3	2.0
40	01 Oct. - 07 Oct.	32.9	22.9	27.9	80.6	120.7	4.0
41	08 Oct. - 14 Oct.	33.2	22.6	27.9	73.4	33.8	2.0
42	15 Oct. – 21 Oct.	34.9	19.4	27.1	69.1	0.0	0.0
43	22 Oct. – 28 Oct.	35.1	19.1	27.1	69.4	0.0	0.0
44	29 Oct. - 04 Nov.	34.1	21.0	27.6	71.6	0.0	0.0
45	05 Nov. -11 Nov.	34.5	17.1	25.8	68.1	0.0	0.0
46	12 Nov. -18 Nov.	33.7	19.4	26.6	72.2	0.0	0.0
47	19 Nov. -25 Nov.	32.7	15.4	24.1	66.9	0.0	0.0
48	26 Nov. - 02 Dec.	32.9	16.0	24.5	65.7	0.0	0.0
49	30 Dec. – 09 Dec.	32.5	17.9	25.2	64.9	0.0	0.0
50	10 Dec – 16 Dec.	30.4	17.9	24.2	75.6	9.0	1.0
Total		-	-	-	-	176.8	9
Mean		33.2	19.3	-	71.4	-	-

3.3 EXPERIMENTAL SOIL

Initial soil samples were collected from 0 - 15 cm soil depth at random in the experimental field before the sowing of blackgram. The samples were dried in shade, powdered and passed through 2 mm sieve. A homogeneous composite sample was prepared and analyzed for various physical and chemical properties by following standard procedures (Table 3.2).

The results indicated that the texture of the soil was clay and was slightly alkaline in reaction (pH 7.85). The soil was low in organic carbon (0.35). Available nitrogen content of the soil was low (188 kg ha⁻¹). Phosphorus and potassium availability status of the soil is medium and high with 47 kg ha⁻¹ and 870 kg ha⁻¹, respectively.

TABLE 3.3. Physical and chemical characteristics of the experimental soil

Property	Value	Method of analysis
Mechanical analysis		
Sand (%)	24	Bouyoucos hydrometer (Piper, 1966)
Silt (%)	18	
Clay (%)	58	
Textural class	Clay	
Chemical analysis		
Soil pH (1:2.5soil-water suspension)	7.8	Glass Electrode Method (Richards,1954)
EC(dS m ⁻¹ at 25°C)	0.26	Digital EC Meter (Jackson,1973)
Organic carbon (%)	0.35	Walkely and Black's modified method (Walkely and Black,1934)
Available nitrogen (kg ha ⁻¹)	188	Alkaline permanganate method (Subbiah and Asija, 1954)
Available P ₂ O ₅ (kg ha ⁻¹)	47	Olsen's extractant method (Olsen <i>et al.</i> , 1954)
Available K ₂ O (kg ha ⁻¹)	870	Neutral normal ammonium acetate method (Jackson, 1973)

3.4. CROPPING HISTORY OF THE EXPERIMENTAL FIELD

The details of the crops grown in the experimental field during the past three years

Year	Season	
	Kharif	Rabi
2013-2014	Jute	Fallow
2014-2015	Bhendi	Fallow
2015-2016	Fallow	Blackgram
2016-2017	Fallow	Blackgram (Present Study)

3.4 EXPERIMENT DETAILS

3.4.1 Treatments

The experiment consisted of the following 10 treatments.

- T₁- Pendimethalin @ 0.75 kg ha⁻¹ (PE) fb one intercultivation (20 DAS) fb hand weeding (30 DAS)
- T₂- Pendimethalin @ 0.75 kg ha⁻¹ (PE) fb Quizalofop ethyl @ 50g ha⁻¹ (PoE) at 20 DAS
- T₃- Pendimethalin @ 0.75 kg ha⁻¹(PE) fb Imazethapyr 50g ha⁻¹ (PoE) at 20 DAS
- T₄- Pendimethalin @ 0.75 kg ha⁻¹ (PE) fb Acifluorfen + Clodinafop Propargyl @ 124 g ha⁻¹ + 60 g ha⁻¹ (PoE) at 20 DAS.
- T₅- Alachlor @ 1.0 kg ha⁻¹ (PE) fb one intercultivation (20 DAS) fb hand weeding (30 DAS)
- T₆- Alachlor @ 1.0 kg ha⁻¹(PE) fb Quizalofop ethyl 50g ha⁻¹ (POE) at 20 DAS
- T₇- Alachlor @ 1.0 kg ha⁻¹(PE) fb Imazethapyr @ 50g ha⁻¹ (POE) at 20 DAS
- T₈- Alachlor @ 1.0 kg ha⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124 g ha⁻¹ + 60 g ha⁻¹ (PoE) at 20 DAS
- T₉- Hand weeding twice (20 and 40 DAS)
- T₁₀- Unweeded check

3.4.2 Design of the Layout

The experiment was laid out in a Randomized Block Design with ten treatments and replicated three times (Fig.3.3)

3.4.3 Varietal Description

The variety selected was GBG.1, developed at Agricultural Research Station, Ghantasala. It is a cross derivative of LBG 685 x PU31. It is a photo insensitive variety. It is resistant to Yellow Mosaic Virus. Pods are hairy. Seeds are medium sized, bold and black shining. Duration is 70-75 days and yield potential is 1500-2000 kg ha⁻¹.

3.4.4 Sampling

For destructive sampling, five successive plants were sampled each time in the second row from the border on either side to record drymatter production. The samples taken were shade dried and then oven dried at 60⁰C till a constant weight was obtained. Sampling was done at 30, 60 DAS and at harvest to study the drymatter production.

3.4.5 Non- destructive Sampling

For non-destructive sampling, 10 representative plants were selected randomly and tagged in each plot after leaving three rows from each side of the plot. The biometric data and post harvest observations were recorded on the tagged plants.

3.5 CULTIVATION DETAILS

The calendar of operations were furnished in Appendix II

3.5.1 Land Preparation

The experimental field was ploughed twice with a tractor drawn cultivator. After thorough land levelling, the area was divided into required number of plots as per the layout plan (Fig. 3.3).

3.5.2 Fertilizer Application

Recommended dose of nitrogen in the form of urea and phosphorus as single super phosphate was applied basally in the last ploughing to meet the requirement of recommended 20 kg N and 50 kg P₂O₅ per ha.

3.5.3 Seeds and Sowing

The seeds of blackgram (GBG 1) were sown by tractor drawn seed drill at recommended seed rate of 20 kg ha⁻¹. Seed treatment was done with thiamethoxam 70 WS @ 5g kg⁻¹ of seed before sowing to protect the crop from sucking pests upto 15-20 days after sowing.

3.5.4 Herbicides

The details of herbicides used in the present investigation are furnished in table 3.5.

3.5.5 Thinning

Gap filling was done in seven days after sowing and the excess seedlings were removed to maintain optimum plant population.

3.5.6 Irrigation

The plots were irrigated at 50 days after sowing with sprinklers to give 20 mm water.

3.5.7 Plant Protection

At 20 days stage of the crop, monocrotophos @ 1.6 ml L⁻¹ of water was sprayed against infestation of stem fly. Incidence of *Maruca vitrata* was observed at flowering stage and Chloropyriphos @ 2.5 ml L⁻¹ + Dichlorovos @ 1.0 ml L⁻¹ of water was sprayed to control the pest.

3.5.8 Harvesting and Threshing

At harvest the border rows were harvested separately. The plants from net plot were harvested and sundried for four days, bundled, tagged, weighed and transported to threshing floor.

3.6 TREATMENT IMPOSITION

The required amount of herbicide for the experimental treatment was calculated by using the following formula

$$S = \frac{R \times 100}{\text{Purity \%}} \times \frac{A}{10,000}$$

S= formulated product required in kg ha⁻¹

R= Active ingredient (kg ha⁻¹) to be sprayed (recommended rate)

A= Area to be sprayed in m²

Thus calculated amount of herbicide was sprayed to each treatment using hand operated knapsack sprayer with flood jet nozzle and a spray volume of 500 litres of water per hectare.

3.6.1 Pre-emergence Herbicides

Pre-emergence herbicides *i.e.* Pendimethalin (Stomp 30 EC @ 0.75 kg ha⁻¹) and Alachlor (Lasso 50 EC @ 1 kg ha⁻¹) were sprayed immediately after sowing as per the treatments.

3.6.2 Post-emergence Herbicides

As there were good rains (120.7 mm) within 10 DAS, post emergence herbicides were sprayed at 20 days after sowing, the post emergence herbicides viz., Quizalofop ethyl (Targa super 5% EC) @ 50 g ha⁻¹, Imazethapyr (Pursuit 10 EC) @ 50 g ha⁻¹, Acifluorfen 16.5% EC + Clodinafop propargyl 8.0% EC (Iris) @124+60 g ha⁻¹ were sprayed according to the treatments.

3.6.3 Intercultivation and Hand Weeding

Intercultivation with manual gorru at 20 DAS and hand weeding at 30 DAS was done in T₁ and T₅ treatments. In the T₉ treatment hand weeding was done at 20 and 40 DAS.

3.6.4 Weedy check

No weeding operation or intercultivation was done in the weedy check treatment.

3.7 OBSERVATIONS RECORDED

3.7.1 On Weeds

3.7.1.1 Weed density

Weed counts of different groups viz., grasses, sedges, broad leaved weeds were recorded at 20, 40 DAS and at harvest using 0.5 m × 0.5 m (0.25 m²) quadrat from four places in net plot. These three groups were added to obtain total weed population per square meter and expressed as number per square meter.

3.7.1.2 Weed drymatter

All the weeds present in a quadrat of 0.5 m × 0.5 m (0.25 m²) area, selected at random in the sampling area kept for destructive sampling were picked up at 30, 60 DAS and at harvest. After sun drying, the samples were put in oven at 60°C till a constant weight is obtained. The weed dry weight was recorded and expressed in g m⁻².

3.7.1.3 Weed control efficiency (%)

Weed control efficiency indicates the effectiveness of a treatment in controlling weeds. The weed control efficiency of different weed control treatments at 30,60 DAS and at harvest was worked out by using the formula given by Mani *et al.* (1973).

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

Where,

X = Dry weight of weeds in unweeded check plot

Y = Dry weight of weeds in the treatment plot.

3.7.1.4 Weed index (%)

Weed index indicates the extent of reduction in yield due to crop weed Competition. It was worked out for different treatments by adopting the formula given by Gill and Kumar, (1969).

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

Where,

X = Grain yield from weed free check or yield from treatment that gave maximum yield. (Pendimethalin @ 0.75 kg ha⁻¹ (PE) fb one intercultivation at 20 DAS fb hand weeding at 30 DAS).

Y = Grain yield from treatment for which weed index is to be calculated.

3.7.2 Observations on Crop

3.7.2.1 Crop stand

Four quadrates each with an area of 0.25 m² were randomly fixed at four different places in the net plot area and the plant population was recorded in each quadrate at 20 and 40 days after sowing. The total crop stand per m² was arrived by adding all the above four quadrants and expressed in number m².

3.7.2.2 Crop injury score:

Injury effects of the herbicides used if any, to the blackgram in each treatment was visually assessed at 7 and 14 days after application of the herbicide as per the phytotoxicity score card.

Table 3.5 Quantitative description of treatment effects on crop in the visual scoring scale of 0-10 (equal to 0-100%)

Effect	Rating	Description
None	0	No injury, normal
	1	Slight stunting, injury or discolour
Slight	2	Some stand loss, stunting /discolour
	3	Injury more pronounced but not persistent
	4	Moderate injury, recovery possible
Moderate	5	Injury more persistent, recovery doubtful
	6	Near severe injury, stand loss
	7	Severe injury, stand loss
Severe	8	Almost destroyed, a few plants surviving
	9	Very few plants alive
Complete	10	Complete destruction

3.7.2.3 Plant height

Five plants were selected at random in the net plot and marked for recording plant height at 30, 60 DAS and at maturity. The plant height was measured from the base of the plant to the tip of terminal bud and expressed in centimeters (cm).

3.7.2.4 Drymatter accumulation

Five successive plants from the destructive sampling area were collected at 30, 60 DAS and at maturity. The plant samples so collected were sun dried and later oven dried at 60°C till a constant weight is obtained. The data was computed and expressed as kg ha⁻¹.

3.7.2.5 Number of pods per plant

The total numbers of pods were counted from the five randomly selected plants in the net plot area and averaged as number of pods per plant.

3.7.2.6 Number of seeds per pod

The total number of seeds present in five pods selected at random from the net plot area was counted and expressed as seeds averaged per pod. After counting, these seeds were added to the net plot seed yield.

3.7.2.7 100 seed Weight

One hundred seeds were counted by drawing a random sample from net plot produce and weighed and expressed in grams. After weighing, these seeds were added to the net plot seed yield.

3.7.2.8 Biological yield

After threshing, cleaning and drying the weight of the seeds was recorded in kilograms per net plot and expressed in kg ha^{-1} after adding the tagged plants yield.

3.7.2.9 Harvest index

Harvest index is the proportion of total dry matter that is accumulated in economic parts. It was worked out using the following formula suggested by Donald, (1962).

$$\text{HI} = \frac{\text{Economics yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

3.8 SOIL MICROBIAL POPULATION

The enumeration of total bacteria and fungi in the soil samples collected from the experimental plots was carried by standard dilution plate count technique. Initial soil sample was taken before sowing of blackgram and later at 10, 20, 30 DAS and at harvest. Nutrient agar (NA) for bacteria and Martin's rose bengal with streptomycin sulphate agar (MRBA) for fungi were used for enumeration of bacteria and fungi. The

petri plates were incubated after plating at 30°C for 2-3 days. Population was counted and expressed as number of cells per gram of soil on dry weight basis for bacteria and cfu g⁻¹ of soil for fungi. The microbial populations *i.e.*, fungi, bacteria and per gram of soil on dry weight basis were estimated by the procedure developed by Allen (1957).

3.9 CHEMICAL ANALYSIS OF SOIL

Composite soil samples were drawn from 0 to 30 cm depth from the experimental site before sowing and from each treatment after harvest of the crop. Both initial and final soil status were analyzed for available nitrogen by alkaline permanganate method (Subbaiah and Asija, 1954) for available phosphorus by Olsen's extractant method (Olsen *et al.*, 1954) and for available potassium by Neutral normal ammonium acetate method (Jackson, 1973).

3.10 ECONOMICS

The cost of cultivation and the gross returns of different weed management treatments were calculated by taking into the input costs and output prices at the time of harvest. The net returns were obtained after deducting the cost of cultivation from gross returns. The benefit-cost ratio was calculated using the following formula

$$\text{Benefit Cost Ratio} = \frac{\text{Gross returns (Rs.ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs.ha}^{-1}\text{)}}$$

3.11 STATISTICAL ANALYSIS

The data obtained on different parameters were analysed statistically using Fisher's method of analysis of variance as suggested by Panse and Sukhatme (1978). The original data on weed densities and weed dry weight were transformed into $\sqrt{X+0.5}$ transformations before subjecting them for statistical analysis. The original values were given in parenthesis.

The significance of treatment effect was tested with the help of F test at 5 percent level of significance in order to compare the treatment means. The results were also depicted by tables and figures where ever necessary.

Chapter IV

RESULTS AND DISCUSSION

The results and discussions of the field experiment “Herbicidal efficacy of certain herbicides and influence on soil microflora in *rabi* blackgram (*Vignamungo*L.)” conducted during *rabi*, 2016 at Research Agricultural Research Station, Lam, Guntur are presented in this chapter.

4.1 WEATHER CONDITIONS AND SOIL

The weather conditions prevailed during the crop growth period was normal. However, there was no rain after 15 days of sowing. The weekly mean temperatures ranged from 24.1°C to 27.9°C with an average of 26.0°C during crop growing period. The weekly relative humidity values during crop growth period varied between 64.9 and 80.6 percent with an average of 72.8 percent. A total rainfall of 176.8 mm was received during the crop growing period. Supplemental irrigation given at pod filling stage has resulted in proper grain filling.

The crop was grown on clay soils with low organic carbon content. The experimental site was slightly alkaline in reaction (7.8), the soil was low in available nitrogen (188 kg ha⁻¹), medium in available phosphorus (47 kg ha⁻¹) and high in available potassium (870 kg ha⁻¹).

4.2 OBSERVATIONS ON WEEDS

4.2.1 Weed Flora

Major weed flora observed during the crop growth period in the experimental plot was reported in Table 4.1 which included 18 species belonging to 14 families consisting of three species under grasses viz., *Cynodon dactylon*, *Dactyloctenium aegyptium*(L.), *Echinochloa colona*(L.), *Dinerba retroflexa*(L.), one sedge viz., *Cyperus rotundus* and 14 broad leaved weed species viz., *Abutilon indicum*(L.), *Acalypha indica*, *Cynotis axillaris*, *Commelina benghalensis*(L.), *Celosia argentic*, *Chorchorus trilocularis*, *Digera arvensis*, *Eclipta alba*, *Cleome viscosa*, *Physalis minima*, *Portulaca quadrifida*, *Trianthema decendra*. Venkateswarlu, 2011 reported similar weed flora in the experiment conducted in black soils of Krishna western delta of Guntur, Andhra Pradesh.

Among the sedges *Cyperus rotundus* was the only species observed and its distribution was not uniform in all the plots in the experiment. Among the grassy weeds *Dinebra retroflexa* was the dominant species and among the broad leaved weeds *Digera arvensis* and *Trianthema portulacastrum* were predominantly observed in the experiment. Higher density of *Trianthema* at 30 DAS was also reported by Kumar *et al.*, 2015.

4.2.2 Weed Density (No.m⁻²)

4.2.2.1 Grasses

The data on density of grasses at 20, 40 DAS and at harvest are presented in table 4.2 and fig. Data revealed that grassy weed population increased from 20 to 40 DAS and further increased as the crop reached maturity stage. Weed management treatments significantly reduced the grassy weed density as compared with weedy check at all the stages.

At 20 DAS, the treatments receiving pre emergence application of pendimethalin @ 0.75 kg ha⁻¹ (T₁ to T₄) and alachlor @ 1.0 kg ha⁻¹ (T₅ to T₈) significantly reduced the grassy weed population when compared to weedy check (76.0) and hand weeding (72). As the first hand weeding at 20 DAS in T₉ was done after the weed sampling, the grassy weed density in hand weeding was more and was on par with weedy check. Reduction grassy weed population due to pre emergence herbicides was reported by Sasikala *et al.* 2014.

At 40 DAS, the lowest grassy weed density (9.3) was with hand weeding (T₉) and was on par with the treatments receiving post emergence application of quizalofop ethyl @ 50 g ha⁻¹ at 20 DAS (T₂ and T₆) and that may be due to effective control of grassy weeds by quizalofop ethyl. The results are in conformity with the findings of Balyan *et al.*, 2016. All the other weed management treatments also recorded significantly low grassy weed density as compared with weedy check (161.3).

At the time of harvest significantly lowest number of grassy weed population was recorded with pre emergence herbicide application of either pendimethalin @ 0.75 kg ha⁻¹ or alachlor @ 1.0 kg ha⁻¹ *fb* intercultivation at 20 DAS *fb* hand weeding at 30 DAS (T₁ and T₅). Similar reduction of grassy weed population with intercultivation was also reported by Khot *et al.*, 2012.

Among the post emergence herbicides at harvest stage, a reduction in grassy weed density observed with post emergence application of imazethapyr @50 g ha⁻¹ (T₃ and T₇) and acifluorfen+ clodinafop propargyl @ 124+60 g ha⁻¹ as compared with quizalofop ethyl @ 50 g ha⁻¹ may be due to the persistence of these herbicides in soil for longer period than quizalofop ethyl. The results are in conformity with those reported by Patil *et.al.*, 2015. The grassy weed population was highest in weedy check at harvest stage (27). The hand weeding treatment (T₉) also recorded more no. of grassy weeds by harvest time which may be due the supplemental irrigation given at 50 days stage of the crop.

4.2.2.2 Sedges

The data recorded on the density of sedges (Table 4.3 and fig.), indicated the gradual increase in the number of sedges from 20 DAS to harvest. However, the spread of the sedge population was not uniform in the experimental plots.

At 20 DAS, all the weed control treatments significantly reduced the sedge population as compared to weedy check, except T₇ i.e. alachlor @ 1.0 kg ha⁻¹ (PE) *fb* imazethapyr @ 50g ha⁻¹(4.06) at 20DAS.

At 40 DAS, comparatively lower sedge population was recorded in treatments with pre emergence application of pendimethalin @ 0.75 kg ha⁻¹ and alachlor @1.0 kg ha⁻¹ followed by intercultivation at 20 DAS and hand weeding at 30 DAS (T₁ and T₅). Intercultivation might have uprooted some of the sedge population.

Different weed management treatments did not show any significant effect on sedge population at harvest stage. However, they recorded significantly low density of sedges as compared with weedy check (50.3).

4.2.2.3 Broad Leaved Weeds

The data on density of broad leaved weeds at 20, 40 DAS and at harvest was represented in table 4.4 and fig. the experimental field was dominated by broad leaved weeds. The density of BLW was significantly high in the weedy check at all the growth stages. Pre emergence application of both pendimethalin @ 0.75 kgha⁻¹ and alachlor @1.0kg ha⁻¹*fb* intercultivation at 20 DAS and hand weeding at 30 DAS (T₁ andT₅) recorded the significantly lowest broad leaved weed density upto harvest stage.

At 20 DAS, significantly lower weed population of broad leaved weeds was recorded with the pre emergence application of pendimethalin @0.75 kg ha⁻¹(T₁ to T₄) when compared to alachlor @1.0 kg ha⁻¹ (T₅ to T₈). Similar results were reported by Ali *et al.*, 2011 in greengram.

Highest population of broad leaved weeds was reported in weedy check (259). Density of BLW in T₉ (187) was also very high because the weed sample collection was done before hand weeding at 20 DAS.

At 40DAS, pre emergence application of pendimethalin @ 0.75 kg ha⁻¹ or alachlor @1.0 kg ha⁻¹ *fb* intercultivation at 20 DAS and hand weeding at 30 DAS treatments (T₁ and T₅) recorded the lowest broad leaved weed density and were on par with the other treatments receiving post emergence application of imazethapyr @50 g ha⁻¹(T₃ and T₇).

Among the post emergence herbicides, acifluorfen+ clodinafop propargyl @ 124+60 g ha⁻¹ at 20 DAS (T₄ and T₈) recorded on par density of BLW with application of imazethapyr @ 50 g ha⁻¹ (T₃ and T₇). Broad leaved weed population was significantly higher in post emergence application of quizalofop ethyl @ 50 g ha⁻¹(T₂ and T₆) when compared to all other post emergence herbicides.

Almost a similar trend was observed at harvest stage also. These results were in agreement with the findings of Khairnair *et al.*, 2014.

4.2.2.4 Total density of weeds (No m²)

The data on total weed density at different intervals of crop growth are presented in table 4.5 and fig. Perusal of the data revealed that the total density of weeds increased as the age of the crop advanced towards harvest. The density of weeds in the experimental plot was very high as indicated by very high values upto harvest in the weedy check.

The total weed density upto 20 DAS reflected the effect of pre emergence herbicides and the data at 40DAS indicated the cumulative effectiveness of PE *fb* post emergence herbicides or PE *fb* intercultivation and hand weeding or hand weeding alone. All the weed management treatments significantly influenced the total weed density at all stages of crop growth.

At 20DAS, all the pre emergence herbicide treatments recorded significantly lower weed density when compared to weedy check (353.3). Among the treatments receiving pre emergence application, pendimethalin @0.75 kg ha⁻¹ recorded significantly lower number of weeds as compared to the treatments receiving alachlor @ 1.0 kg ha⁻¹. It may be due to better control of broad leaved weeds with pendimethalin @ 0.75 kg ha⁻¹ as compared with alachlor. These results were in accordance with Balyan *et al.* (2016). The first hand weeding in T₉ was done after weed data collection and hence, recorded highest weed density (269) which was on par with weedy check (353).

At 40 DAS, the significantly lowest weed density was recorded with pre emergence application of either pendimethalin @ 0.75 kg ha⁻¹ (37.3) or alachlor @ 1.0 kg ha⁻¹ followed by intercultivation at 20 DAS *fb* hand weeding at 30 DAS (T₁ and T₅). Among the post emergence herbicide treatments, application of imazethapyr @ 50 g ha⁻¹ (T₃ and T₇) recorded the significantly lowest weed density. This was on par with the density recorded with acifluorfen+ clodinafop propargyl @ 124+60 g ha⁻¹ at 20 DAS (T₄ and T₈) and hand weeding twice at 20 and 40 DAS (T₉). Almost a similar trend was observed with weed density at the time of harvest.

In general, pre emergence herbicides along with intercultivation at 20 DAS *fb* hand weeding at 30 DAS (T₁ and T₅) recorded the lesser weed density compared to sequential application of pre and post emergence herbicides. The reduced weed density might be due to initial control of weeds by pre emergence herbicides and at later stage by intercultivation or sequential application of herbicides. The results are corroborating with those reported by Patil *et al.*, 2015. Treatments receiving imazethapyr (T₃ and T₇) recorded lowest weed density upto harvest stage which may be due to the effective control of weeds that emerged at later stages of crop growth due to the pre emergence action of imazethapyr. Similar results were reported by Singh *et al.*, 2015.

4.2.3 Weed dry matter (g m⁻²)

The extent of dry matter production of weeds denotes the competition offered by them and is presented in Table 4.6 and fig. In general, the dry matter production increased with the advancement of crop growth upto harvest in all the treatments. At all the stages of crop growth, the maximum dry matter production was observed with weedy check (T₁₀) recording 239, 2856, 3337 g m⁻², respectively at 30, 60 DAS and at harvest.

Significantly lowest dry matter recorded with pendimethalin @ 0.75 kg ha⁻¹ (PE) followed by one intercultivation at 20 DAS followed by hand weeding at 30 DAS (T₁) at all the growth stages.

At 30 DAS, pendimethalin @0.75 kg ha⁻¹(PE) *fb* acifluorfen + clodinafop propargyl (PoE) @ 124+60 g ha⁻¹(T₄) at 20 DAS recorded lowest dry weight (21.3 gm⁻²) which was on a par with T₁,T₃ and T₉.

At 60 DAS, significantly lowest weed dry matter was recorded with pendimethalin @ 0.75 kg ha⁻¹ *fb* intercultivation at 20 DAS and hand weeding at 30 DAS i.e. T₁ (44 g m⁻²) and was on a par with T₅ (67 g m⁻²) and T₉ (93 g m⁻²). Among post emergence herbicides the treatment receiving pendimethalin @ 0.75 kg ha⁻¹*fb* imazethapyr @50g ha⁻¹(T₃) recorded significantly lowest weed dry weight (229 g m⁻²) than post emergence of quizalofop ethyl @ 50g ha⁻¹(T₂ and T₆) and was on par with T₄ i.e. pendimethalin @ 0.75 kg ha⁻¹ (PE) *fb* acifluorfen + clodinafop propargyl (PoE) @ 124+60 g ha⁻¹(308 g m⁻²).

At harvest, the lowest weed dry matter(556 g m⁻²)with pendimethalin @ 0.75 kg ha⁻¹ (PE) followed by one intercultivation at 20 DAS followed by hand weeding at 30 DAS (T₁) and was on a par withT₃,T₅,T₄ and T₇.Weed dry matter was highest in treatments with post emergence application of quizalofop ethyl @ 50 g ha⁻¹(T₂ and T₆) which was on par with weedy check which recorded the highest weed dry matter accumulation (3337 g m⁻²).

Pre emergence application of herbicides along with intercultivation at 20 DAS followed by hand weeding at 30 DAS resulted in lower weed dry matter as compared to sequential application of PE and PoE. The reduced weed dry weight in these treatments could be due to effective control of broad leaved weeds, grasses and sedges at critical stage of crop growth. Similar results on beneficial effect of application of herbicides along with intercultivation were reported by Patil *et.al.*, 2015. Among the herbicide treatments a significant reduction in dry weight was recorded with sequential application pre emergence herbicide *fb* imazethapyr @ 50 g ha⁻¹at 20 DAS which may be due to broad spectrum of weed control with imazethapyr. These results are in agreement with the findings of Balyan *et al.*, 2016. The herbicidal treatment with acifluorfen + clodinafop propargyl @ 124+60 g ha⁻¹ (T₄) at 20 DAS was effective when sprayed along with pre emergence application of pendimethalin than alachlor.

4.2.4 Weed Control Efficiency

Weed control efficiency denotes the efficiency of applied herbicides or treatment effect in reducing the dry weight of weeds. It was computed by utilizing the dry matter production data on weeds at 30, 60 DAS and at harvest (Table 4.7). Weed management treatments significantly influenced the weed control efficiency at all the stages of crop growth and the efficiency of the treatments decreased by the time of harvest.

At 30 DAS, all the herbicidal treatments recorded more than 60% WCE and the treatments receiving pendimethalin @ 0.75 kg ha⁻¹ as pre emergence (T₁ to T₄) recorded highest weed control efficiency and were on par with T₉ that received hand weeding. However, alachlor @1.0 kg ha⁻¹ applied as pre emergence, (T₆ to T₈) recorded lower WCE indicating the comparatively lower efficacy of alachlor as pre emergence as compared with pendimethalin.

At 60 DAS, significantly high weed control efficiency (98.5 %) was recorded with pendimethalin @ 0.75 kg ha⁻¹ followed by intercultivation at 20 DAS followed by hand weeding at 30 DAS (T₁) which was at par with all other treatments except T₂, T₆ and T₈. These results are in agreement with the findings of Gupta *et al.*, 2014.

Almost similar trend was observed in weed control efficiency at harvest. At harvest lowest values of weed control efficiency were reported with post emergence application of quizalofop ethyl 50g ha⁻¹ following both pendimethalin and alachlor pre emergence application which may be because of the domination of broad leaved weed with the supplemental irrigation given at 50 days stage. Among the post emergence herbicide treatments weed control efficiency of T₃ and T₇ receiving imazethapyr @ 50 g ha⁻¹ increased from 30 to 60 DAS because of the persistence of the herbicide after application. While T₄ and T₈ receiving acifluorfen +clodinafop propargyl @ 124+60 g ha⁻¹ at 20 DAS weed control efficiency decreased towards harvest. Similar finding were also reported by Bera *et al.*, 2012. Treatments T₂ and T₆ receiving quizalofop ethyl 50 g ha⁻¹ recorded lowest weed control efficiency values as it advanced from 30 DAS to harvest stage.

4.3 OBSERVATIONS ON CROP

4.3.1 Phyto Toxicity Scoring

The data on crop injury score (phytotoxicity scoring) as effected by different herbicide treatments observed at 7 and 14 days after pre and post emergence application are represented in table 4.8.

A perusal of the data revealed that both pre and post emergence herbicides applied were found to be safe with zero score of toxicity rating except imazethapyr @ 50 g ha⁻¹ at 20 DAS (T₃ and T₇), in which slight discoloration of developing leaves and stunting in blackgram was observed at 7 DAA with an injury score of 1 (10 %) and which vanished by 14 DAA.

4.3.2 Crop Stand

Data pertaining to crop stand (No.m⁻²) as influenced by weed control treatments recorded at 20 and 40 DAS are presented in Table 4.9. The germination of the crop was not affected and no mortality afterwards was observed at both 20 and 40 days after the spraying of pre and post emergence herbicide treatments and none of the weed control treatments nor weedy check could alter this parameter to a statistically perceptible magnitude.

4.3.3 Plant height (cm)

Data on plant height of blackgram at different stages of crop growth was presented in Table 4.10, revealed that plant height increased upto harvest stage and was significantly influenced by different weed management treatments except at 30DAS.

At 60 DAS and at harvest stage, significantly higher plant height (36.3 and 38.9 cm, respectively) was observed in weedy check. It was on par with treatments T₆ and T₂ at 60 DAS and with T₆ at harvest. High weed competition in weedy check and in the treatments that received quizalofop ethyl @ 50 g ha⁻¹ at 20 DAS (T₆ and T₂) particularly by broad leaved weeds which forced the plants to grow taller and resulted in higher plant height. A similar observation of increase of plant height in weedy check was reported by Choudary *et al.*, 2016 in greengram.

The plant height recorded with hand weeding twice at 20 and 40 DAS (T₉) was significantly low at 60 DAS (27.4 cm) and at harvest stages (29.9 cm) which reflected short statured growth habit of the variety under low competition from weeds. The treatments T₃ and T₇ recorded lower plant height than all other treatments (10.5 and 10.4 cm, respectively) at 30 DAS and (30.8 and 31.1 cm, respectively) at 60 DAS which may be due to suppression of plant growth for a period of 7-10 days after application of imazethapyr @ 50 g ha⁻¹ at 20 DAS. However, the plant height of T₃ and T₇ were on par with other treatments at harvest stage. Similar reduction of plant height with imazethapyr application was also reported by Veeraputhiran and Chinnusamy (2008) in blackgram.

4.3.4 Crop Dry matter Production

Perusal of data pertaining to the dry matter production of blackgram at 30, 60DAS and at harvest, in Table 4.13 revealed that the weed management treatments significantly influenced the crop dry matter production which increased gradually with advance in growth stages and was maximum at harvest.

At 30 DAS, all the weed control treatments resulted in significantly higher crop dry matter over weedy check. The higher crop dry matter accumulation (141 kg ha⁻¹) was recorded with pendimethalin @ 0.75 kg ha⁻¹fb intercultivation at 20 DAS and hand weeding at 30 DAS(T₁) and was on par with T₄ (139 kg ha⁻¹), T₅ (134 kg ha⁻¹) and T₉ (128 kg ha⁻¹).

At 60 DAS also T₁ recorded significantly higher crop dry matter production (2090 kg ha⁻¹) which was on par with T₅ (1812 kg ha⁻¹) and T₉ (1687 kg ha⁻¹). Similar results were observed at harvest stage also.

The highest crop dry matter production at all the growth stages recorded with T₁ and T₅ receiving pre emergence application of either pendimethalin @ 0.75 kg ha⁻¹ or alachlor @ 1.0 kg ha⁻¹fb intercultivation at 20 DAS and hand weeding at 30DAS could be attributes to less weed competition, more soil moisture conservation and better uptake of nutrients by the plants. Similar increase with intercultivation and hand weeding was also reported by Patel *et al.* (2015)

Among the post emergence herbicides, the crop dry matter production at 30 DAS recorded with T₄ and T₈ receiving acifluorfen + clodinafop propargyl @ 124+60 g ha⁻¹ at 20 DAS (139 and 112 kg ha⁻¹, respectively) was higher than that of T₃ and T₇ (110 and 117 kg ha⁻¹, respectively) receiving imazethapyr @ 50 g ha⁻¹ at 20 DAS, the differences were on par at 60 DAS and at harvest stages. Similar results were reported by Naidu *et al.* (2011) with imazethapyr.

At all growth stages the crop dry matter recorded was significantly low with weedy check as compared to all other weed management treatments except T₂ and T₆ that received pre emergence herbicide *fb* quizalofop ethyl @ 50 g ha⁻¹ at 20 DAS.

4.3.5 Days to 50 % Flowering

The days to 50% flowering ranged from 44 (T₉) to 51 (T₁₀ and T₆) DAS in different treatments. However, the differences were not significant (table 4.11).

4.3.6 Number of pods plant⁻¹

Data pertaining to number of pods plant⁻¹ is presented in table 4.12. An examination of the data indicated that all the weed control treatments recorded significantly higher number of pods plant⁻¹ as compared with the weedy check (10.6). Pre emergence application of pendimethalin @ 0.75kg ha⁻¹ followed by intercultivation at 20 DAS and hand weeding at 25 DAS (T₁) was found superior in registering significantly the highest number of pods plant⁻¹(21.8) and was on par with T₅ (20.6), T₉ (19.9), T₃ (19.5) and T₇ (19.2). These results are in agreement with the findings of Aggarwal *et al.* 2014.

4.3.7 No. of seeds per pod

The data on no. of seed per pod presented in Table 4.12 revealed that the weedy check recorded lowest number (5.3) which was on par with T₂ and T₆ this might be due to severe competition from weeds for soil nutrients. All other treatments recorded seed number on par with each other. Numerically highest value is with (T₁) pendimethalin @ 0.75 kg ha⁻¹ *fb* intercultivation at 20 DAS and hand weeding at 30DAS (7.3). Mundra and Maliwal, 2012 reported similar observations.

4.3.8 Test Weight (100 grain weight)

A perusal of the data on test weight presented in Table 4.12 inferred that significantly higher test weight was recorded in all the weed management treatments as compared with weedy check (3.8) and were on par with each other except T₆. This can be attributed to severe stress faced by the crop during pod filling stage for moisture in the weedy check and T₆ where the weed density was very high. Similar observation was reported by Asaduzzaman *et al.*, 2010 in blackgram.

4.3.9 Seed Yield

The data on seed yield per hectare as influenced by different weed management treatments was furnished in Table 4.14. Significant disparities were noticed in seed yield of blackgram due to various weed management treatments.

Among all the weed control treatments, pendimethalin @ 1.0 kg ha⁻¹ followed by intercultivation at 20 DAS followed by hand weeding at 30 DAS (T₁) was superior in registering significantly higher seed yield (1132 kg ha⁻¹) and was on par (1054 kg ha⁻¹) with pre emergence application of alachlor @1.0 kg ha⁻¹ followed by one intercultivation at 20 DAS and hand weeding at 30 DAS (T₅) and hand weeding twice at 20 and 40 DAS (T₉) recording 1010 kg ha⁻¹. Low weed density, weed dry matter and high crop dry matter and well formed pods recorded with the treatments might have resulted in higher seed yield. Intercultivation at 20 DAS done in T₁ and T₅ might have helped the crop in conserving soil moisture as there was no rain after 15DAS and supplemental irrigation was not given up to pod filling stage. Similar results were reported by Patel *et al.* (2015).

Among the post emergence herbicide treatments the seed yield was statistically on par with treatments that received imazethapyr @ 50 g ha⁻¹ at 20 DAS(T₃ and T₇) and acifluorfen + clodinafop propargyl @ 124+60 g ha⁻¹ at 20 DAS(T₄ and T₈).which may be due to effective control both BLW and grassy weeds by the two herbicides. This is in agreement with the findings of Gousia and Rao, 2006a and Veeraputhiran *et al.*, 2008 in blackgram with imazethapyr and Pal *et al.* (2013) in soybean with acifluorfen + clodinafop propargyl.

The seed yield recorded with treatments T₂ (639 kg ha⁻¹) and T₆ (565 kg ha⁻¹), that received post emergence application of quizalofop ethyl @ 50 g ha⁻¹ at 20DAS was significantly lower than other herbicidal treatments . This may be due to higher competition from broad leaved weeds resulting in low dry matter production and low yield attributes in the crop. Significant reduction in seed with quizalofop ethyl was also reported by Kumar *et al.* (2015) and Naidu *et al.* (2011).

The lowest seed yield (394kg ha⁻¹) was observed in weedy check with an yield loss of 65.2% as compared to pendimethalin @ 1.0 kg ha⁻¹ followed by intercultivation at 20 DAS followed by hand weeding at 30 DAS (T₁). The minimum yield and yield attributing characters in weedy check could be due to season long weed competition as evidenced by maximum weed density and weed dry matter. Similar reduction in blackgram seed yield due to severe weed competition was reported by Venkateswarlu, 2011 and Sasikala *et al.*, 2014.

Similarly the seed yield loss with post emergence application of quizalofop ethyl@ 50g ha⁻¹ i.e. T₂ and T₆ was 43.6% and 50.1%, respectively.

In general, the seed yield data of the investigation indicated that pendimethalin @ 1.0 kg ha⁻¹ followed by intercultivation at 20 DAS followed by hand weeding at 30 DAS (T₁) was the best method to avoid weed infestation in blackgram. As blackgram is sensitive to weed interference during 10-45 DAS, intercultivation at 20 DAS and hand weeding at 30 DAS (T₁) had lead to higher yields. Similar findings were also reported by Gousia, 2005.

4.3.9 Haulm Yield

A critical examination of the data on haulm yield (Table 4.14) revealed that the trend remained same as it was observed in the case of seed yield.

The haulm yield recorded with T₅, T₁, T₉, T₃ and T₇ (2973, 2875, 2775, 2695 and 2628 kg ha⁻¹) was higher and on par with each other. This can be attributed to the higher crop dry matter production recorded with these treatment. The lowest haulm yield (1971 kg ha⁻¹) was observed with weedy check.

4.3.10 Harvest Index

The data presented in Table 4.14 revealed that harvest index of all weed management treatments except T₂ and T₆ were significantly superior to weedy check (16.7%). The lower values may be due to poor seed yield that resulted because of severe weed infestation in the above treatments.

Highest harvest index value was recorded with T₁ (28.3 %) which was on par with all other weed management treatments.

4.3.11 Weed Index

The data pertaining to weed index worked out for various weed control treatments are furnished in table 4.15. The lowest weed index of 6.9 % with alachlor @1.0 kg ha⁻¹ followed by one intercultivation at 20 DAS followed by hand weeding at 30 DAS (T₅) and it was significantly on a par with T₉ (10.8%), T₃(12.5%), and T₇ (13.2%). Better weed control efficiency and broad spectrum of weed control of these treatments might have reduced weed index significantly. The highest weed index (65.2 %) was recorded with weedy check. Gupta *et al.*, 2014 also reported similar results.

The treatments receiving post emergence application of quizalofop ethyl @ 50 g ha⁻¹, recorded higher values of weed index which may be due to its lower weed control efficiency as result of non control of broad leaved weed population by quizalofop ethyl. This was in accordance with the findings of Balyan *et al.*, 2016.

4.4 SOIL MICROFLORAL ANALYSIS

Soil microbial population viz., total bacteria and fungi per gram of soil are presented in table 4.17 and 4.18.

A decrease in the population of soil bacteria was observed from the initial values at 10 DAA and 20 DAA of pre emergence herbicides except hand weeded (80) and weedy check (90). The relative decrease of soil bacterial population was more when pre emergence application of pendimethalin @ 0.75 kg ha⁻¹ was taken up as compared to pre emergence application of alachlor @1.0 kg ha⁻¹. The results are in accordance with Rodriguez *et al.* (2004).

A gradual rise in bacterial count was observed at 30DAS (10 DAA after PoE application) and upto the stage of harvest. The total bacterial count (280) is significantly highest in weedy check (T₁₀) followed by hand weeding at 20 and 40 DAS (T₉) when compared to all the weed management treatments at harvest.

Among the herbicide treated plots the significantly highest microbial population was recorded in pendimethalin @ 0.75 kg ha⁻¹ followed by quizalofop ethyl @50 g ha⁻¹(T₂) and alachlor @ 1.0 kg ha⁻¹ followed by quizalofop ethyl @ 50 g ha⁻¹(T₇) and was on a par with treatments consisting of intercultivation and hand weeding (T₁ and T₅). The increase in bacterial population in intercultivation is due to proper incorporation of organic matter which leads to prolific growth of aerobic microbial population.

The soil fungal population also decreased from initial value at 10 and 20 DAA of pre emergence herbicides and also upto harvest stage. The decrease in fungal population at the time of harvest may be due to its long proliferation time when compared to bacteria and actinomycetes.

The increased microbial population of soil in weedy check could be due to the indirect effect of root exudates in the rhizosphere soil, densely covered flora (weeds and crop plants) leading to increase in organic matter content that favoured the growth of microflora. Next to weedy check hand weeding recorded higher microbial population due to adequate moisture, less weed competition for moisture leads to increase in microbial population. The results are in accordance with Jaya malhotra *et al.*(2015), Suresh *et al.*(2010), Rupela *et al.*2005, Rodriguez *et al.*, 2004.

4.5 SOIL NUTRIENT ANALYSIS

The data of soil nutrient uptake of N, P and K are given in table 4.16. The values ranged from 120-180 (Low), 42-48 (medium) ,680-746(High) respectively for N, P and k and no deviation was observed from the initial soil N, P and K status (188, 48 and 870 kg ha⁻¹, respectively).

4.6 ECONOMICS

The practical utility of any weed control measure can be best judged on the basis of its benefit-cost ratio (BCR) in terms of rupees benefited from rupee invested. Perceptible differences were observed among weed control treatments with regard to gross and net returns as well as B: C ratio (Table 4.19).

Among the weed management practices, the higher gross returns of Rs.96, 220 ha⁻¹ were recorded with pendimethalin @ 1.0 kg ha⁻¹ followed by intercultivation at 20 DAS *fb* hand weeding at 30 DAS (T₁), Rs. 89,590 ha⁻¹ with alachlor @1kg ha⁻¹*fb* intercultivation at 20 DAS followed by hand weeding at 30 DAS (T₅) and Rs.85,350 ha⁻¹ with two hand weeding at 20 and 40 DAS.

Among post emergence herbicide treatments post emergence application of imazethapyr @ 50 g ha⁻¹(T₃ and T₇) and acifluorfen + clodinafop propargyl @ 124 g ha⁻¹ + 60 g ha⁻¹at 20 DAS(T₄ and T₈) recorded almost similar gross return values. Highest cost of cultivation was recorded with hand weeding (Rs.36,285 ha⁻¹).Highest benefit cost ratio (3.9) was recorded with T₃and T₇ followed by T₄and T₈.

The highest gross returns, net returns with (T₁) pendimethalin @ 0.75 kg ha⁻¹ followed by one intercultivation at 20 DAS and hand weeding at 30DAS might be due to higher seed yield, barring labour costs and effective working of pendimethalin, intercultivation, hand weeding compared to other treatments. Similar results were reported by Bera *et al.* (2012), Pal *et al.* (2013) and Jha *et al.* (2014).

Chapter - V

SUMMARY AND CONCLUSIONS

A field experiment entitled “Herbicidal efficacy of certain herbicides and their influence on soil microflora in *rabi* blackgram (*vigna mungo L.*)” was conducted on clay soils of Regional Agricultural Research Station, Lam during *rabi*, 2016. The design adopted was randomized block design with three replications comprising ten weed management treatments viz., T₁ - Pendimethalin @ 0.75 kg ha⁻¹ (PE) *fb* one intercultivation (20 DAS) *fb* handweeding at 30 DAS, T₂ - Pendimethalin @ 0.75 kg ha⁻¹ (PE) *fb* Quizalofop ethyl @ 50g ha⁻¹ (PoE) at 20 DAS, T₃- Pendimethalin @0.75 kg ha⁻¹ (PE) *fb* Imazethapyr @ 50g ha⁻¹ (PoE) at 20 DAS, T₄-Pendimethalin @ 0.75 kg ha⁻¹ (PE) *fb* Acifluorfen + Clodinafop propargyl @ 124+60 g ha⁻¹ (PoE) at 20 DAS, T₅- Alachlor @ 1.0kg ha⁻¹ (PE) *fb* one Intercultivation (20 DAS) *fb* handweeding at 30 DAS, T₆ - Alachlor @ 1.0 kg ha⁻¹ (PE) *fb* Quizalofop ethyl 50 g ha⁻¹ (PoE) at 20 DAS, T₇ - Alachlor @ 1.0 kg ha⁻¹ (PE) *fb* Imazethapyr @50 g ha⁻¹(PoE) at 20 DAS, T₈ - Alachlor @ 1.0 kg ha⁻¹ (P.E) *fb* Acifluorfen +Clodinafop Propargyl @ 124+60g ha⁻¹ (PoE) at 20 DAS, T₉ - Hand weeding at 20 and 40 DAS, T₁₀ -Unweeded check. The salient findings of the experiment are summarized here under.

The observed species were *Abutilon indicum*, *Acalyphaindica*, *Commelinabenghalensis*, *Celosia argentia*, *Chorchorustrilocularis*, *Digeraarvensis*, *Cleomeviscose*, *Physalis minima*, *Portulaca quadrifida*, *Phyllanthus madaraspatanense*, *Trianthema portulacastrum*, *Echinocloacolona*, *Dactylocteniumaegyptium*, *Dinerbaretroflex* and *Cyperus rotundus*. *Trianthema portulacastrum* was the dominant weed among all the species at all the intervals of observation.

Pre emergence application of pendimethalin @0.75 kg ha⁻¹ recorded significantly lower density of weeds as compared to alachlor @ 1.0 kg ha⁻¹ at 20 DAS indicating higher efficacy of pendimethalin in controlling broad leaved weeds which were dominant in the experiment. At 40 DAS, pre emergence application of either pendimethalin @ 0.75 kg ha⁻¹ or alachlor @ 1.0 kg ha⁻¹ *fb* intercultivation at 20 DAS *fb* hand weeding at 30 DAS recorded lower weed density (T₁ and T₅). Among the post emergence herbicides, imazethapyr @50 g ha⁻¹ recorded the significantly lowest

weed density which was on par with acifluorfen+ clodinafop propargyl @ 124+60 g ha⁻¹ at 20 DAS and hand weeding twice at 20 and 40 DAS. Treatments receiving imazethapyr recorded lowest weed density upto harvest stage than the other herbicides. On the whole pre emergence herbicides along with intercultivation at 20 DAS *fb* hand weeding at 30 DAS recorded the lesser weed density compared to sequential application of pre and post emergence herbicides upto harvest.

Significantly low weed dry matter production (26.7 g m⁻²) and high weed control (89%) efficiency recorded at 30 DAS with pendimethalin @ 0.75 kg ha⁻¹ (PE) *fb* intercultivation at 20 DAS *fb* hand weeding at 30 DAS and remained more or less the same at all the growth stages. Even though pendimethalin @ 0.75 kg ha⁻¹ (PE) *fb* acifluorfen + clodinafop propargyl @ 124+60 g ha⁻¹ at 20 DAS (T₄) recorded lowest dry weight at 30 DAS, by the time of harvest the weed dry matter with pendimethalin @ 0.75 kg ha⁻¹ *fb* imazethapyr @ 50 g ha⁻¹ (T₃) was lower with WCE as high as 78%. Pre emergence application of herbicides along with intercultivation at 20 DAS followed by hand weeding at 30 DAS (T₁ and T₅) resulted in lower weed dry matter and high WCE as compared to sequential application of PE and PoE. The reduced weed dry weight in these treatments could be due to effective control of broad leaved weeds, grasses and sedges at critical stage of crop growth. Highest weed dry matter and low WCE was recorded with post emergence application of quizalofop ethyl @ 50 g ha⁻¹ which was on par with weedy check because of the uncontrolled broad leaved weeds.

The germination, growth and dry matter production of black gram was normal without any phytotoxicity with the application of weed management treatments except that imazethapyr showed a phyto toxicity score of 1 at 7 DAA and however, the crop recovered by 14 DAA.

Plant height increased significantly in weedy check and in the treatments that received quizalofop ethyl @ 50 g ha⁻¹ at 20 DAS indicating the lanky growth of plants under high weed competition. In all other treatments the plants were sturdy, well branched and determinate. The highest crop dry matter production at all the growth stages was recorded with T₁ and T₅ receiving pre emergence application of either pendimethalin @ 0.75 kg ha⁻¹ or alachlor @ 1.0 kg ha⁻¹ *fb* intercultivation at 20 DAS and hand weeding at 30 DAS. Among the post emergence herbicides, the crop dry matter

production at 30 DAS recorded with T₄ receiving acifluorfen + clodinafop propargyl @ 124+60 g ha⁻¹ at 20 DAS was higher than that of T₃ and T₇ receiving imazethapyr @ 50 g ha⁻¹ at 20 DAS. However, the differences were on par at 60 DAS and at harvest stages

Among all the treatments pendimethalin @ 0.75 kg ha⁻¹ followed by intercultivation at 20 DAS followed by hand weeding at 30 DAS (T₁) recorded the higher pods plant⁻¹, seed pod⁻¹ and test weight and all other treatments are on par with each other except in post emergence application of quizalofop ethyl @ 50g ha⁻¹ (PoE) at 20 DAS

The highest seed yield was recorded with pre emergence application of either pendimethalin @ 0.75 kg ha⁻¹ or alachlor @ 1.0 kg ha⁻¹ followed by intercultivation at 20 DAS followed by hand weeding at 30 DAS (T₁ and T₅) with high harvest index and low weed index values.

Among the post emergence herbicides, seed yield recorded with pendimethalin @ 0.75 kg ha⁻¹ (PE) *fb* imazethapyr @ 50g ha⁻¹ (PoE) at 20 DAS and that of pendimethalin @ 0.75 g ha⁻¹ followed by acifluorfen + clodinafop propargyl @ 124+60 g ha⁻¹ at 20 DAS (T₄) on par with each other. Lowest seed yield recorded with post emergence application of quizalofop ethyl @ 50g ha⁻¹ (PoE) at 20 DAS (T₂ and T₆). Harvest index followed the same trend as that observed with seed yield. The low yield recorded with T₉ as compared to T₁ and T₅ can be attributed to the high weed intensity upto first hand weeding at 20 DAS.

The weedy check recorded highest weed index (70.1%) and lowest harvest index (16.7 %) followed by the treatments receiving post emergence application of quizalofop ethyl @ 50 g ha⁻¹.

The bacterial population was low in all the weed control treatments receiving pre emergence herbicides as recorded at 10 and 20 DAA. Highest bacterial count was recorded with weedy check (T₁₀). The decrease was more in treatments received pendimethalin @ 0.75 kg ha⁻¹ when compared to treatments receiving pre emergence of alachlor @ 1.0 kg ha⁻¹. Similar decrease was also observed with post emergence herbicides. However, by harvest the bacterial population recovered as that of initial population. Fungal population was recorded less during harvest due to its longer proliferation time to develop in soil when compared to bacteria.

The highest benefit cost ratio was obtained with pendimethalin @ 0.75 kg ha⁻¹(PE) fb imazethapyr @ 50g ha⁻¹(PoE) at 20 DAS (T₃) followed by pendimethalin @0.75 g ha⁻¹ followed by acifluorfen +cladinafoppropargyl @ 124+60 g ha⁻¹ at 20 DAS (T₄) as compared with the weed management treatments including hand weeding and intercultivation where the yield levels were high.

Based on the results of the present field experiment the following conclusions can be drawn.

1. Pre emergence application of either pendimethalin @ 0.75 kg ha⁻¹ followed by intercultivation at 20 DAS and hand weeding at 30 DAS can be the best option for weed control in blackgram where ever feasible because of higher plant growth, yield and yield attributes.
2. Among the pre emergence herbicides application of pendimethalin @ 0.75 kg ha⁻¹ was more effective with broad spectrum of weed control as compared with alachlor.
3. Among the post emergence herbicides imazethapyr @50g ha⁻¹at 20 DAS was found effective with long persistence and broader spectrum of weed control. Application of acifluorfen + cladinafop propargyl @ 124+60 g ha⁻¹ at 20 DAS was effective with high WCE upto 60 DAS, however, remained next to imazethapyr in respect of WCE and weed index by harvest.
4. Even though the treatments receiving pre emergence herbicide followed intercultivation at 20 DAS and hand weeding at 30 DAS or hand weeding twice at 20DAS and 40 DAS recorded higher yield, the sequential application of pre emergence (pendimethalin @ 0.75 kg ha⁻¹or alachlor @ 0.75 kg ha⁻¹) followed by post emergence herbicide(imazethapyr @ 50g ha⁻¹or acifluorfen + cladinafop propargyl) @ 124+60 g ha⁻¹was found economically viable recording high benefit cost ratio.

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***Original not seen**

Note: The pattern of Literature Cited presented above is in accordance with the guidelines for thesis presentation, Acharya N.G. Ranga Agricultural University, Guntur.



Plate 1. A general view of the experiment (replication i)



Weedy check



Hand weeding at 20 and 40 DAS

Plate 2. View of treatment T₁₀ and T₉



Alachlor @ 1.0 kg ha⁻¹ fb intercultivation at 20 DAS and hand weeding at 30 DAS



Pendimethalin @ 0.75 kg ha⁻¹ fb intercultivation at 20 DAS and hand weeding at 30 DAS

Plate 3. View of treatment T₅ and T₁



Pendimethalin @ 0.75 kg ha⁻¹ *fb* Quizalofop ethyl @ 50 g ha⁻¹ at 20 DAS



Alachlor @ 1.0 kg ha⁻¹ *fb* Quizalofop ethyl @ 50 g ha⁻¹ at 20 DAS

Plate 4. View of treatment T₂ and T₆



**Pendimethalin @ 0.75 kg ha⁻¹ fb Imazethapyr @ 50 g ha⁻¹
at 20 DAS**



**Alachlor @ 1.0 kg ha⁻¹ fb Imazethapyr @ 50 g ha⁻¹ at
20 DAS**

Plate 5. View of treatment T₃ and T₇

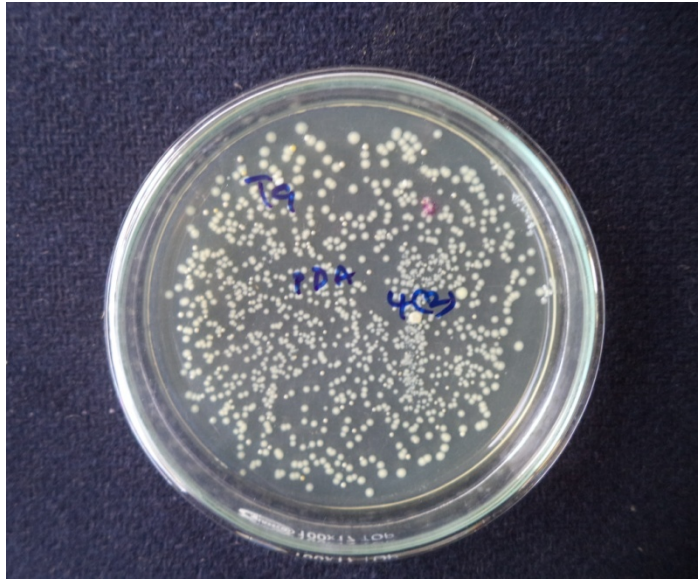


**Pendimethalin @ 0.75 kg ha⁻¹ (PE) fb Acifluorfen +
Clodinafop propargyl @ 124+60 g ha⁻¹ (PoE) at 20 DAS**

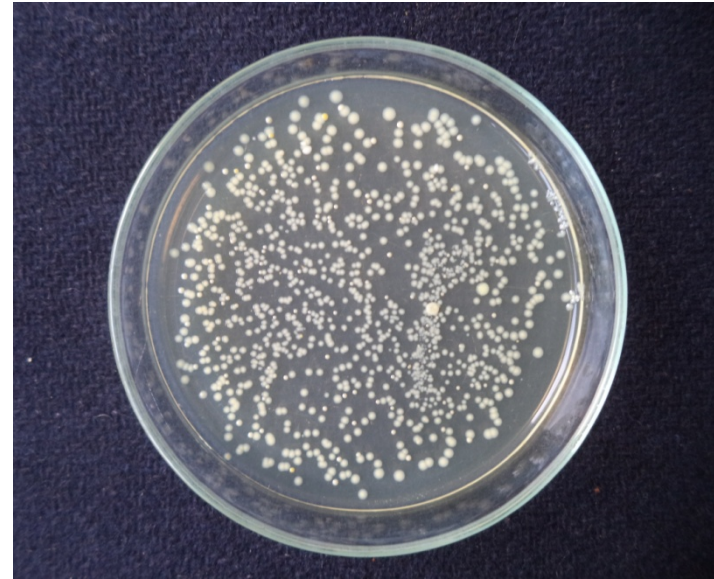


**Alachlor @1.0 kg ha⁻¹ (PE) fb Acifluorfen + Clodinafop
propargyl @ 124+60 g ha⁻¹ (PoE) at 20 DAS**

Plate 6. View of treatment T₄ and T₈

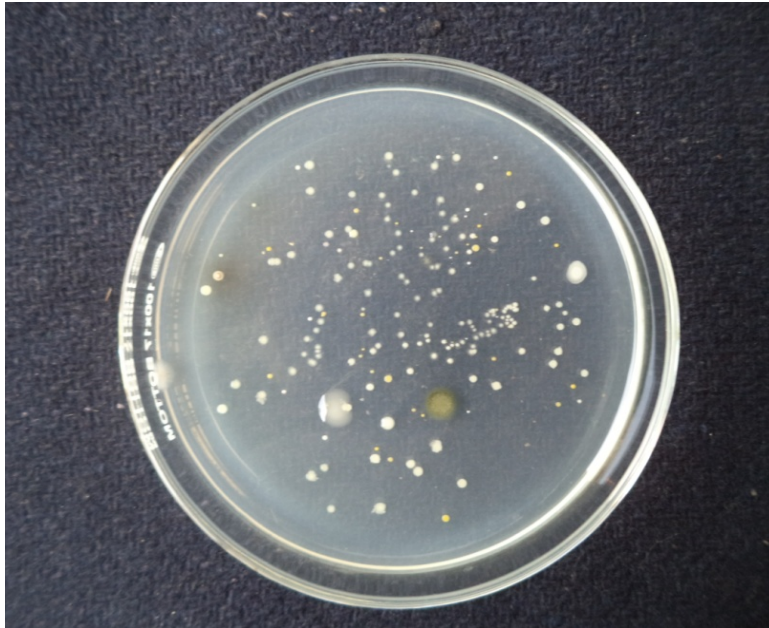


Pendimethalin @ 0.75 kg ha⁻¹ (PE)

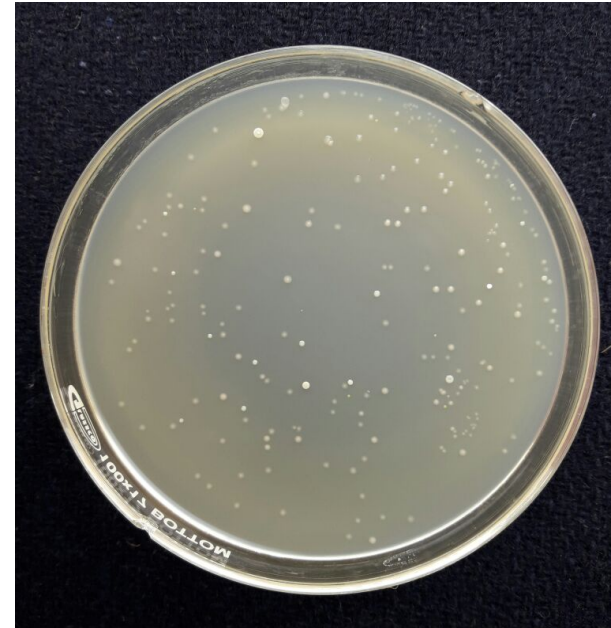


Alachlor @ 1.0 kg ha⁻¹ (PE)

Plate 7. Bacterial population at 10 DAA as influenced by Pendimethalin @ 0.75 kg ha⁻¹ (PE) and Alachlor @ 1.0 kg ha⁻¹ (PE)



Pendimethalin @ 0.75 kg ha⁻¹ (PE)



Alachlor @ 1.0 kg ha⁻¹ (PE)

Plate 8. Bacterial population at 20 DAA as influenced by Pendimethalin @ 0.75 kg ha⁻¹ (PE) and Alachlor @ 1.0 kg ha⁻¹ (PE)

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LIST OF SYMBOLS AND ABBREVIATIONS

@	:	At the rate of
a. i.	:	Active ingredient
BCR	:	Benefit cost ratio
⁰ C	:	Degree Celsius
C D (P=0.05%)	:	Critical difference at 5 per cent probability level
CFU	:	Colony forming units
cm	:	Centimeter
CV	:	Co-efficient of variance
DAA	:	Days after application
DAS	:	Days after sowing
dS m ⁻¹	:	Deci Siemens per metre
Ec	:	Electrical conductivity
EC	:	Emulsifiable concentration
<i>et al.</i> ,	:	and other workers
<i>fb</i>	:	Followed by
Fig.	:	Figure
g	:	Gram
ha ⁻¹	:	Per hectare
<i>i.e.</i> ,	:	Which is to say, in other words
K	:	Potassium
K ₂ O	:	Potassium oxide
kg	:	Kilogram
kg ha ⁻¹	:	Kilogram per hectare
L	:	Litre
L ⁻¹	:	Per litre
ml	:	Millilitre
ml l ⁻¹	:	Millilitre per litre

m ⁻²	:	Per square metre
m ha	:	Million hectare
max	:	Maximum
min	:	Minimum
mm	:	Millimetre
MSL	:	Mean sea level
N	:	Nitrogen
No. m ⁻²	:	number per square meter
NS	:	Non significant
P	:	Phosphorus
%	:	Per cent
pH	:	Potential of hydrogen ion concentration
PE	:	Pre-emergence
PoE	:	Post-emergence
RH	:	Relative humidity
₹	:	Rupees
SEm+	:	Standard error of mean
SL	:	Soluble liquid
SSP	:	Single superphosphate
t	:	Tonne
t ha ⁻¹	:	Tonnes per hectare
<i>viz.</i> ,	:	Namely
WCE	:	Weed control efficiency

ABSTRACT

Name of the author : **SHAIK RAZIA**
Title of the thesis : **Herbicidal efficacy of certain herbicides and influence on soil microflora in *rabi* blackgram (*Vigna mungo* L.)**
Major advisor : **Dr. B.Pramila rani**
Degree to which it is submitted : M.Sc. (Ag.)
Faculty : Agriculture
Discipline : **AGRONOMY**
College : **Agricultural College, Bapatla**
University : **ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY**
Year of submission : **2017**

A field experiment entitled “**Herbicidal efficacy of certain herbicides and influence on soil microflora in *rabi* blackgram (*Vigna mungo* L.)**” was conducted at Regional Agricultural Research station, Lam, on clay soils during *rabi*, 2016. The experiment was laid out in RBD with three replications and the treatments consisted of ten different weed management practices viz., T₁ - Pendimethalin @ 0.75 kg ha⁻¹ (PE) *fb* one intercultivation at 20 DAS *fb* hand weeding at 30 DAS, T₂ - Pendimethalin @ 0.75 kg ha⁻¹ (PE) *fb* Quizalofop ethyl @ 50 g ha⁻¹ (PoE) at 20 DAS, T₃ - Pendimethalin @ 0.75 kg ha (PE) *fb* Imazethapyr @ 50 g ha⁻¹ (PoE) at 20 DAS, T₄ - Pendimethalin @ 0.75 kg ha⁻¹ (P E) *fb* Acifluorfen + Clodinafop Propargyl @ 124+60 g ha⁻¹ (PoE) at 20 DAS, T₅ - Alachlor @ 1.0 kg ha⁻¹ (PE) *fb* one intercultivation 20 DAS *fb* hand weeding at 30 DAS), T₆ - Alachlor @ 1.0 kg ha⁻¹ (P E) *fb* Quizalofop ethyl 50 g ha⁻¹ (PoE) at 20 DAS, T₇ - Alachlor @ 1.0 kg ha⁻¹ (P E) *fb* Imazethapyr @ 50 g ha⁻¹ (PoE) at 20 DAS, T₈ - Alachlor @ 1.0 kg ha⁻¹ (PE) *fb* Acifluorfen + Clodinafop Propargyl @ 124+60 g ha⁻¹ (PoE) at 20 DAS, T₉ - Hand weeding twice (20 and 40 DAS), T₁₀ - Unweeded check.

The important weed flora observed in the experimental field consisted of *Abutilon indicum*, *Acalypha indica*, *Commelinabenghalensis*, *Celosia argentea*, *Chorchorustrilocularis*, *Digera arvensis*, *Cleome viscosa*, *Physalis minima*, *Portulaca quadrifida*, *Phyllanthus madaraspatanense*, *Trianthema portulacastrum*, *Echinochloa colonum*, *Dactyloctenium aegyptium*, *Dinerba retroflex* and *Cyperus rotundus*.

All the weed management treatments recorded significantly lower density of weeds when compared to weedy check. The lowest weed density, weed dry matter and high WCE was observed with pre emergence

application of either pendimethalin @ 0.75 kg ha⁻¹ or alachlor @ 1.0 kg ha⁻¹ followed by one intercultivation at 20 DAS and hand weeding at 30 DAS (T₁ and T₅) than sequential application of herbicides. Among post emergence herbicides the treatments receiving imazethapyr @ 50 g ha⁻¹ recorded the significantly lowest weed density and weed dry matter followed by pendimethalin @ 0.75 kg ha⁻¹ (P E) *fb* acifluorfen + clodinafop propargyl @ 124+60 g ha⁻¹ (PoE) at 20 DAS (T₄) at harvest stage.

The germination, growth and dry matter production of blackgram was not affected by application of any of the herbicides and recorded zero values of phytotoxicity score after 14 DAA. Optimum plant height was recorded at harvest with treatments receiving pre emergence followed by either post herbicide or intercultivation or hand weeding. Plants were lean and lanky in weedy check with less crop dry matter production at all the stages of crop growth and also with treatments receiving post emergence application of quizalofop ethyl @ 50 g ha⁻¹ due to higher weed competition. The higher plant dry matter accumulation was recorded with pendimethalin @ 0.75 kg ha⁻¹ *fb* intercultivation at 20 DAS and hand weeding at 30 DAS (T₁).

The yield attributing characters viz., number of pods plant⁻¹, seeds pod⁻¹, 100 seed weight and harvest index were significantly influenced by weed management treatments. The highest values were obtained with T₁ and T₅ receiving pre emergence herbicide *fb* intercultivation at 20 DAS and hand weeding at 30 DAS. Maximum seed and haulm yield were obtained with T₁ and T₅ and followed by T₃, T₄, T₇, T₉ which were on par with each other.

No marked change in the soil nutrition status was observed after crop harvest and Nitrogen, phosphorus and potassium status of soil after harvest remained low, medium and high respectively as observed in the initial status. The reduction in the soil microbial population was high at 20 days stage with pre emergence application of pendimethalin @ 0.75 kg ha⁻¹ when compared to pre emergence application of alachlor @ 1.0 kg ha⁻¹. Intercultivation and hand weeding increased the soil microbial population significantly when compared with sequential application of herbicides. Application of post emergence herbicides did not show any detrimental effect on soil microflora at harvest stage.

The maximum benefit cost ratio was obtained with pre emergence application of pendimethalin @ 0.75 kg ha⁻¹ *fb* imazethapyr @ 50 g ha⁻¹ at 20 DAS which was closely followed by pendimethalin @ 0.75 kg ha⁻¹ *fb* post emergence application of acifluorfen + clodinafop propargyl @ 124+60 g ha⁻¹.

APPENDIX - II

CALENDAR OF OPERATIONS

S.No.	Particulars of the field operations performed	Date
1	Land preparation	28-09-2016
2	Layout	28-09-2016
3	Basal application of fertilizer as per recommended dose	28-09-2016
4	Collection of soil samples for initial N,P,K and microbial analysis	28-09-2016
5	Sowing of blackgram	29-09-2016
6	Pre emergence herbicide application	29-09-2016
7	Thinning and gap filling	07-09-2016
8	Soil sample collection for microbial analysis	08-10-2016
9	Media preparation for microbial analysis	14-10-2016
10	Spraying of monocrotophos	14-10-2016
11	Plating of media for microbial analysis	15-10-2016
12	Hand weeding in T ₉	18-10-2016
13	Post emergence herbicide application	19-10-2016
14	Intercultivation in T ₁ and T ₅	19-10-2016
15	Soil sample collection for microbial analysis	19-10-2016
16	Media preparation for microbial analysis	20-10-2016
17	Plating of media	21-10-2016
18	Soil sample collection for microbial analysis	29-10-2016
19	Hand weeding in T ₁ and T ₅	29-10-2016
20	Spraying of Chloropyriphos + Dichlorovos	31-10-2016
21	Hand weeding in T ₉	9-11-2016
22	Irrigation	20 -11-2016
23	Samples of plant and weeds taken for recording weed density, weed dry matter accumulation, plant height, plant dry matter accumulation	12-12-2016
24	Soil samples collected for microbial analysis	22-12-2016
25	Soil samples taken for final soil N, P, and K analysis	23-12-2016
26	Harvesting of blackgram	25-12-2016
27	Threshing of blackgram	30-12-2016

APPENDIX – III

Composition of Media used for Microbial Analysis in soil

Nutrient Agar (NA) media: Ingredients used for making 1 L media

Glucose	: 5 g
NaCl	: 5g
Beef extract	: 3g
Peptone	: 5g
Agar agar	: 16g
Distilled Water	: 1 L

Martin's Rose Bengal Agar Media (MRBA): Ingredients used for making 1 L media

K ₂ HPO ₄	: 1.25g
KH ₂ PO ₄	: 1.25g
MgSO ₄ .7H ₂ O	: 1.25g
Dextrose	: 25g
Peptone	: 12.5g
Yeast extract	: 1.25g
Rose Bengal	: 25µg
Streptomycin	: 3µg
Agar agar	: 16g
Distilled Water	: 1 L

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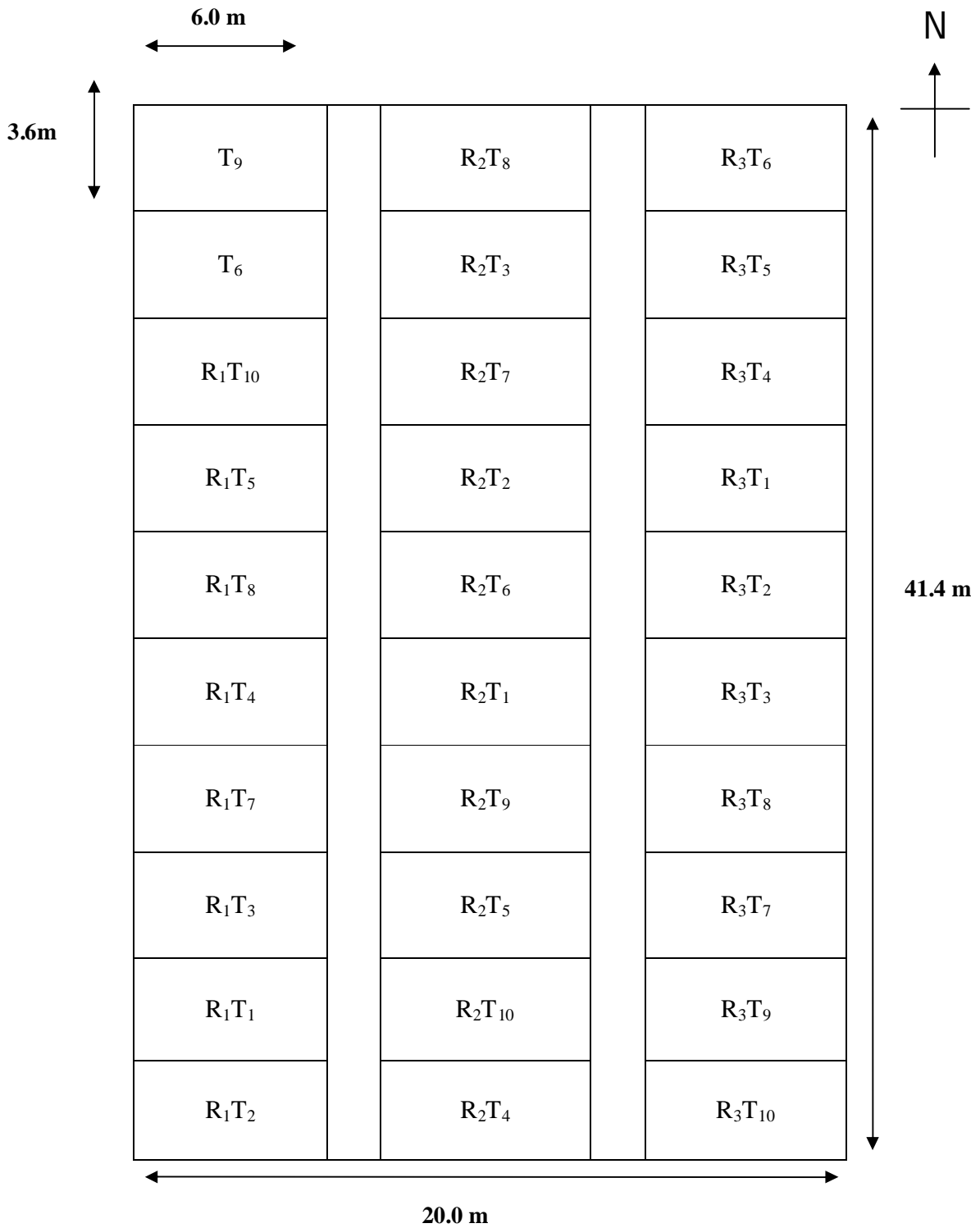
APPENDIX – I
Cost of cultivation Rs ha⁻¹

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
LAND PREPARATION										
a. Working with tractor drawn cultivator (twice)	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
SEEDS AND SOWING										
a. Seed cost @ Rs.180 kg ⁻¹ (20 kg ha ⁻¹)	3600	3600	3600	3600	3600	3600	3600	3600	3600	3600
b. Sowing charges	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
FERTILIZERS										
a. N @ 20 kg ha ⁻¹ (43.5 kg urea)	244	244	244	244	244	244	244	244	244	244
b. P @ 50 kg ha ⁻¹ (312.5 kg single super phosphate)	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250
c. Application cost	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
WEEDING										
a. First hand weeding (50 labour @ Rs.200 head ⁻¹)									10,000	
b. Second hand weeding (40 labour @ Rs.200 head ⁻¹)	8000				8000				8000	
c. Intercultivation	1500				1500					

HERBICIDES										
a. Pendimethalin @ Rs. 490 l ⁻¹ (2.5 l ha ⁻¹)	1225	1225	1225	1225						
b. Alachlor @ Rs. 510 l ⁻¹ (2.5 l ha ⁻¹)					1275	1275	1275	1275		
c. Quizalofop ethyl @ Rs. 1775 l ⁻¹ (1 .0 l ha ⁻¹)		1775				1775				
d. Imazethapyr @ Rs 890 500 ml ⁻¹ (0.5 l ha ⁻¹)			890				890			
e. Aciflurfen + Clodinafop propargyl @ Rs. 798 400 ml ⁻¹ (1 .0 l ha ⁻¹)				2000				2000		
f. Labour charges	500	1000	1000	1000	500	1000	1000	1000		
PLANT PROTECTION										
a. Seed treatment with Thiamethoxam @ 100 g ha ⁻¹ (Rs.117 100 g ⁻¹)	117	117	117	117	117	117	117	117	117	117
b. Monocrotophos @ 1.2 l ha ⁻¹ (Rs.428 l ⁻¹)	514	514	514	514	514	514	514	514	514	514
c. Chloropyriphos @ 1.9 l ha ⁻¹ (Rs.246 l ⁻¹)	468	468	468	468	468	468	468	468	468	468
d. <u>Dichlorovos @ 0.75 l ha⁻¹ (389 l⁻¹)</u>	292	292	292	292	292	292	292	292	292	292
e. Application cost @ Rs.500 ha ⁻¹ (twice)	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Irrigation (3 labour @ Rs 300 head⁻¹)	900	900	900	900	900	900	900	900	900	900
Harvesting and threshing	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500
TOTAL COST OF CULTIVATION (Rs. ha⁻¹)	29510	22285	21400	22510	29560	22335	21450	22560	36285	18285

Table 3.6 Details of herbicides used in the present investigation

Particulars	Pendimethalin	Alachlor	Quizalofop ethyl	Imazethapyr	Acifluorfen	Clodinafop Propargyl
Trade name	Stomp	Lasso	Targa super	Pursuit	Iris	Iris
Active ingredient	30 %	50 %	5 %	10 %	16.5 %	8 %
Formulation	EC	EC	EC	EC	EC	EC
Chemical name	3,4-dimethyl-2,6-dinitro- <i>N</i> -pentan-3-yl-aniline	2-Chloro- <i>N</i> -(2,6-diethyl phenyl)- <i>N</i> -(methoxy methyl) acetamide	(<i>RS</i>)-2-[4-(6-Chlorochinoxalin-2-yloxy) phenoxy] propionsaure	5-ethyl-2-(4-isopropyl-4-methyl-5-oxo-4,5-dihydro-1H-imidazol-2-yl) nicotinic acid	5-(2-Chloro-4-trifluoromethyl phenoxy-2-nitro benzoic acid	2-{4{5-Chloro-3 fluoro-2-pyrimyl)oxy} phenoxy)-2-propynyl ester
Chemical family	Dinitroaniline	Chloroacetamide	Aryloxy-phenoxy propionate	Imidazolinone	Diphenylether	Oxyphenoxy acid ester
Emperical formula	C ₁₃ H ₁₉ N ₃ O ₄	C ₁₄ H ₂₀ ClNO ₂	C ₁₇ H ₁₃ ClN ₂ O ₄	C ₁₇ H ₁₇ N ₃ O ₃	C ₁₄ H ₇ ClF ₃ NO ₅	C ₁₇ H ₁₃ ClFN ₂ O ₄
Mode of action	Microtubule assembly inhibition	Inhibition of cell division	Inhibition of acetyl co A carboxylase	Inhibition of Acetolactate synthase	Inhibition of proto porphyrinogen oxidase	Inhibition of acetyl co A carboxylase



Design : RBD	Variety : GBG-1
Season : Rabi 2016	Spacing : 30 cm × 10 cm
Replication : 3	Gross plot size : 3.6 m × 6.0 m
Treatments : 10	Net plot size : 2.4 m × 5.6 m

Fig. 3.3 Layout of the experiment

Table 4.1 Weed flora observed in experimental plot

S. No.	Botanical name	Common name	Family
Grasses			
1.	<i>Echinochloa colona</i>	Barnyard Grass	Gramineae
2.	<i>Dactyloctenium aegyptium</i>	Egyptian Grass	Poaceae
3.	<i>Dinerba retroflexa</i>	Viper Grass	Poaceae
Sedges			
4.	<i>Cyperus rotundus</i>	Nut Sedge	Cyperaceae
Broad leaved weeds			
5.	<i>Abutilon indicum</i>	Indian Mallow	Malvaceae
6.	<i>Acalypha indica</i>	Indian Acalypha	Euphorbiaceae
7.	<i>Trianthema portulacastrum</i>	Giant Pigweed	Aizoaceae
8.	<i>Commelina benghalensis</i>	Tropical Spiderwort	Commelinaceae
9.	<i>Celosia argentea</i>	Cocks Comb	Amaranthaceae
10.	<i>Cardiospermum helicacabum</i>	Balloon Vine	Sapindaceae
11.	<i>Chrozophora rotleri</i>	Croton Rottleri	Euphorbiaceae
12.	<i>Chorchorus trilocularis</i>	Nalta Jute	Tiliaceae
13.	<i>Digera arvensis</i>	False Amaran	Amaranthaceae
14.	<i>Eclipta alba</i>	Bringaraja	Asteraceae
15.	<i>Cleome viscosa</i>	Spider Flower	Capparidaceae
16.	<i>Physalis minima</i>	Goose Berry	Solanaceae
17.	<i>Portulaca quadrifida</i>	Pig Weed	Portulacaceae
18.	<i>Phyllanthus madaraspatanense</i>	Madras leaf flower	Euphorbiaceae

Table 4.2 Density of grasses as influenced by weed management treatments at different stages in *rabi* blackgram

Treatments	Density of grasses (No. m ⁻²)		
	20 DAS	40 DAS	At harvest
T ₁ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb one intercultivation at 20 DAS fb hand weeding at 30 DAS	3.50* (12.0)	3.34 (10.7)	4.52 (20.0)
T ₂ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	4.38 (18.7)	3.13 (9.3)	7.94 (62.7)
T ₃ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	4.06 (16.0)	3.34 (10.7)	6.36 (40.0)
T ₄ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	4.06 (16.0)	3.71 (13.3)	7.24 (52.0)
T ₅ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb one intercultivation 20 DAS fb hand weeding at 30 DAS	4.52* (20.0)	2.40 (5.3)	5.70 (32.0)
T ₆ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	5.07 (22.3)	4.06 (16.0)	8.51 (72.0)
T ₇ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	5.33 (18.0)	3.53 (12.0)	6.76 (45.3)
T ₈ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	5.41 (19.3)	4.38 (18.7)	7.69 (58.7)
T ₉ : Hand weeding twice at 20 and 40 DAS	8.51* (72.0)	3.13* (9.3)	8.97 (80.0)
T ₁₀ : Weedy check	8.74 (76.0)	12.72 (161.3)	16.46 (270.7)
S.Em _±	0.48	0.26	0.45
CD (P=0.05)	1.14	0.80	1.34
CV (%)	16.3	10.7	9.8

Data were subjected to square root transformation $\sqrt{x+0.5}$. Figures in parenthesis are original values.

*Weed data was collected before the hand weeding at 20 DAS and 40 DAS in T₉ and after intercultivation in T₁ and T₅.

Table 4.3 Density of sedges as influenced by weed management treatments at different stages in *rabi* blackgram

Treatments	Density of sedges (No. m ⁻²)		
	20 DAS	40 DAS	At harvest
T ₁ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb one intercultivation at 20 DAS fb hand weeding at 30 DAS	0.71* (0.0)	3.89 (14.7)	5.33 (28.0)
T ₂ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	3.34 (10.7)	3.13 (9.3)	5.81 (33.3)
T ₃ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	2.68 (6.7)	4.81 (22.7)	6.04 (36.0)
T ₄ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	2.68 (6.7)	4.38 (18.7)	5.33 (28.0)
T ₅ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb one intercultivation 20 DAS fb hand weeding at 30 DAS	3.34* (10.7)	3.71 (13.3)	5.58 (30.7)
T ₆ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	2.91 (8.0)	5.07 (25.3)	6.26 (38.7)
T ₇ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	4.06 (16.0)	4.06 (16.0)	4.94 (24.0)
T ₈ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	3.13 (9.3)	5.21 (26.7)	5.95 (35.0)
T ₉ : Hand weeding twice at 20 and 40 DAS	3.34* (10.7)	4.06 (16.0)	5.21 (26.7)
T ₁₀ : Weedy check	4.38 (18.7)	3.34* (10.7)	7.12 (50.3)
S.Em±	0.33	0.44	0.37
CD (P=0.05)	0.47	0.62	1.12
CV (%)	19.3	18.5	11.4

Data were subjected to square root transformation $\sqrt{x+0.5}$. Figures in parenthesis are original values.

*Weed data was collected before the hand weeding at 20 DAS and 40 DAS in T₉ and after intercultivation in T₁ and T₅.

Table 4.4 Density of broad leaved weeds as influenced by weed management treatments at different stages in *rabi* blackgram

Treatments	Density of broad leaved weeds (No.m ⁻²)		
	20 DAS	40 DAS	At harvest
T ₁ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb one intercultivation at 20 DAS fb hand weeding at 30 DAS	8.03* (64.0)	5.09 (26.7)	5.69 (34.3)
T ₂ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	7.05 (49.3)	10.20 (100.0)	13.14 (172.3)
T ₃ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	8.68 (74.7)	5.44 (29.3)	8.60 (75.0)
T ₄ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	5.45 (29.3)	6.87 (46.7)	8.97 (80.3)
T ₅ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb one intercultivation 20 DAS fb hand weeding at 30 DAS	10.85* (117.3)	4.38 (18.7)	5.58 (30.7)
T ₆ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	10.96 (120.0)	12.01 (145.3)	14.75 (217.0)
T ₇ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	8.87 (108.0)	5.75 (33.3)	10.02 (100.3)
T ₈ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	9.25 (85.3)	7.33 (53.3)	11.80 (124.7)
T ₉ : Hand weeding twice at 20 and 40 DAS	13.68* (186.7)	9.15* (84.0)	10.85 (117.3)
T ₁₀ : Weedy check	16.08 (258.7)	15.51 (240.0)	15.58 (243.3)
S.Em±	1.10	0.665	0.60
CD (P=0.05)	3.28	1.97	1.81
CV (%)	19.4	14.2	10.1

Data were subjected to square root transformation $\sqrt{x+0.5}$. Figures in parenthesis are original values.

*Weed data was collected before the hand weeding at 20 DAS and 40 DAS in T₉ and after intercultivation in T₁ and T₅.

Table 4.5 Total density of weeds as influenced by weed management treatments at different stages in *rabi* blackgram

Treatments	Total density of weeds (No. m ⁻²)		
	20 DAS	40 DAS	At harvest
T ₁ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb one intercultivation at 20 DAS fb hand weeding at 30 DAS	7.76 (64)	7.15 (52)	9.09 (82.3)
T ₂ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	8.89 (78.70)	10.85 (118.7)	16.40 (268.3)
T ₃ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	9.88 (97.3)	7.94 (62.7)	12.30 (151)
T ₄ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	7.2 (52)	8.89 (78.7)	12.65 (160.3)
T ₅ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb one intercultivation 20 DAS fb hand weeding at 30 DAS	12.09 (148)	6.13 (37.3)	13.01 (169)
T ₆ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	12.37 (153)	13.62 (186.7)	18.11 (327.7)
T ₇ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	12.25 (152.0)	7.82 (60.13)	13.04 (169.7)
T ₈ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	12.3 (153.3)	9.96 (98.7)	14.77 (218.3)
T ₉ : Hand weeding twice at 20 and 40 DAS	16.22 (269.0)	10.48 (109.3)	14.79 (224)
T ₁₀ : Weedy check	18.81 (353.3)	20.31 (412)	23.74 (564.3)
S.Em _±	1.057	0.59	1.07
CD (P=0.05)	3.140	1.754	3.204
CV (%)	15.6	9.9	12.7

Data were subjected to square root transformation $\sqrt{x+0.5}$. Figures in parenthesis are original values.

*Weed data was collected before the hand weeding at 20 DAS and 40 DAS in T₉ and after intercultivation in T₁ and T₅.

Table 4.6 Weed dry matter as influenced by weed management treatments at different stages in *rabi* blackgram

Treatments	Weed dry matter (g m ⁻²)		
	30 DAS	60 DAS	At harvest
T ₁ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb one intercultivation at 20 DAS fb hand weeding at 30 DAS	5.21 (26.7)	6.67 (44.0)	23.59 (556.0)
T ₂ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	6.51 (42.0)	32.03 (1025)	51.64 (2667)
T ₃ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	5.55 (30.7)	15.15 (229)	26.64 (709)
T ₄ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	4.67 (21.3)	17.56 (308)	28.03 (785)
T ₅ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb one intercultivation 20 DAS fb hand weeding at 30 DAS	6.87 (46.9)	8.197 (67)	24.75 (612)
T ₆ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	7.60 (57.6)	38.16 (1456.0)	54.92 (3016.0)
T ₇ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	9.75 (94.7)	19.21 (387)	28.33 (804)
T ₈ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	8.35 (70.0)	28.32 (801)	41.58 (1728)
T ₉ : Hand weeding twice at 20 and 40 DAS	5.79 (33.3)	9.69 (93)	43.57 (1899)
T ₁₀ : Weedy check	15.46 (238.7)	53.45 (2856)	57.77 (3337)
S.Em±	0.32	1.77	1.99
CD (P=0.05)	0.95	5.26	5.93
CV (%)	7.3	13.5	9.2

Data were subjected to square root transformation $\sqrt{x+0.5}$. Figures in parenthesis are original values.

*Weed data was collected before the hand weeding at 20 and 40 DAS in T₉ and after intercultivation in T₁ and T₅.

Table 4.7 Weed control efficiency as influenced by weed management treatments at different stages in *rabi* blackgram

Treatments	Weed control efficiency (%)		
	30 DAS	60 DAS	At harvest
T ₁ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb one intercultivation at 20 DAS fb hand weeding at 30 DAS	89.0	98.5	83.5
T ₂ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	82.4	63.9	20.0
T ₃ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	87.1	92.0	78.7
T ₄ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	91.3	89.2	76.4
T ₅ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb one intercultivation 20 DAS fb hand weeding at 30 DAS	80.4	97.7	81.5
T ₆ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	75.4	49.0	9.6
T ₇ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	60.1	86.6	75.8
T ₈ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	67.9	71.8	48.2
T ₉ : Hand weeding twice at 20 and 40 DAS	87.4	96.8	43.5
T ₁₀ : Weedy check	0.0	0.0	0.0
S.Em±	4.16	3.88	4.24
CD (P=0.05)	12.4	11.5	12.6
CV (%)	10	9.1	14.2

Table 4.15 Weed index as influenced by different weed management treatments in *rabi* blackgram

Treatments	Weed index (%)
T ₁ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb one intercultivation at 20 DAS fb hand weeding at 30 DAS	0.0
T ₂ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	43.6
T ₃ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	12.5
T ₄ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	20.1
T ₅ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb one intercultivation 20 DAS fb hand weeding at 30 DAS	6.9
T ₆ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	50.1
T ₇ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	13.2
T ₈ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	21.5
T ₉ : Hand weeding twice at 20 and 40 DAS	10.8
T ₁₀ : Weedy check	65.2
S.Em±	2.4
CD (P=0.05)	7.16
CV (%)	13.6

Table 4.8 Phytotoxicity score of herbicide treatments in *rabi* blackgram

Treatments	Phytotoxicity score (0-10)			
	Pre emergence herbicides		Post emergence herbicides	
	7 DAA	14 DAA	7 DAA	14 DAA
T ₁ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb one intercultivation at 20 DAS fb hand weeding at 30 DAS	0	0	-	-
T ₂ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	0	0	0	0
T ₃ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	0	0	1	0
T ₄ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	0	0	0	0
T ₅ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb one intercultivation 20 DAS fb hand weeding at 30 DAS	0	0	-	-
T ₆ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	0	0	0	0
T ₇ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	0	0	1	0
T ₈ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	0	0	0	0
T ₉ : Hand weeding twice at 20 and 40 DAS	-	-	-	-
T ₁₀ : Weedy check	-	-	-	-

Table 4.9 Crop stand as affected by different weed management treatments in *rabi* blackgram

Treatments	Crop stand (No.m ⁻²)	
	20 DAS	40 DAS
T ₁ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb one intercultivation at 20 DAS fb hand weeding at 30 DAS	32	32
T ₂ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	32	31
T ₃ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	33	32
T ₄ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	34	33
T ₅ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb one intercultivation 20 DAS fb hand weeding at 30 DAS	32	31
T ₆ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	32	32
T ₇ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	33	32
T ₈ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	33	33
T ₉ : Hand weeding twice at 20 and 40 DAS	33	31
T ₁₀ : Weedy check	33	31
S.Em±	0.84	0.71
CD (P=0.05)	NS	NS
CV (%)	4.5	3.9

Table 4.10 Plant height as influenced by weed management treatments at different stages in *rabi* blackgram

Treatments	Plant height (cm)		
	30 DAS	60 DAS	At harvest
T ₁ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb one intercultivation at 20 DAS fb hand weeding at 30 DAS	10.3	31.3	30.9
T ₂ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	12.3	32.9	32.9
T ₃ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	10.5	30.8	33.3
T ₄ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	10.8	30.4	31.4
T ₅ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb one intercultivation 20 DAS fb hand weeding at 30 DAS	10.4	32.4	32.8
T ₆ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	11.3	33.0	35.7
T ₇ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	10.4	31.1	32.5
T ₈ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	12.1	31.4	33.7
T ₉ : Hand weeding twice at 20 and 40 DAS	13.1	27.4	29.9
T ₁₀ : Weedy check	14.3	36.3	38.9
S.Em±	0.96	1.29	1.34
CD (P=0.05)	NS	3.8	4.0
CV (%)	14.5	7.1	7.0

Table 4.11 Days to 50% flowering as influenced by weed management treatments in *rabi* blackgram

Treatments	Days to 50% flowering
T ₁ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb one intercultivation at 20 DAS fb hand weeding at 30 DAS	46
T ₂ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	50
T ₃ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	46
T ₄ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	47
T ₅ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb one intercultivation 20 DAS fb hand weeding at 30 DAS	47
T ₆ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	51
T ₇ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	47
T ₈ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	48
T ₉ : Hand weeding twice at 20 and 40 DAS	44
T ₁₀ : Weedy check	51
S.Em±	1.37
CD (P=0.05)	NS
CV (%)	5

Table 4.12 Yield attributes as influenced by different weed management treatments in *rabi* blackgram

Treatments	Pods Plant ⁻¹	Seeds pod ⁻¹	Test weight (g)
T ₁ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb one intercultivation at 20 DAS fb hand weeding at 30 DAS	21.8	7.3	4.8
T ₂ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	15.1	5.3	4.3
T ₃ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	19.5	6.7	4.8
T ₄ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	18.6	6.3	4.6
T ₅ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb one intercultivation 20 DAS fb hand weeding at 30 DAS	20.6	6.8	4.9
T ₆ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	15.4	5.2	4.0
T ₇ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	19.2	6.3	4.7
T ₈ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	18.7	6.0	4.7
T ₉ : Hand weeding twice at 20 and 40 DAS	19.9	7.0	4.6
T ₁₀ : Weedy check	10.6	5.3	3.8
S.Em±	0.82	0.44	0.19
CD (P=0.05)	2.5	1.3	0.6
CV (%)	8.0	12.4	7.2

Table 4.14 Seed yield, haulm yield and harvest index as influenced by different weed management treatments in *rabi* blackgram

Treatments	Seed yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)	Harvest index (%)
T ₁ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb one intercultivation at 20 DAS fb hand weeding at 30 DAS	1132	2875	28.3
T ₂ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	639	2270	22.0
T ₃ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	990	2695	26.9
T ₄ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	905	2497	26.6
T ₅ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb one intercultivation 20 DAS fb hand weeding at 30 DAS	1054	2973	26.2
T ₆ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	565	2568	18.0
T ₇ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	983	2628	27.2
T ₈ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	889	2504	26.2
T ₉ : Hand weeding twice at 20 and 40 DAS	1010	2775	26.3
T ₁₀ : Weedy check	394	1971	16.7
S.Em±	46	202	1.8
CD (P=0.05)	137	601	5.3
CV (%)	9.3	13.5	12.4

Table 4.16 Soil N,P,K status at the time of harvest as influenced by different weed management treatments in *rabi* blackgram

Treatments	Soil N, P, K at harvest (kg ha ⁻¹)		
	N	P ₂ O ₅	K ₂ O
T ₁ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb one intercultivation at 20 DAS fb hand weeding at 30 DAS	165	42	682
T ₂ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	151	44	733
T ₃ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	134	45	708
T ₄ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	180	42	720
T ₅ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb one intercultivation 20 DAS fb hand weeding at 30 DAS	141	41	747
T ₆ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	134	44	732
T ₇ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	143	43	733
T ₈ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	137	46	738
T ₉ : Hand weeding twice at 20 and 40 DAS	147	48	708
T ₁₀ : Weedy check	120	41	707

Table 4.13 Crop dry matter production as influenced by different weed management treatments in *rabi* blackgram.

Treatments	Crop dry matter (kg ha ⁻¹)		
	30 DAS	60 DAS	At harvest
T ₁ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb one intercultivation at 20 DAS fb hand weeding at 30 DAS	141	2090	4224
T ₂ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	103	1052	2099
T ₃ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	110	1394	3689
T ₄ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	139	1401	3679
T ₅ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb one intercultivation 20 DAS fb hand weeding at 30 DAS	134	1812	4127
T ₆ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	99	929	2668
T ₇ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	117	1364	3454
T ₈ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	112	1273	3384
T ₉ : Hand weeding twice at 20 and 40 DAS	128	1687	3830
T ₁₀ : Weedy check	84	868	2332
S.Em±	6	139	141
CD (P=0.05)	18	412	418
CV (%)	9.1	18.3	7.3

Table 4.17 Soil bacterial population as influenced by different weed management treatments at different stages in *rabi* blackgram

Treatments	Soil bacterial population (CFU g ⁻¹ of soil)			
	PE		PoE	At harvest
	10 DAA	20 DAA	10 DAA	
T ₁ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb one intercultivation at 20 DAS fb hand weeding at 30 DAS	61	23	3	53
T ₂ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	72	29	33	77
T ₃ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	46	24	27	52.5
T ₄ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	27	21	20	75
T ₅ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb one intercultivation 20 DAS fb hand weeding at 30 DAS	67	46	58	114
T ₆ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	61	42	53	115
T ₇ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	45	35	59	60
T ₈ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	57	47	51	117
T ₉ : Hand weeding twice at 20 and 40 DAS	80	75	83	180
T ₁₀ : Weedy check	90	80	87	280
S.Em±	1.88	1.24	5.99	15.31
CD (P=0.05)	6	4	18	46
CV (%)	5.6	5.5	19.1	23.5

Initial count : 83 × 10⁸ CFU g⁻¹ of soil

Table 4.18 Soil fungal population as influenced by different weed management treatments at different stages in *rabi* blackgram

Treatments	Soil fungal population (CFU g ⁻¹ of soil)			
	PE		PoE	At harvest
	10 DAA	20 DAA	10 DAA	
T ₁ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb one intercultivation at 20 DAS fb hand weeding 30 DAS	11	8	10	4
T ₂ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	5	2	12	3
T ₃ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	22	8	16	2
T ₄ : Pendimethalin @ 0.75 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	12	12	16	3
T ₅ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb one intercultivation 20 DAS fb hand weeding at 30 DAS	24	10	10	6
T ₆ : Alachlor @ 1.0 kg ha ⁻¹ (PE) fb Quizalofop ethyl @ 50 g ha ⁻¹ (PoE) at 20 DAS	16	8	17	9
T ₇ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Imazethapyr @ 50 g ha ⁻¹ (PoE) at 20 DAS	11	9	6	3
T ₈ : Alachlor @1.0 kg ha ⁻¹ (PE) fb Acifluorfen + Clodinafop propargyl @ 124+60 g ha ⁻¹ (PoE) at 20 DAS	7	6	6	8
T ₉ : Hand weeding twice at 20 and 40 DAS	9	8	13	6
T ₁₀ : Weedy check	8.1	5.3	8.6	12
S.Em±	0.77	1.59	2.06	1.11
CD (P=0.05)	2	5	6	3
CV (%)	10.7	37.1	31.3	34.6

Initial count : 16×10^4 CFU g⁻¹ of soil

Table 4.19 Economics of *rabi* blackgram as influenced by different weed management treatments

Treatments	Seed yield (kg ha⁻¹)	Gross returns (₹. ha⁻¹)	Weed management cost (₹. ha⁻¹)	Total cost of cultivation (₹. ha⁻¹)	Net returns (₹. ha⁻¹)	Benefit cost ratio
T ₁	1132	96220	11025	29510	66710	3.26
T ₂	639	54315	3600	22285	32030	2.44
T ₃	990	84150	2715	21400	62750	3.93
T ₄	905	76925	3825	22510	54415	3.42
T ₅	1054	89590	11075	29560	60030	3.03
T ₆	565	48025	3650	22335	25690	2.15
T ₇	983	83555	2765	21450	62105	3.90
T ₈	889	75565	3875	22560	53005	3.35
T ₉	1010	85350	18000	36285	47565	2.37
T ₁₀	394	33490	--	18285	15205	1.83

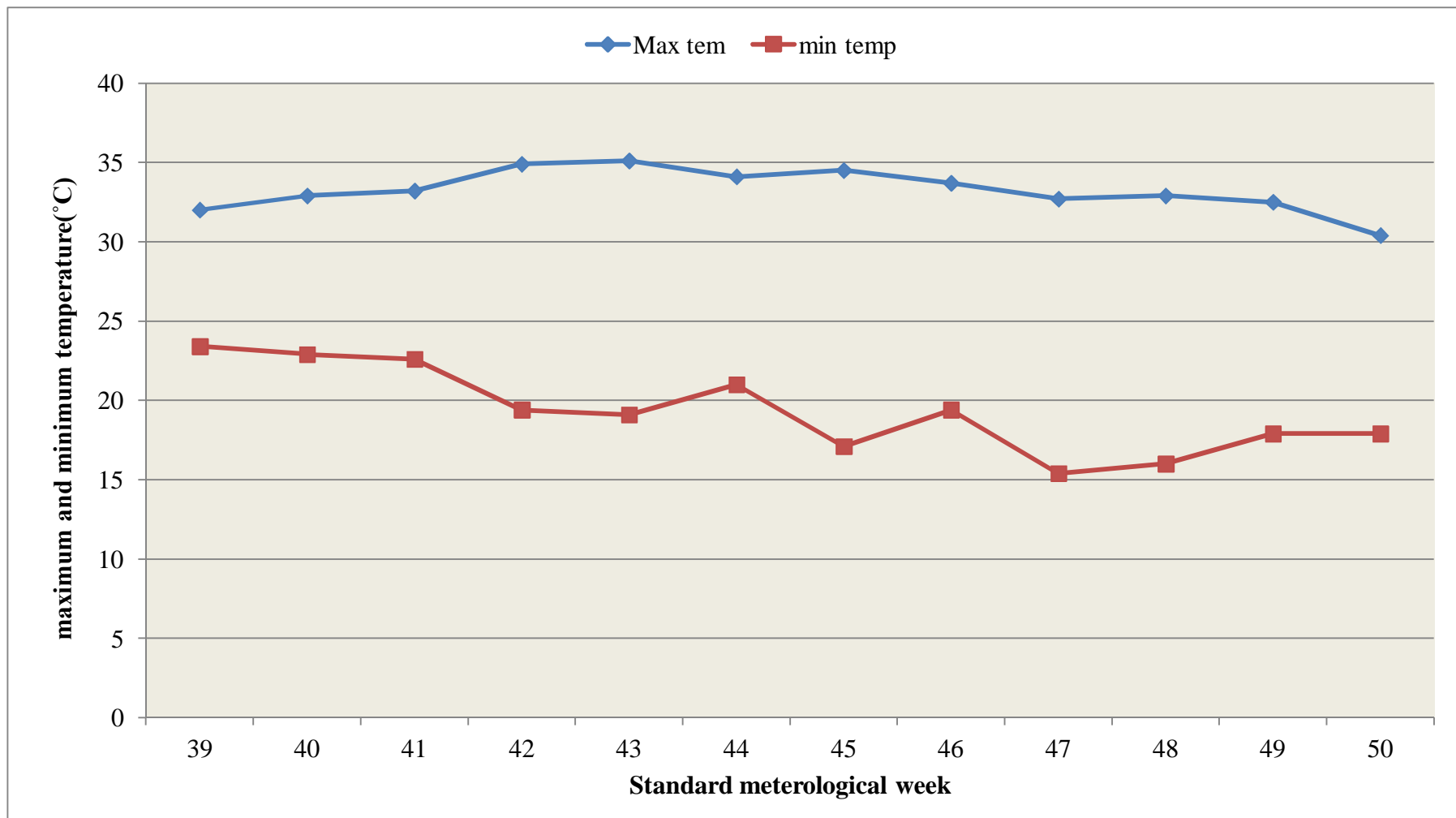


Fig. 3.1 Temperature data during the crop period

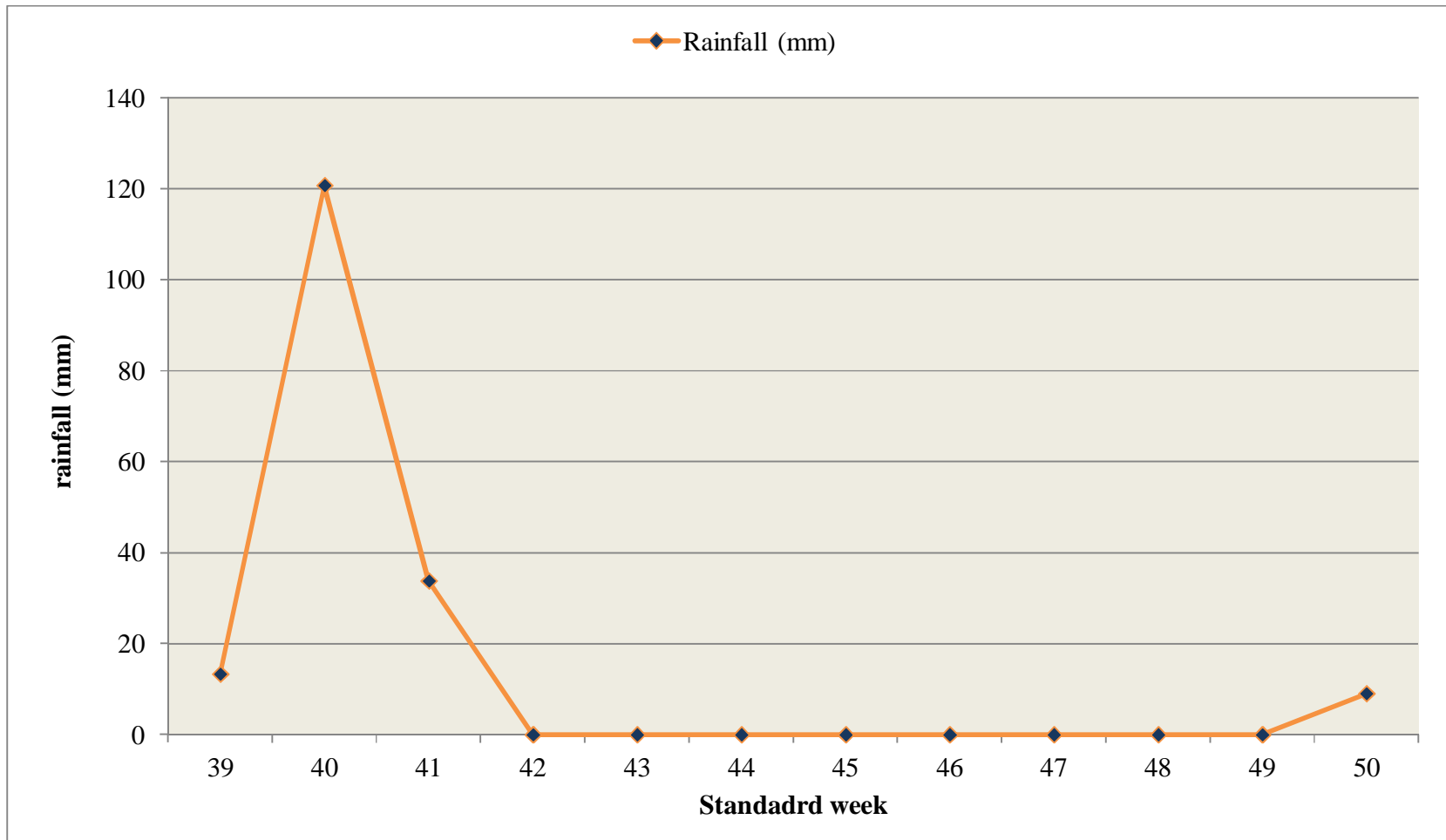


Fig. 3.2 Rainfall data during the crop period

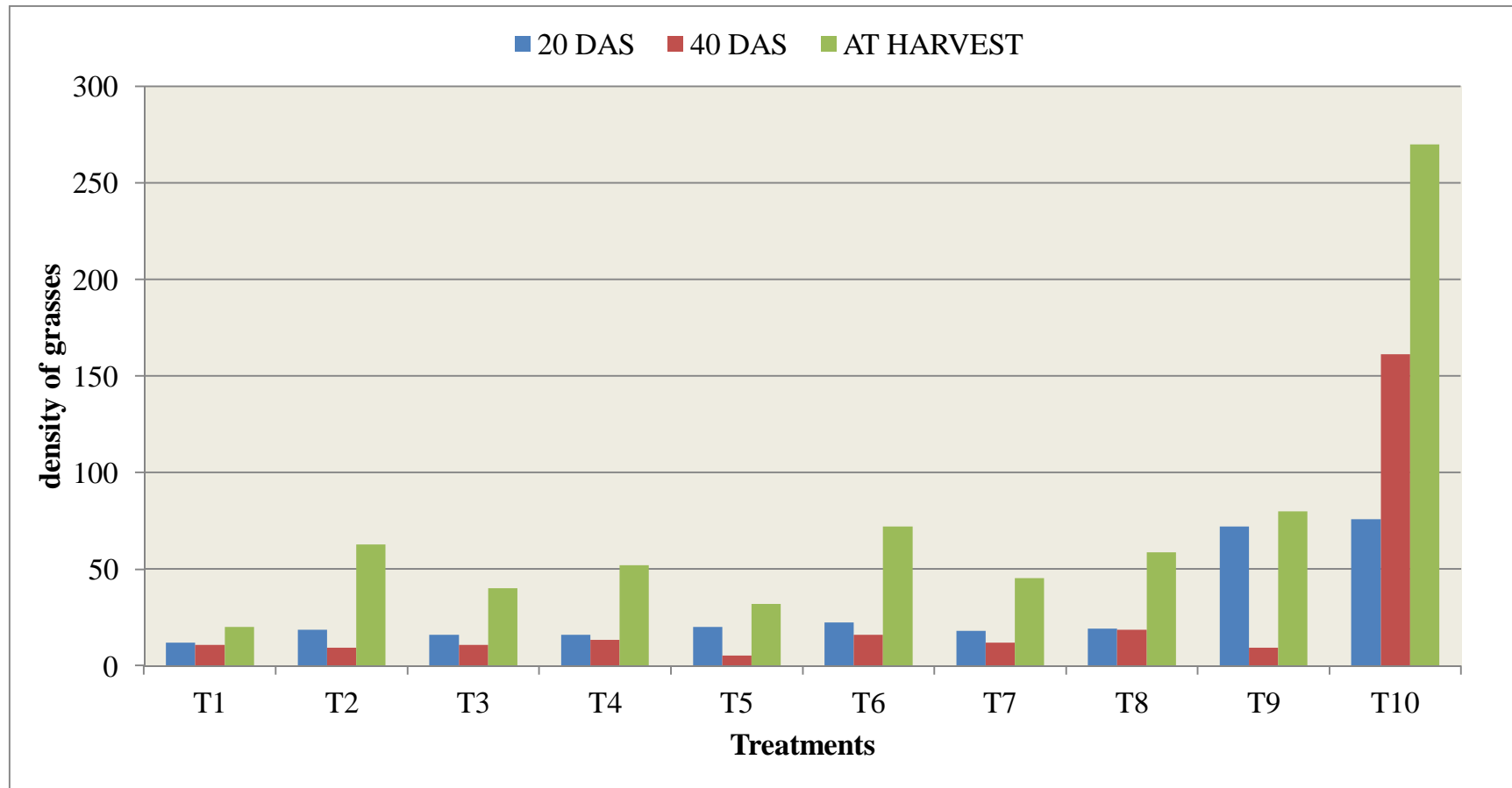


Fig. 4.1 Density of grasses as influenced by weed management treatments at different stages in *rabi* blackgram

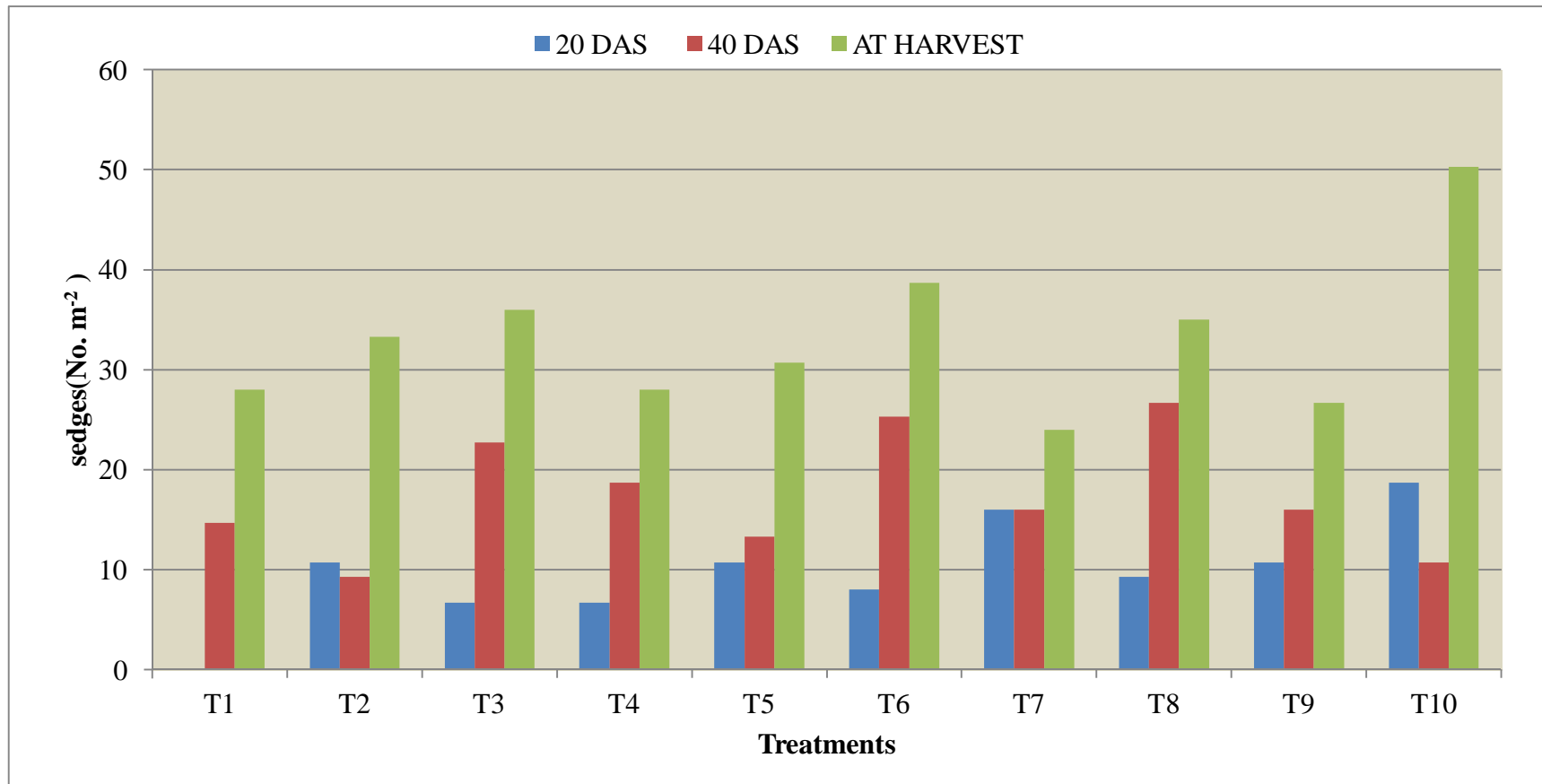


Fig. 4.2 Density of sedges at 20, 40 DAS and at harvest in *rabi* blackgram

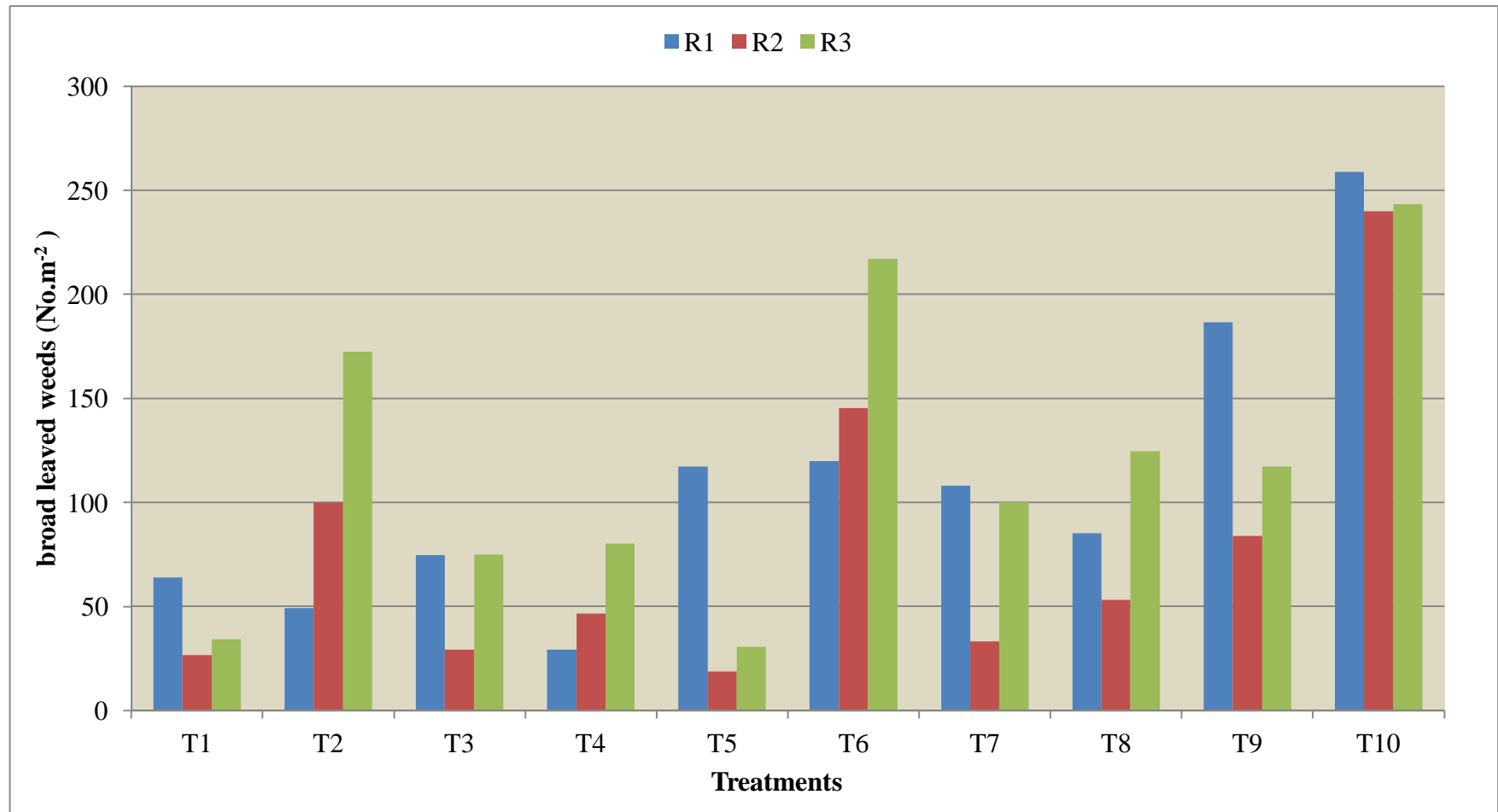


Fig. 4.3 Density of broad leaved weeds at 20, 40 DAS and at harvest inn *rabi* blackgram

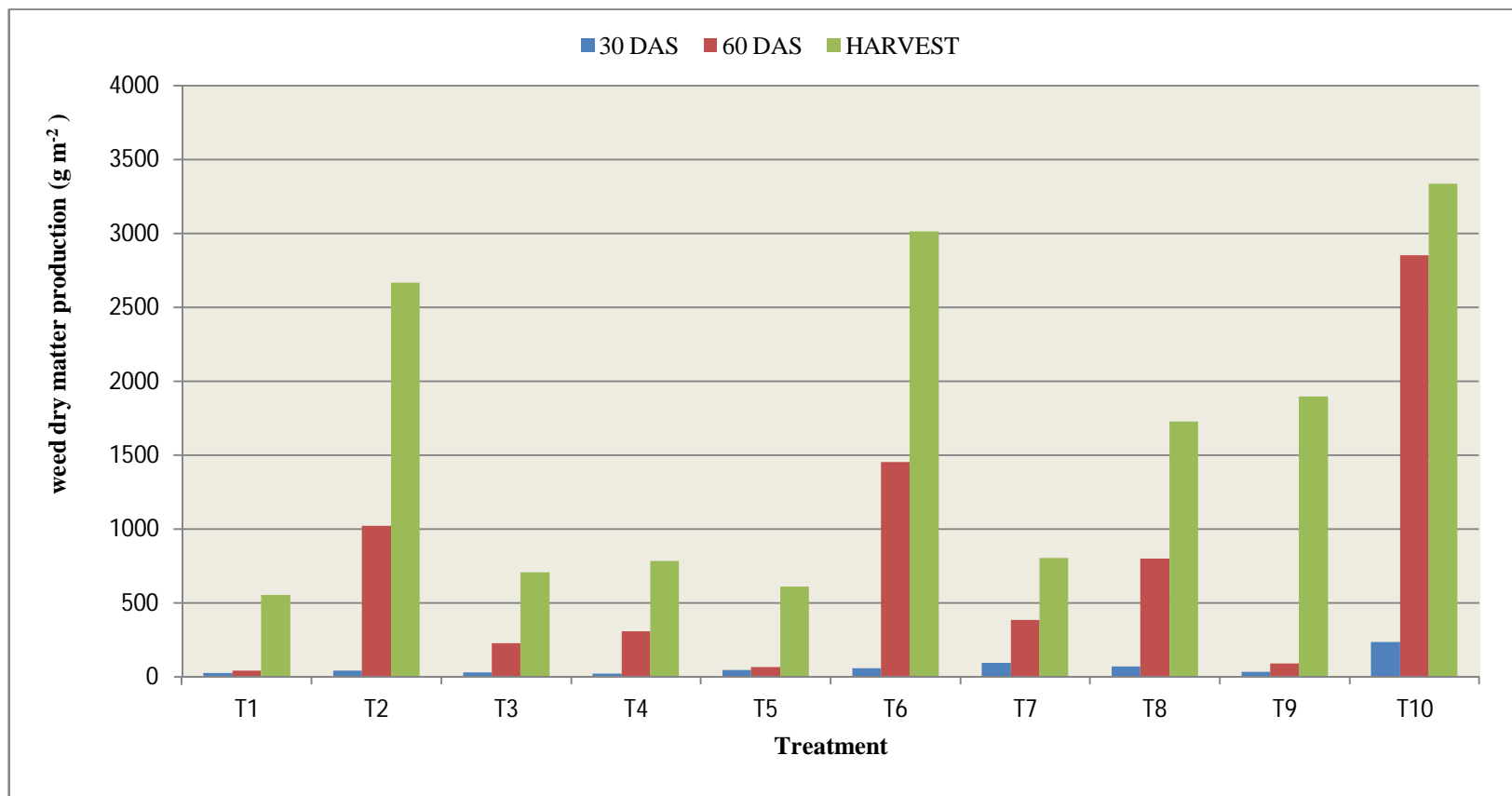


Fig. 4.4 Weed dry matter production (g m⁻²) at 30,60 DAS and at the time of harvest in *rabi* blackgram

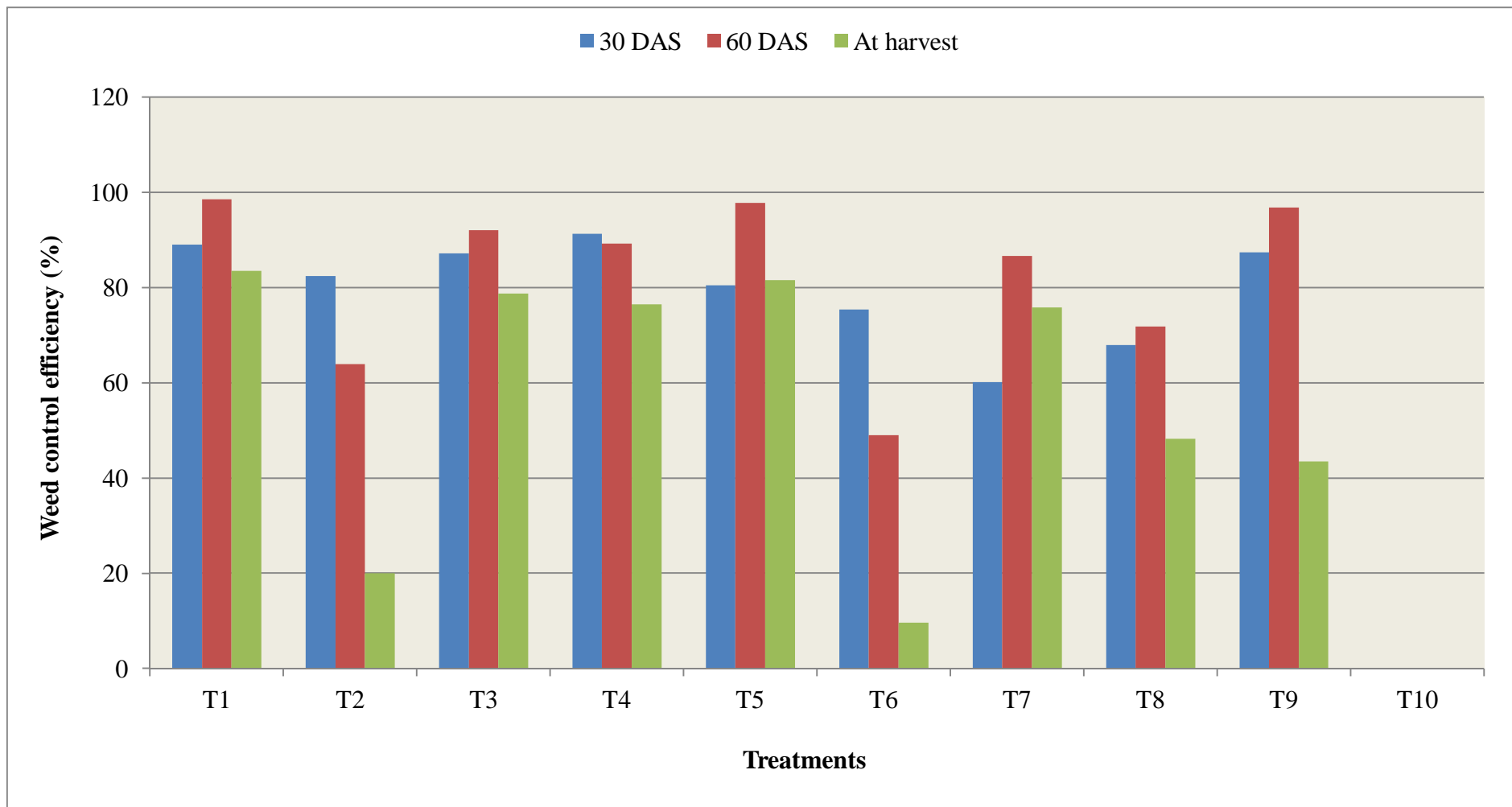


Fig. 4.5 Weed control efficiency as influenced by weed management treatments at different stages in *rabi* blackgram

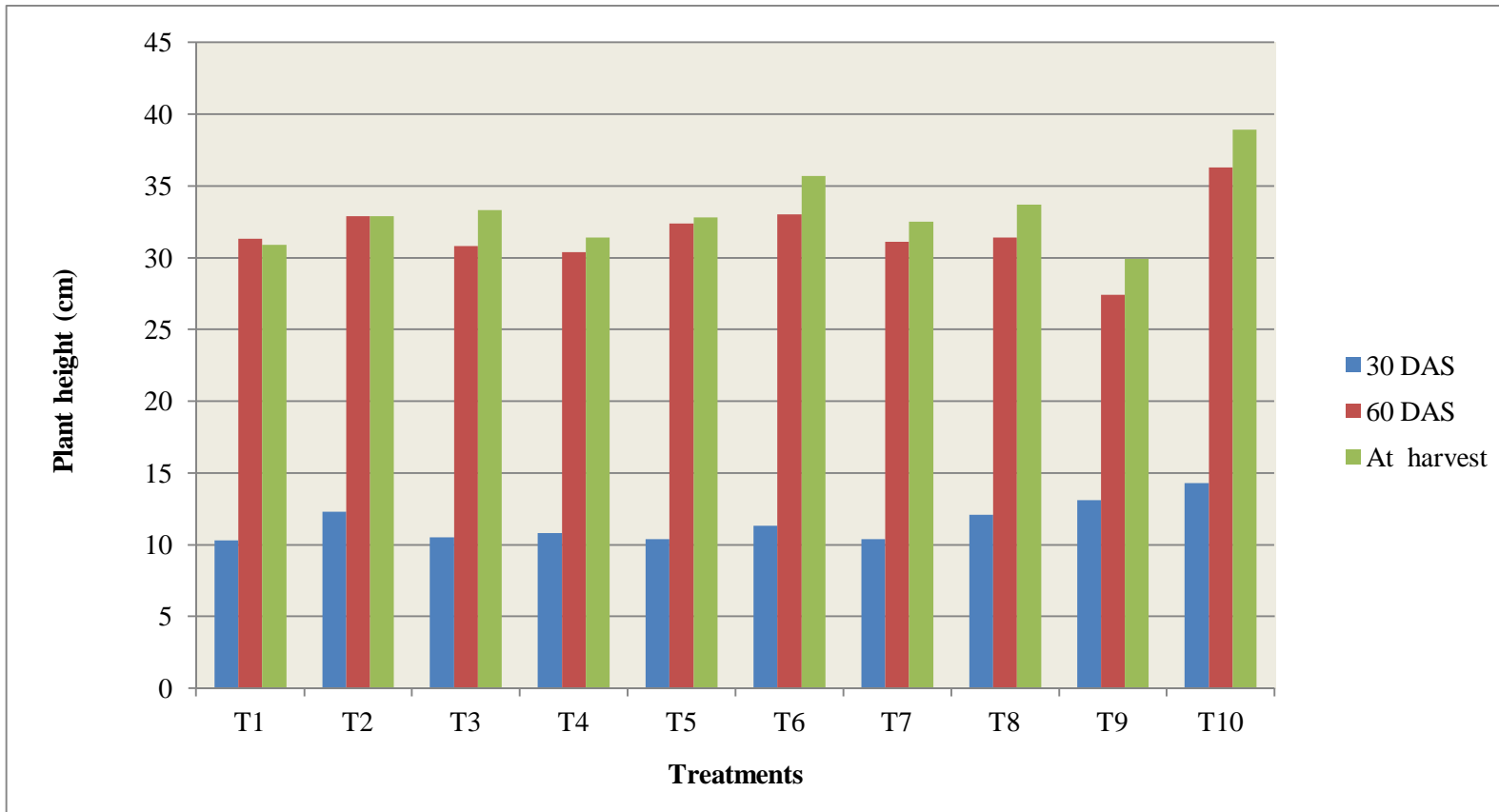


Fig. 4.6 Plant height as influenced by weed management treatments at different stages in *rabi* blackgram

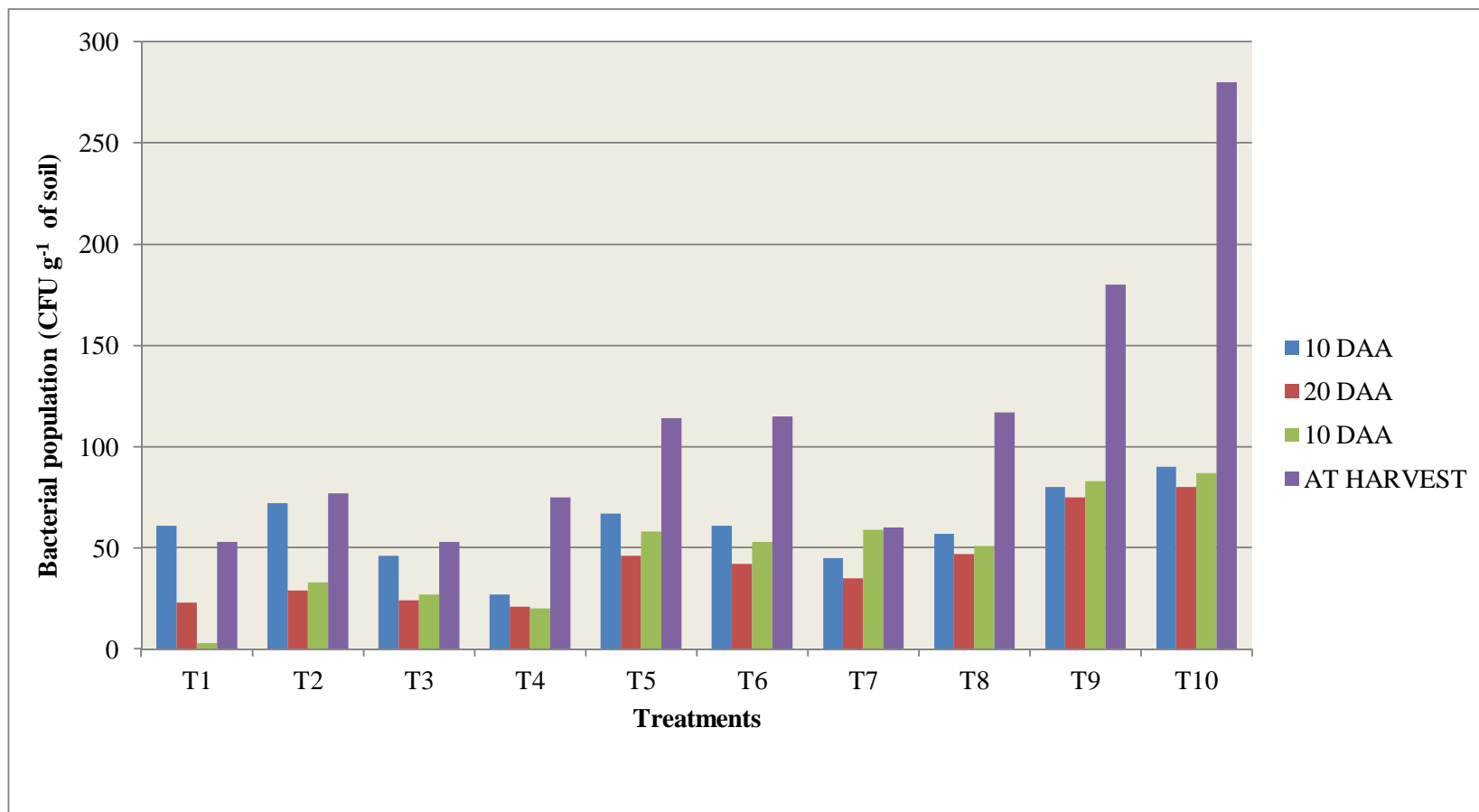


Fig. 4.7 Soil bacterial population as influenced by different weed management treatments in *rabi* blackgram

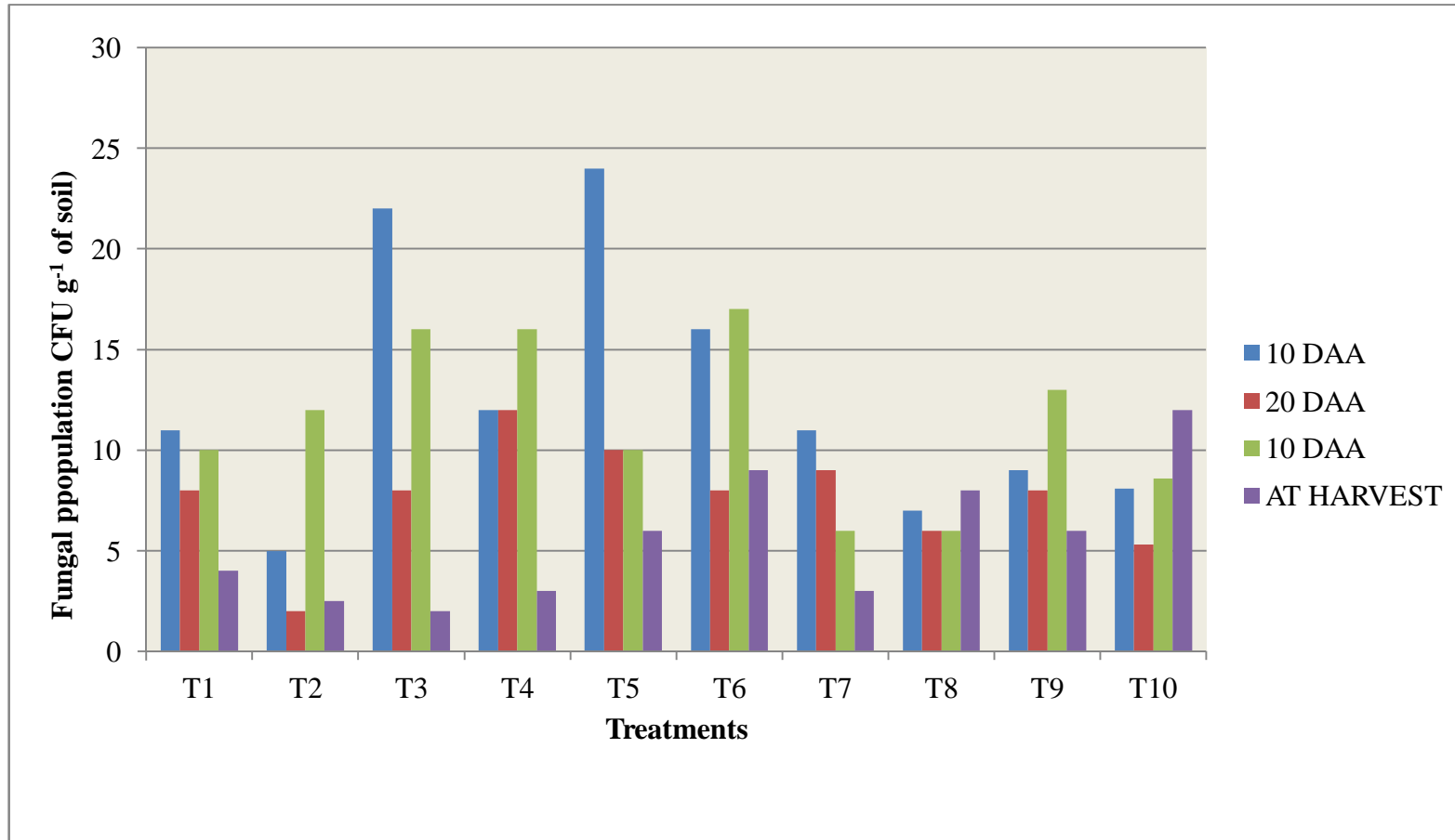


Fig. 4.8 Soil fungal population as influenced by different weed management treatments in *rabi* blackgram