# Integrated Weed Management in Greengram [*Vigna radiata (*L.) Wilczek.] in Arid Region

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**Komal Kataria**

**Thesis**

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

**2014**

**Department of Agronomy**
**COLLEGE OF AGRICULTURE**
**SWAMI KESHWANAND**
**RAJASTHAN AGRICULTURAL UNIVERSITY, BIKANER**

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# Thesis

**Submitted to the**

**Swami Keshwanand**

**Rajasthan Agricultural University, Bikaner**

**in partial fulfillment of the requirement for**

**the degree of**

Master of Science in Agriculture
(Agronomy)

**BY**

**Komal Kataria**

**2014**

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This is to certify that the thesis entitled **"Integrated Weed Management in Greengram [*Vigna radiata* (L.) Wilczek.] in Arid Region"** submitted for the degree of **Master of Science in Agriculture** in the subject **Agronomy** embodies bonafide research work carried out by **Miss Komal Kataria** under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been fully acknowledged. The draft of the thesis was also approved by the advisory committee on ……………..

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This is to certify that **Miss Komal Kataria** of the **Department of Agronomy, College of Agriculture, Bikaner** has made all corrections/modifications in the thesis entitled **"Integrated Weed Management in Greengram [*Vigna radiata* (L.) Wilczek] in Arid Region"** which were suggested by the external examiner and the advisory committee in the oral examination held on ___/___/2014. The final copies of the thesis duly bound and corrected were submitted on ___/___/2014 are enclosed herewith for approval.

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**Place: Bikaner** **(Komal Kataria)**
**Dated: … /… / 2014**

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# 1. INTRODUCTION

Greengram [*Vigna radiata* (L.) Wilczek.] is one of the major pulse crops in India which is cultivated in arid and semi-arid region. It is also called as moong or golden gram. It is tolerant to drought and best suited for light textured soils with poor water holding capacity and in areas with low and erratic rainfall. It is generally grown for grain, green fodder and for green manuring. Seeds as well as forage of greengram are rich in protein, fat and minerals. Its grain contains about 24.5 per cent protein of high digestibility and quality. Sprouted seeds synthesize vitamin-C in them. It is also good source of riboflavin and thiamine. The straw and husk are used as a fodder for cattle. It is good green manure and erosion resisting cover crop. The grains are mainly used as *Dal* or to make flour. Green pods are used as vegetables. Being a leguminous crop, greengram adds to the fertility of soil by fixing 30-40 kg atmospheric nitrogen per hectare. It is a short duration crop, and fits well in various multiple and intercropping systems.

In India, greengram is the third important pulse crop after chickpea and pigeonpea. It is cultivated in area about 3.35 million hectares and produce 1.82 million tones with productivity 512 kg $ha^{-1}$ (AICRP, 2011). Major greengram growing states are Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, Maharashtra, Rajasthan, Bihar, Gujarat and Orissa. In Rajasthan it is mainly cultivated in Nagaur, Jaipur, Jodhpur, Sikar, Pali, Jhunjhunu and Ajmer districts on 1050 thousand hectares with production of 652 thousand tones and productivity of 621 kg $ha^{-1}$ (AICRP, 2011).

Lack of improved cultural practices, cultivation on marginal and sub marginal lands of poor fertility, inadequate fertilization, monsoon dependent cultivation, heavy weed infestation, high sensitivity to pests and diseases and non-availability of suitable varieties are the major factors responsible for low yield of *kharif* pulses including greengram.

Generally in agriculture, weeds cause more damage compared to insects, pest and diseases, but due to hidden loss caused by weeds in crop production, it has not drawn much attention of farmers. Heavy weed infestation is recognized as a major bottleneck in realizing its full yield potential. Being a rainy season crop, it is invaded by a large number of fast growing weeds. The critical period of weed competition in pulses is during the first 30 – 40 days after sowing. Weeds grow quickly during this time taking the advantage of crops' slow initial growth. Weeds smoother this crop at every stage of its growth by competing for moisture, light, space and take a heavy toll of the applied as well as native nutrients. The problem is further increased under moisture stress conditions, where, most of the available soil moisture in root zone depth is exhausted by dense foliage cover of fast growing weeds. Therefore, research needs to be conducted to ascertain the critical period of crop-weed competition and to evolve appropriate weed management programme for exploiting the yield potential of greengram.

Physical or mechanical methods are the traditional methods of weed control in greengram. Often 2-3 hand weedings are required to keep the crop weed free. Manual weeding is not only time consuming but labour intensive and also it is very costly. Sometimes weed growing within the crop rows and continuous rainfall in rainy season does not permit hand weeding to operate timely. Although mechanical weeding provides advantages like aeration and soil moisture conservation but, with the increasing crisis of labour, exploring the possibility of herbicidal weed control in greengram deserves attention. Identification of a selective and cost effective herbicide can be a good alternative to provide weed free environment during early growth period in such an important crop. The use of herbicides has revolutionized weed management and reduces the cost of cultivation.

Besides benefits, chemical methods of weed control have some limitations. Application of selective herbicide may control certain species or group of weeds but may not be effective on other weed species. In such situation, while one group of weeds effectively eliminated, other group takes over and offers severe competition to the crop. Higher dose of herbicides may leave residue in the soil to injure the subsequent crops and also create the pollution problem (Pahwa and Prakash, 1996). The extent of damage by herbicide residue will, however, depend on nature of herbicide, dose applied and sensitivity in succeeding crop. Continuous use of the herbicides may also lead to resistance in weeds. Cultivators should be aware of proper dose of herbicides, time of application, their toxic effects and persistence in the soil.

Manual weeding or spraying of recommended pre-emergence herbicide is sometime difficult in rainy season for efficient weed control and pre-emergence herbicides controls weed during early growth stage, but later, newly germinated weeds flora cannot be controlled by pre-emergence application. This warrants the use of post emergence herbicide for weed control. Under this situation, supplement of herbicides along with physical method prove in augmenting the yield of green gram (Gupta *et. al.* 1990).

Integrated weed management involving the use of two or more weed control techniques *viz*., cultural, mechanical and chemical in a well-planned sequence. The integrated management approach is advantageous because one technique rarely achieve complete long and effective control of all weeds during crop season and even a relatively few surviving weeds can produce sufficient number of seeds to perpetuate the species. The judicious use of herbicides in crop land, generally results in increase crop yield, improve crop quality and reduce production costs. Therefore, herbicides used alone or in combination with other weed management techniques reduce crop weed competition and the risk of weeds growing unchecked in period of adverse weather or soil condition.

In recent years, pendimethalin has performed well in pulse crops as pre-emergence herbicide. Pendimethalin is a selective and pre-emergence herbicide, absorbed by roots and leaves. Affected plants die shortly after germination or following emergence from the soil. Experimental evidences are available that the use of pendimethalin as pre-emergence spray can completely control early emerged broad leaf and annual grassy weeds (Gurjar *et al*., 2001 and Chauhan *et al.,* 2002). If the farmers skipped to apply this herbicide due to one or other reasons, application of post-emergence herbicide is the only option left with them. In view of paucity of information on weed management especially the application of post-emergence herbicides in moongbean, an attempt has been made to test imazethapyr and imazamox as post emergence herbicides, as these have shown encouraging results in other pulses.

Imazethapyr is systemic, post-emergence herbicide, absorbed by the roots and foliage with translocation in the xylem and phloem and accumulation in the meristematic regions. The use of this herbicide controlled major annual and perennial grasses and broad leaved weeds in leguminous crops (Dixit and Varshney, 2007 and Savu *et al.,* 2006).

Imazamox is a systemic post-emergence herbicide that moves throughout the plant tissue and prevents plants from producing a necessary enzyme, acetolactate synthase (ALS), which is not found in animals. Susceptible plants will stop growing soon after treatment, but plant death and decomposition will occur over several weeks. It control certain annual grasses and broad leaved weeds in field pea, legume-based pastures, lucerne, peanut and soybean.

Keeping all these points in view, an experiment entitled **"Integrated Weed Management in Greengram [*Vigna radiata* (L.) Wilczek.] in Arid Region"** was conducted during *Kharif*-2013 at Agronomy Farm of Agriculture Research Station, S.K. Rajasthan Agricultural University, Bikaner with the following objectives :

1. To find out the effect of integrated weed control treatments on growth, yield and quality of greengram.
2. To find out suitable herbicides for weed management in greengram.
3. To study effect of integrated weed management on nutrient uptake by crop and weeds.
4. To study the economics of different integrated treatments under study.

# 2. REVIEW OF LITERATURE

A brief review related to the research work done on "Integrated Weed Management in Greengram [*Vigna radiata* (L.) Wilczek.] in Arid Region" is presented in this chapter. Since the work done on the Integrated Weed Management in Greengram is meagre, pertinent research finding involving other legumes have also been included in this text wherever felt necessary under the following broad topics.

## 2.1 Weed flora

Singh *et al.* (1991) reported that weed flora of mungbean during monsoon season were *Echinochloa colonum* L., *Dactyloctenium aegypticum* L., *Eleusina indica* L., *Digitaria sangunalis* (L.) Scop, *Phyllanthus niruri* L., *Cleome viscose* L., *Cyperus rotundus* L. and *Cyperus iria* L. Mishra and Singh (1993) at G. B. Pant University of Agriculture and Technology, Pantnagar (Uttaranchal), found that most problematic weeds in blackgram were *Echinochloa colonum, Cyperus rotundus, Cleome viscose, Celosia argentea, Cucumis trigonus, Eleusine indica* and *Physalis minima.* Sandhu *et al.* (1993) observed *Trianthema portulacastrum L., Acrachne racemosa (Heyne) Ohwi, Digitaria sangunalis (L.) Scop, Eleusina aegyotiaeum, Comelina benghalenisis L., Digera arvensis Frosk, Cleome viscose L., Tribulus terrestris L.* and *Cyperus rotundus L.* weeds in greengram at Ludhiana. Panwar (1999) at Shamli, Uttar Pradesh observed that the major weeds of greengram were *Cyperus rotundus, Chenopodium album, Trianthema portulacastrum, Digera arvensis* and *Cynodon dactylon.*

Kumar and Kundra (2001) observed that the weeds of mungbean were annual (*Cleome viscosa, Digera arvensis, Cucumis trigonus, Eleusine aegyptiacum, Euphorbia hirta, and Leucas aspera*) and perennial (*Cynodon dactylon, Cyperus rotundus, and Convolvulus* *arvensis*) at Ludhiana, Punjab, India. Tiwari *et al.* (2004) reported that major weed flora in mungbean were *P. hysterophorus, Trianthema monogyna* [*T. portulacastrum*], *Echinochloa colona* and *Dactyloctenium aegyptium* at Kanpur during *kharif* 2001 and 2002 . Singh and Shweta (2005) reported that the main problematic weeds were *Echinochloa colonum, Eleusine indica, Medicago denticulate, Trianthema monogyna, Commelina benghalensis, Cynodon dactylon* and *Cyperus rotundus* in blackgram at G. B. Pant University of Agriculture and Technology, Pantnagar (Uttaranchal). Yadav and Singh (2005) reported that the predominant weeds of mungbean were *Cyperus rotundus, Cynodon dactylon* and *Echinochloa crusgalli* at U.P.

Angiras *et al.* (2006) observed that major predominant weeds of the experimental field in weedy plots at 60 DAS were *Ageratum conyzoides* (39.4per cent), *Cyperus iria* (14.6per cent), *Echinochloa colona* (13.8per cent), *Commelina benghalensis* (12.1per cent), *Polygonum alatum* (11.4per cent), and *Panicum dichotomiflorum* (8.8per cent) in blackgram. Gousia and Rao (2006) observed that the main weeds in blackgram crop were *Echinochloa colonum, Echinochloa crusgalli, Leersia hexandra, Panicum repens, Cyperus rotundus, Cyperus kyllinga, Eclipta alba, Grangea maderaspatana, Cardanthera uliginosa, Xanthium strumarium, Ammannia baccifera* and *Commelina benghalensis.* Sardana *et al.* (2006) observed that the most dominant weeds of blackgram were *Eleusine aegyptiacum, Cyperus rotundus* and *Cynodon dactylon* among grasses and *Digera arvensis* and *Commelina benghalensis* among broadleaf weeds.

Yadav *et al.* (2010) conducted a field experiment at Meerut and reported that major weed species of mungbean were *Echinochloa spp., Trianthema monogyna, Parthanium hysterophorus, Ccysrus rotundus, Digera arvensis* and *Cynodon dectylon*. Ali *et al*. (2011) reported that the most dominant weeds of mungbean were *Cynodon dactylon, Cenchrus* *biflorus, Dactylocatenium aegypticum, Boerhavia diffusa, Trianthema monogyna, Corchorus olitorius, Portulaca oleracea, Tribulus terrestris, Spergula arvensis and Cyperus rotundus* at Sardarkrushinagar, Banaskantha, Gujarat. Nandan *et al.* (2011) reported that predominant weed flora of mungbean comprised of *Echinochloa colona* (80%), *Cynodon dactylon* (15%) and *Cyperus rotundus* (5%) in monocots and *Commelina benghalensis* (75%) and *Ageratum conizoides* (15%) in dicot. Punia *et al.* (2011) observed that the most dominant weeds of clusterbean were *Digera arvensis, Trianthema portulacastrum, Physallis minima, Corchorus olitorius, Solanum nigrum* and *Cyprus rotundus.* Singh (2011) observed that major weed flora of blackgram were *Trianthema portulacastrum, Eleusine aegyptiacum, Digitaria sanguinalis* and *Cyperus rotundus*. Bhuller and Kaur (2012) reported that weed flora in the experimental field found were *Dactyloctenium aegyptiacum, Eragrostis tennela, Echinochloa crusgalli, Echinochloa colona, Commelina benghalensis, Acrachne racemose, Digitaria ciliaris* among grasses and *Cyperus rotundus* and *Cyperus compressus* among broadleaf*.* The most dominant weeds of clusterbean in Bikaner region are *Boerhavia diffusa, Cynodon dactylon, Cyperus rotundus, Cenchrus biflorus, Corchorus olitorius, Dactylocatenium aegypticum, Digiteria cilliaris, Portulaca oleracea, Tribulus terrestris and Trianthema portulacastrum* (SKRAU, 2012).

Chhodavadia *et al.* (2013) reported that most dominant weeds of summer mungbean were *Panicum colonum* L., *Cynodon dactylon* L., *Cyperus rotundus* L., *Digera arvensis* Forsk, *Euphorbia hirta* L., *Leucas aspera* Spreng., *Phyllanthus niruri* L., *Portulaca oleracea* L. and *Indigoflora glandulosa* L. Sangeetha *et al*. (2013) reported that *Dactyloctenium aegyptium*, *Acrachne racemosa* and *Bracharia reptans* were the dominant grassy weeds, *Cyperus rotundus* was the only sedge and *Digera arvensis, Boerhavia diffusa, Parthenium hysterophorus* and

*Trichodesma indicum* were dominant broad leaved weeds in soybean. Singh *et al*. (2014) carried out a field experiment during *kharif* 2013 at SKRAU, Bikaner and resulted that major weed flora of experiment field were *Amaranthus viridis, Gisekia poiedious, Digera arvensis, Chenchrus biflorus, Eragristis pilosa* and *Eragristis tannela* in Clusterbean.

## 2.2 Losses caused by weeds

Balyan and Bhan (1989) observed a reduction of 22.4 per cent and 66.1 per cent in cowpea and mungbean yield, respectively with infestation carpetweed (*Trianthema portulacastrum*) during rainy seasons of 1983 and 1984. Singh *et al.* (1991) conducted an experiment on crop weed competition in greengram and blackgram and revealed that the period during first 30 days after sowing was the most critical for crop-weed competition for monsoon sown greengram crop. Ali (1992) conducted an experiment in different parts of India for five years and found that uncontrolled weeds suppressed growth of mungbean and reduced the yield about 28 per cent over weed free. Weed causes a considerable reduction in yield of agricultural crops by competing for nutrients, moisture, light, air and space (Tyagi *et al.*, 1993).

Patro and Prusty (1994) at Berhampur (Orissa) observed that grain yield of mungbean was reduced by 67.7 per cent when weeding operation was not carried out throughout the crop period. Singh *et al.* (1994) at Jabalpur (M.P.) reported that grain yield of summer mungbean was reduced by 49.15 per cent due to competition with weeds, when weeds were not removed for entire crop season. Mishra and Mishra (1995) reported 58.7 per cent drops down in blackgram yield when weeds were allowed to grow with the crop throughout crop season.

Kumar *et al*. (2004) reported that yield losses in greengram due to weeds have been estimated to range between 30-50 per cent. Mishra and

Chandrabhanu (2006) reported that yield of summer blackgram was reduced by almost 63.8 per cent due to presence of weeds as compared to weed free check. Vivek *et al.* (2008) indicated that grain yield loss was increased with the increase in the duration of weed competition and maximum loss (67 per cent) was occurred due to full season competition in blackgram. Meena *et al.* (2011) conducted a field experiment to evaluate the efficacy of post emergence applications of imazethapyr and reported that yield was reduced with infestation of grassy weeds (51.6%), broad leaf weeds (34.1%) and sedges (13.2%) of soybean. Singh (2011) conducted field experiments during summer season for four years (2002, 2003, 2004 and 2005) and during kharif season for three years (2002, 2003 and 2005) and showed that unchecked weeds caused a reduction of 41.2 and 41.6 per cent in blackgram yield during the two respective seasons.

Patil *et al.* (2014) reported that the losses caused by weeds much higher and the soybean crop yield losses may occur up to the extent of 20 to 77 per cent. Singh *et al.* (2014) noted that being a rainy season crop, mungbean is heavily infested with weeds which reduced yield of crop by 28 to 57 per cent.

## 2.3 Critical period of crop-weed competition

Satyanarayan Rao and Weeranna (2001) reported that among the weed management practices, hand weeding at 3 WAS followed by hoeing at 5 WAS recorded higher grain yield of 1020 kg $ha^{-1}$, which was closely followed by hoeing at 3, 4 and 5 WAS (998 kg $ha^{-1}$) and pre-emergence pendimethalin spray and hoeing at 3 and 5 WAS (969 kg $ha^{-1}$). Shaikh *et al*. (2002) at Parbhani, reported maximum seed yield of blackgram was obtained when crop was weeded 3 and 5 weeks after sowing. Singh and Bhan (2002) at Jabalpur observed 54.20 per cent reduction in the grain yield of soybean due to presence of weeds throughout the growing season. Singh *et al*. (2003) at Pantnagar reported that on an average season long weed competition caused 82 per cent reduction in grain yield of soybean compared with weed free condition on loamy soils. Sumachandrika *et al.* (2003) have found the highest number of pods plant$^{-1}$ (15.6), seed yield (3.9 g plant$^{-1}$) and the grain yield (1222 kg ha$^{-1}$) in blackgram when critical time of weed control was 20 to 40 DAS.

Kumar *et al.* (2004) revealed that during early period, less crop canopy coverage considerably reduced yield of soybean. Kumar *et al*. (2004) reported that the most critical period of weed competition in groundnut was early period of weed growth causing considerable reduction in yield of the crop. Saxena *et al.* (2004) at Jodhpur found that the competition between weeds and crop caused 53.7 per cent reduction in seed yield of cluster bean. They also concluded that this crop required an initial 40 days as weed free period for better yield and maximum net returns.

Sheoran *et al.* (2008) conducted a field experiment for two consecutive rainy seasons of 2003 and 2004 at ZRS for *Kandi* Area, Ballowal Saunkhri and reported that unchecked weed competition caused 53.7 per cent greengram seed yield reduction compared to weed free check. Most significant reduction in seed yield occurred when weed free conditions were maintained for the initial 20 days of sowing and unchecked weed infestation upto 40 DAS and thereafter. Thus, the critical period of crop weed competition lies between 20-40 days after sowing in rainy season seeded greengram under rainfed conditions. Vivek *et al.* (2008) observed that the critical crop-weed competition period was 30-45 DAS in blackgram crop. They indicated that grain yield loss was increased with the increase in the duration of weed competition and maximum loss (67 per cent) was occurred due to full season competition in blackgram.

Patel *et al*. (2014) at AAU, Gujarat observed that weeds compete severally with crop for nutrients, moisture and light which reduced yield 30-50 per cent of blackgram and the critical period of crop weed competition in blackgram was found 15-45 DAS.

## 2.4 Effect of integrated methods of weed control on weed growth

Mishra *et al.* (1998) conducted an experiment in *kharif* (monsoon) 1989-90 and 1991-92 at Ambikapur with pigeonpea and soybean crop. They reported that hand weeding resulted in lowest weed dry weight. Singh *et al.* (1988) carried out a field experiment during 1984 and 1985 to study the effect of weed management on grain yield of mungbean. They reported the weed free plots of *Vigna radiata* cv. Jawahar (hand weeding 4 times at 15 days interval) provided the lowest weed dry weight (70-91 kg $ha^{-1}$) and the highest grain yields (1046 kg $ha^{-1}$) compared to an unweeded control which gave average weed dry weight of 295 kg $ha^{-1}$ and yields of 588 kg $ha^{-1.}$. Gupta *et al.* (1991) in summer mungbean observed that 3 harrowing resulted in significantly lower weed dry matter than 1 harrowing. Reddy *et al*. (1998) observed from an experiment conducted during the rainy season (June to September) of 1996 in Hyderabad, India, to determine the efficacy of pendimethalin, metolachlor, alachlor, fluchloralin and butachlor for the control of *Cyperus rotundus* in green gram (*Vigna radiata*) fields. None of the herbicides gave an effective level of control of *Cyperus rotundus*. However, hand weeding at 20 days after sowing resulted in the highest seed yield compared to any herbicide treatment. Mandloi *et al.* (2000) in soybean at JNKV, Jabalpur reported that two hand weeding at 30 and 45 DAS recorded higher weed control efficiency, pods per plant, seeds per pod and seed yield as compared to any herbicide treatment. Parasuram (2000) at TNAU, Paiyur on the basis of two year experimentation observed that, an application of herbicides pendimethalin at 3 DAS was found effective in controlling weeds and recorded lower weed population and dry matter of weed. He also noted marked increase in crop yield and was comparable with hand weeding twice at 15 and 30 DAS in rainfed cowpea and greengram. Parasuram (2000) at TNAU, Paiyur in greengram reported that two hand weedings, application of pendimethalin at 1.5 kg $ha^{-1}$ + hand weeding at 30 DAS controlled the weeds to the extent of 82.1 and 80.6 per cent, respectively.

Fontes *et al.* (2001) conducted two field experiments at Coimbia and Vicosa (Brazil) during summer autumn and spring summer seasons of 1996 and 1997 to determine the effects of single and double hoeing time in mungbean, with no weed control and weed control throughout the crop life cycle. They reported that in the summer autumn one hoeing treatment, at approximately 21 DAS, resulted in grain yield, which were not, significantly different from those obtained when weed was controlled throughout the mungbean lifecycle. While, in the spring summer two hoeing (first at 14 DAS and second at 28 DAS) resulted in grain yields similar to those obtained with weed control throughout the crop life cycle.

Kang *et al.* (2001) reported that pendimethalin was effective in reducing weed density and weed dry weight. The herbicide was also best for yield and quality of soybean. Kushwah and Kushwaha (2001) reported that the highest weed control efficiency and seed yield of soyabean ware obtained with the pre-emergence application of pendimethalin @ 1.0 kg $ha^{-1}$ supplemented with hand weeding at 30 DAS. Khaliq *et al*. (2002) investigated the efficacy of different weed management strategies in mungbean during the spring season of 2001 at Faizalabad, Pakistan. The results indicated that two hand hoeings at 15 and 30 DAS resulted in the lowest weed dry weight (79 per cent) and the maximum plant height and pre-emergence application of pendimethalin @ 165 g $ha^{-1}$ + sorgaab @ 1.0 lit $ha^{-1}$ at 15 and 30 DAS reduced the total weed dry weight by 75 per cent. Randhawa *et al.* (2002) while studying at Amritsar reported significant reduction in weed density and dry weight due to one hand weeding in black gram. Concomitant increase in seed yield was 27 per cent as compared to weedy check (722 kg $ha^{-1}$). Sharma and Shrivastava (2002) during a study at Bhagwanpura (M.P.) reported significant reduction in weed density, weed dry weight and increased weed control efficiency due to two hand weedings in soybean. This treatment significantly improved plant height, branches $plant^{-1}$, pod yield $plant^{-1}$ and seed yield of soybean over weedy check.

Rao and Rao (2003) conducted a field experiment at Bapatla, A.P. and observed that one hand weeding at 25 DAS produced higher grain yield of black gram as compared to chemical treatments *viz.* clodinafop-propargyl (0.037 0.045, 0.052, 0.060 and 0.075 kg $ha^{-1}$), imazethapyr (0.062 kg $ha^{-1}$) and thiobencarb (2.0 kg $ha^{-1}$). Rao *et al.* (2003) conducted a field experiment during post-rainy seasons of 2000-01 and 2001-02 in Guntur, Andhra Pradesh, India, to determine the effects of integrated weed management on post-rainy season pigeon pea (cv. LRG 30) + mungbean (cv. LGG 450) intercropping system. The intercropping system of pigeon pea + mungbean was superior to sole cropping of pigeon pea at normal spacing in minimizing weed population, profitability and lowest weed density, weed dry matter at harvest and weed index and the highest weed control efficiency among all treatments. Reager *et al*. (2003) while conducting weed control experiment in clusterbean at Jobner found that pre emergence application of pendimethalin 1.0 kg $ha^{-1}$ supplemented with hand weeding resulted in the highest reduction in weed dry matter and weed density. Bhandari *et al*. (2004) at Amritsar (Punjab) found that pre-emergence application of pendimethalin @ 1.0, 1.5, 2.0 kg $ha^{-1}$ gave higher seed yield followed by fluchloralin @1.0 and 1.5 kg $ha^{-1}$ and also increased the pods per plant, seeds per pod and test weight in blackgram. Kalpana and Velayatham (2004) in an experiment at TNAU (Tamilnadu) reported that post emergent imazethapyr 100 g $ha^{-1}$ in soybean resulted in significant reduction in grasses and sedges and thus significantly increased grain yield by 126 per cent over weedy check (583 kg $ha^{-1}$). Kumar et *al*. (2004) at Hissar noted the lowest density of carpet weed and purple nutsedge and dry matter accumulation of weeds in greengram using pendimethalin at 1.5 kg $ha^{-1}$ + one hand weeding at 30 DAS. It was closely followed by one hand weeding at 30 DAS and pendimethalin at 1.5 kg $ha^{-1}$ treatments. Murti *et al*. (2004) at Faizabad (U.P.) revealed that Pendimethalin applied at 0.75 kg $ha^{-1}$ as PE significantly reduced the dry matter per plant at 40 and 50 DAS in urdbean crop. Rathi *et al.* (2004) at Kanpur noted the lowest density of *Cyperus rotundus, Parthenium hysterophorus, Trianthema monogyna* and *Phyllanthus niruri* and dry matter of weeds with two hand weedings at 20 and 45 DAS and was accompanied by pendimethalin at 0.5 kg $ha^{-1}$ + one hand weeding at 30 DAS. It witnessed the weed control efficiency of 67.8 per cent.

Malik *et al*. (2005) based on their two years consecutive study at Hissar concluded that two hand weedings at 25 and 45 DAS and pendimethalin at 1.5 kg $ha^{-1}$ + hoeing at 45 DAS were the most effective treatments in reducing the density and dry weight of most of the weed flora in greengram. Pandya *et al.* (2005) at Udaipur reported that two hand weedings 20 and 40 days after sowing in soybean significantly reduced total weed dry matter, N and P uptake by weeds compared to weedy check. This treatment also significantly increased seed yield (17.18 q $ha^{-1}$) and straw yield (26.47 q $ha^{-1}$) over weedy check (8.48 q $ha^{-1}$ and 14.30 q $ha^{-1}$, respectively).

Kumar et *al*. (2006) at Hissar in greengram observed that the maximum reduction in weed population and dry matter accumulation of weeds was obtained with pendimethalin at 0.75 kg $ha^{-1}$ + one hand weeding at 30 DAS though, but hand weeding twice was also found equally effective. Kushwah and Vyas (2006) in a field study at Sehore reported that two hand weedings 20 and 40 DAS in soybean significantly reduced total density and weed biomass compared to weedy check. They further reported the highest soybean grain yield under this treatment compared to all other weed control treatments. Mishra and Chandrabhanu (2006) at NRCW, Jabalpur in summer black gram observed that PE application of pendimethalin 1.0 kg $ha^{-1}$ gave significantly lower weed population, weed dry weight, higher seed weight per plant, 1000 seed weight and seed yield of black gram as compared to any herbicide treatment. Maximum grain yield and yield attributes was obtained by weed free treatment followed by imazethapyr 0.1 kg $ha^{-1}$. Savu *et al.* (2006) during the study on chemical weed control in groundnut at Chhattisgarh plains found that imazethapyr 80 g $ha^{-1}$ (PoE) showed significant reduction in weed population and dry matter production and produced significantly higher yield attributes and yield over weedy check.

Dixit and Varshney (2007) in a study at Jabalpur reported that post emergence application of imazethapyr 100 g $ha^{-1}$ was found the most effective in reducing weed density and weed biomass in soybean. The per cent reduction in weed density due to this treatment was 39.79 compared to weedy check. Likewise the respective values for weed biomass reduction due to this treatment were 67.29 and 18.75 per cent. The per cent increase in grain yield was 40.30 due to this treatment compared to weedy check (779 kg $ha^{-1}$). Tiwari *et al.* (2007) at Jabalpur found that imazethapyr 0.075 kg $ha^{-1}$ in soybean 21 DAS recorded significant reduction in weed biomass and recorded weed control efficiency and weed index with a value of 52 and 42 per cent, respectively and thus significantly increased pods $plant^{-1}$, seeds $pod^{-1}$, seed and straw yield compared to weedy check. The per cent increase in seed and straw yield due to this treatment was 61.8 and 58.4, respectively.

Angiras *et al*. (2008) in a study at Palampur reported that hand weedings twice 30 and 60 DAS in soybean significantly reduced weed dry matter and recorded highest weed control efficiency (86.8 per cent) compared to all other weed control treatments. They further reported significant increase in branches plant$^{-1}$, pods plant$^{-1}$, test weight and seed yield compared to weedy check. Malliswari *et al.* (2008) at Tirupati (AP) in blackgram observed that hand weeding twice at branching and flowering recorded the highest seed yield, weed control efficiency and net return followed by pre-emergence application of pendimethalin @ 1.5 kg ha$^{-1}$.

Kulkarni and Babu (2009) conducted an experiment at Bidar to evaluate post emergence herbicide imazethapyr at different doses against weeds in balckgram and reported that grain yields were significantly higher with pre-emergence application of either fluchloralin 1 kg ha$^{-1}$ or pendimethalin 1kg ha$^{-1}$ with one inter culture and one hand weeding, when compared to different doses of imazethapyr and farmers' method of weed control. Post-emergence application of imazethapyr at lower doses (50, 75 or 100 g ha$^{-1}$) resulted in significantly higher yield over higher doses of 125 g ha$^{-1}$ and 200 g ha$^{-1}$, which was because of phytotoxic effects of higher doses on the crop resulting in chlorosis, scorching and wilting based on the scoring. The yield with lower doses of 50 g ha$^{-1}$ and 75 g ha$^{-1}$ were at par with the yields in farmers' practice, indicating the importance of application of post emergence herbicide between 15 to 25 DAS to overcome the problem of delayed weeding either due to incessant rains or scarcity of labour during the period of critical weed crop competition. Maliwal and Mundra (2009) in a field experiment at Udaipur found that post-emergence imazethapyr 0.100 kg ha$^{-1}$ in groundnut recorded the lowest weed density of monocot (7.79 m$^{-2}$) as against 11.44 weeds m$^{-2}$ recorded under unweeded check. However, the density of dicot weeds was recorded minimum (4.78 m$^{-2}$) under post-emergent imazethapyr 0.150 kg ha$^{-1}$ but it was found at par with post emergent imazethapyr 0.100 kg ha$^{-1}$. They further concluded that post emergent imazethapyr 0.100 kg $ha^{-1}$ significantly decreased weed biomass recorded 30 days after treatment compared to post emergent imazethapyr 0.050 kg $ha^{-1}$ and weedy check. This treatment also significantly increased plant height, number of pods $plant^{-1}$, number of seeds $pod^{-1}$, 1000 seed weight, pod and biological yield compared to weedy check.

Tripathi *et al.* (2010) at Raipur in urdbean reported that significantly maximum plant height, number of branches and seed $pod^{-1}$ were observed with imazethapyr 75 g $ha^{-1}$ + hand weeding 40 DAS. Whereas, significantly maximum pods $plant^{-1}$ was recorded with HW 20 and 40 DAS. Significantly maximum 100 seed weight was observed with imazethapyr 75 g $ha^{-1}$ + chlorimuron ethyl 9 g $ha^{-1}$ (PoE). Significantly maximum seed and straw yield were recorded with hand weedings 20 and 40 DAS. Yadav *et al.* (2010) conducted a field experiment at Meerut of mungbean and reported that all the weed control measures lead to significant reduction in the weed population and weed dry matter accumulation as compare to weedy check. Application of pendimethalin at 0.5 kg $ha^{-1}$ followed by one hand weeding at 30 DAS produced the highest grain yield of mungbean attributed lowest of weed density and weed dry matter accumulation.

Ali *et al*. (2011) on sandy loam soil of S.K. Nagar concluded that application of Imazethapyr 100 g ha $^{-1}$ was found most effective in reducing population and dry weight of weeds. Meena *et al.* (2011) conducted a field experiment to evaluate the efficacy of post emergence applications of imazethapyr on weed control and reported that application of imazethapyr 150 g $ha^{-1}$ as post emergence significantly reduced the density of all grassy, broad leaf weeds sedges and their dry weight, and provided maximum number of branches $plant^{-1}$, pods $plant^{-1}$, seeds $pod^{-1}$ and seed yield of soybean as compared to weedy check and imazethapyr

50 g ha$^{-1}$. Nandan *et al.* (2011) conducted an experiment during *kharif* season of 2006 and 2007 in Jammu to study the efficacy of pre and post emergence herbicides for controlling weeds of mungbean under limited moisture conditions of Kandi belt of Jammu and reported that hand weeding twice at 20 and 40 DAS produced the highest average seed yield which was at par with metolachlor (PE, 0.75kg ha$^{-1}$ *fb* one hand weeding at 20 DAS). Among the other herbicidal treatments, pendimethalin (PE 1.0 kg ha$^{-1}$ *fb* one hand weeding at 30 DAS) was superior in controlling weeds and increasing the seed yield. Yadav *et al.* (2011) reported that one hand weeding done at 20 DAS, two hand weeding done at 20 and 40 DAS, pendimethalin @ 1kg ha$^{-1}$, imazethapyr @ 0.1 kg ha$^{-1}$, pendimethalin + one hand weeding at 40 DAS, imazethapyr + one hand weeding at 40 DAS treatments were found equally effective and reduce the dry weight of weed flora. Punia *et al.* (2011) observed that 21 to 28 DAS application of imazethapyr @ 80-100 g/ha provided season long control (85-95 per cent) of clusterbean weeds and maximum seed yield (1424 kg ha$^{-1}$) of clusterbean with weed free check. Yadav *et al.* (2011) carried out a field experiment at Udaipur during kharif 2010 of clusterbean and reported that weed control treatments significantly reduced the dry weight of complex weed flora, although they differed in their effect on monocot and dicot weeds. Seed and haulm yield under weed free check was found significantly superior over all weed control treatments except two hand weedings (20 and 40 DAS) and imazethapyr 100 g ha$^{-1}$ 20 DAS + hand weeding 40 DAS which were at par with each other.

Jadhav and Gadade (2012) carried out a field experiment at Parbhani during 2011 and 2012 to evaluate the performance of post emergence herbicides for weed control in soybean showed that grain yield as well as straw yield was highest with two hand weeding and hoeing treatments, which was at par with imazethapyr + imazamox 30 g ha$^{-1}$ and imazethapyr 0.1 kg ha$^{-1}$ as PoE at 20 DAS and significantly higher than rest of the treatments during both the years of experimentation. Two hand weedings at 20 and 40 DAS significantly reduced weed density and dry weed weight at 30 DAS and 60 DAS respectively over weedy check, and was at par with imazethapyr + imazamox 30 g $ha^{-1}$ and imazethapyr 0.1 kg $ha^{-1}$ as PoE at 20 DAS.

Ram *et al.* (2012) at Kota revealed that hand weeding observed lowest weed density (2.37 per $m^2$) and weed biomass (3.45 g $m^{-2}$) recorded at 30 days after sowing and remained statistically at par with pendimethalin + imazethapyr 0.75 kg $ha^{-1}$, pendimethalin 1.0 kg $ha^{-1}$, pendimethalin 0.75 kg $ha^{-1}$ and pendimethalin 1.0 kg $ha^{-1}$ over the rest of the herbicide treatments and weedy check, respectively of mungbean. Maximum and significantly higher seed yield was observed with hand weeding at 20 DAS followed by pendimethalin + imazethapyr 0.75 kg $ha^{-1}$, pendimethalin 1.0 kg $ha^{-1}$ and weedy check. Bhuller and Kaur (2012) reported that pendimethalin 0.75 kg $ha^{-1}$ gave effective control of *Acrachne* and *Eleusine* while imazethapyr 50 to 100 g $ha^{-1}$ was more effective against *Commelina* and *Cyperus* sp., however it did not control *Eleusine* of green gram. Sequential application of pendimethalin and imazethapyr gave complete control of all the weeds. Imazethapyr was more effective against grasses when applied at 30 days while in case of sedges it was more effective at 20 day stage. Some phyto-toxicity and growth suppression on green gram plants with imazethapyr was recorded when it was applied at 20 days stage, however, the plants recovered over time. Sequential application of pendimethalin 0.75 kg $ha^{-1}$ PE and imazethapyr 75 g $ha^{-1}$ PoE recorded green gram seed yield at par with two hoeing. Upadhyay *et al.* (2012) at Jabalpur in soybean (*Glycine max* L.) reported that density and dry weight of weeds were higher under weedy check treatment. However, identical reduction in density and dry weight of weeds were observed when weeds were controlled chemically. Significantly higher weed control efficiency, branches $plant^{-1}$, leaf area index (LAI), dry matter production and pods plant$^{-1}$ and seed yield was observed under Odyssey (mixture of imazethapyr + imazamox) +adjuvant (87.5 g + 1000 ml ha$^{-1}$). The maximum net profit (` 43233 ha$^{-1}$) and B: C ratio (3.67) was also recorded under the same treatment.

Gupta *et al.* (2013) conducted an experiment on urdbean and reported that highest seed yield was observed with two hand weedings at 20 and 40 DAS and the values were found statistically at par with PoE application of imazethapyr 25 g ha$^{-1}$ at 20 DAS. Kalhapure *et al.* (2013) at Rahuri and reported that weed free check (two hand weeding at 20 and 40 DAS and manually uprooting of weeds at 60 DAS) was found more effective to control weeds in groundnut and recorded lowest weed density, weed dry matter and weed index and highest weed control efficiency. It was also recorded significantly highest growth and yield attributes in groundnut over all the other treatments *viz*. plant height, dry matter weight of plant, number of pods plant$^{-1}$ and pod yield hectare$^{-1}$. Sangeetha *et al.* (2013) in soybean (*Glycine max*) at Tamil Nadu reported that early post-emergence(EPOE) application of imazethapyr reduced the density and dry biomass of broad-leaved weeds as well as grasses significantly as compared to pre-emergence herbicide under study. The lowest weed density and biomass were recorded with hand weedings twice on 30 days after sowing (DAS) followed by imazethapyr at 200 and 100 g ha$^{-1}$. Imazethapyr at 100 g ha$^{-1}$ was found to be the economic method of weed management by giving higher net returns with grain yield. Upadhyay *et al*. (2013) conducted a field experiment during kharif of 2009-10 at research farm JNKVV, Jabalpur and concluded that all the weed control treatments including odyssey (imazethapyr+imazamox) significantly reduced the dry weight of weeds compared with weedy check in soybean crop.

Deshmukh *et al*. (2014) reported that odyssey (imazethapyr+ imazamox) was effective in reducing weed number and weed dry matter as well as showed higest B:C ratio in soybean at Akola, Maharastra. Singh *et* *al*. (2014) carried out a field experiment at SKRAU, Bikaner during kharif 2013 and resulted that imazethapyr + imazamox 40 g $ha^{-1}$ and imazethapyr alone 40 g $ha^{-1}$ at 3-4 leaf stage significantly reduced the density and dry weight of weeds in clusterbean. Singh *et al.* (2014) conducted an experiment during rainy season of 2013 at Jabalpur and resulted that application of imazethapyr significantly reduced the weed dry weight and higher dose of imazethapyr and imazethapyr + imazamox (odyssey) was also effective for controlling the weeds in soybean crop.

## 2.5 Effect of integrated methods of weed control on growth, yield attributes and yield of the crop

Panwar *et al.* (1982) at Shamli (UP) in greengram observed that plant height (33.15 cm), number of branches (5.13) and pods per plant (93.38) and seed yield (1305.51 kg $ha^{-1}$) were higher with application of pre-emergence fluchloralin @ 0.75 kg $ha^{-1}$ and hoeing at 25 days after sowing. Weed population and dry matter of weed were lowest with fluchloralin @ 0.75 kg $ha^{-1}$ and one hoeing at 25 days after sowing, resulting in the height weed control efficiency (92.39%). Balyan *et al.* (1988) at Hissar in mungbean observed that pre-emergence application of fluchloralin @1.6 kg $ha^{-1}$ + 1 hand weeding at 25 DAS, and pre-emergence application of pendimethalin @ 1.0 kg $ha^{1}$ + 1 HW at 15 DAS, were the superior treatments in terms of control of weed *Trianthema portulacastrum* and *Echinochola colonum* and mungbean seed yield. Kumar and Kairon (1989) conducted a field experiment at Haryana during 1983 and 1984. They reported that weed free treatment recorded significantly higher pods per plant and highest grain yield of mungbean (1645 kg $ha^{-1}$) than wheel hoeing and unweeded treatment. Vaishya and Singh (1989) at Faizabad reported that seed yield of mungbean for weed free control was similar to than obtained with (a) hand weeding 20 days after sowing (DAS), (b) hand weeding 20 and 40 DAS, (c) interculture

+hand weeding 20 DAS and (d) bentazone @ 1.0 kg ha $^{1}$ 20 DAS alone or in combination with hand weeding at 30 DAS. Chin and Pandey (1991) at New Delhi reported that imazethapyr @ 0.005-0.075 kg ha$^{-1}$ was compared with manual weed control for controlling weeds in black gram *(Vigna mungo).* The grain and pod yields were greatest with manual weed control and imazethapyr. Gupta *et al.* (1991) carried out field trials during 1987 and 1988 on sandy loam soil to study the integrated weed management in summer mungbean. The highest grain yields in both years were obtained with pendimethalin @ 1.5 kg ha$^{-1}$, followed by 1 hoeing at 20 days after sowing.

Pre-emergence application of pendimethalin @1.0 kg ha$^{-1}$ gave highest number of branches per plant (4.7), number of pods per plant (12.7) and yield of green gram (615 kg ha$^{-1}$) among different weed control treatments at Jobner were reported by Singh and Chaudhary (1992). Arvadiya and Arvadiya, (1996) at Navsari, Gujarat agricultural university, observed that pendimethalin (1 liter ha$^{-1}$) and 2 hand weeding (20 and 40 days after sowing) gave higher grain yield of green gram c.v.K-851. Bayan and Saharia (1996) at Biswanath Chariali (Assam) reported that effective weed management could be achieved with one hand weeding at 20 days after seeding resulted in a significant incrase in plant dry matter compared with no weeding. Branches per plant, pod per plant and grain yield were significantly influenced by weed management practices in both the years. The highest cost: benefit ratio was obtained with a weed free treatment followed by one hand weeding.

Bhadoria *et al*. (2000) at Gwalior found that weed free plot had the highest seed yield (19.1 q ha$^{-1}$) and weed control efficiency (79.3%) whereas unchecked weed growth resulted in 47 per cent reduction in seed yield and concluded that weed free field for the first 30 days increased seed yield of clusterbean significantly. Parasuraman (2000) concluded that seed yield and net return of greengram was found higher with two hand weeding at 15 and 30 DAS as compared to pendimethalin 1.5 kg ha$^{-1}$ + one hand weeding at 30 DAS.

Gurjar *et al.* (2001) at Gwalior reported that pendimethalin (1.0 and 1.5 kg ha$^{-1}$) noted significantly higher seed yield, yield attributing characters and weed control efficiency in soybean compared to weedy check. Kushwah and Kushwaha (2001) reported that the highest weed control efficiency and seed yield of soyabean were obtained with the pre-emergence application of pendimethalin @ 1.0 kg ha$^{-1}$ supplemented with hand weeding at 30 DAS. Grichar (2002) in an experiment at Texas (USA) reported that post-emergent imazethapyr 0.07 kg ha$^{-1}$ in peanut effectively controlled monocot weeds and also recorded in higher yield attributes and yields than untreated control plots. Raskar and Bhoi (2002) in a weed control experiment at Rahuri reported that application of pursuit 75 g ha$^{-1}$ 15 DAS in soybean significantly reduced weed count (20.83 m$^{-2}$) and total weed dry matter (253.66 kg ha$^{-1}$) as against the weed count and total weed dry matter reported under weedy check and pre emergence application of pendimethalin 1.0 kg ha$^{-1}$. He also reported significantly higher grain as well as biological yield under this treatment over weedy check and the per cent increases were 51.95 and 30.69, respectively compared to yield obtained under weedy check (849 and 2956 kg ha$^{-1}$). In a field experiment conducted at Prabhani, two hand weedings and hoeings 3 and 5 weeks after sowing recorded higher weed control efficiency (56 per cent), plant height (31.36 cm) and seed yield (6.91 q ha$^{-1}$) as compared to pendimethalin 0.75 kg ha$^{-1}$ and unweeded check in blackgram (Shaikh *et al.,* 2002).

Gaikwad and Pawar, (2003) at Rahuri, reported that two hand weedings (20 and 40 DAS) gave 100 per cent weed control and 3158 kg ha$^{-1}$ yield of soybean when compared to weedy check (2168 kg ha$^{-1}$) and resulted in significant enhancement in nutrient uptake by soybean crop. Kumar *et al*. (2003) while studying at Durgapura, (Rajasthan) on weed control in groundnut (*Arachis hypogaea*) found that pre emergence application of pendimethalin 1.0 kg $ha^{-1}$ + one hand weeding 45 DAS significantly improved the seed yield and yield components over rest of treatments and weedy check. This treatment recorded pod and haulm yield of 32.14 and 47.91 q $ha^{-1}$, respectively compared to 12.53 and 22.44 q $ha^{-1}$ over weedy check. Naeem and Ahmad (2003) noted 43.8 to 45.1 per cent increase in grain yield of greengram from hand weeding treatment over unweeded control plots. Pendimethalin applied as pre emergence showed better results than its pre plant incorporation. Rao and Rao (2003) conducted a field experiment at Bapatla, A.P. and observed that one hand weeding at 25 DAS produced higher grain yield of black gram as compared to chemical treatment *viz.* imazethapyr (0.062 kg $ha^{-1}$). Singh *et al*. (2003) in their experiment conducted at Sumerpur found that the maximum number of pods per plant, seeds per pod, seed yield and net returns in greengram were obtained with alachlor at 2.0 kg ha-1 . Remaining at par, it was followed in the order of trifluralin at 1.0 kg, pendimethalin at 1.0 kg, alachlor at 1.5 kg, metolachlor at 1.0 kg and fluchloralin at 1.0 kg ha $^{-1}$. Weed free treatment also produced seed yield equal to alachlor at 2.0 kg $ha^{-1}$ but it provided lower net returns of ` 1130 ha $^{-1}$ than the best treatment. Sumachandrika *et al.* (2003) reported that number of pods per plant, seed yield per plant and grain yield of black gram were found higher with two hand weeding at 20 and 40 DAS as compared to other treatment *viz.* imazethapyr 0.1 kg $ha^{-1}$.

Jaibir *et al.* (2004) at Uttar Pradesh reported that pendimethalin at 1.0 kg $ha^{-1}$ + hand weeding at 30 DAS gave the highest yield. Mishra *et al.* (2004) at NRCWS, Jabalpur observed that PE application of pendimethalin 1.0 kg $ha^{-1}$ gave significantly higher seeds per pod, 100 seed weight and seed yield of black gram when it is compared with pendimethalin 0.5 kg $ha^{-1}$ and imazethapyr 0.1 and 0.05 kg $ha^{-1}$. Rajput and Kushwah (2004) reported that two hand weedings 20 and 30 DAS gave highest weed control efficiency (85.6 per cent), seed yield (1860 kg $ha^{-1}$) and net return (` 8086 $ha^{-1}$). This was followed by pre-emergence application of pendimethalin 1.0 kg $ha^{-1}$ supplemented with one hand weeding 30 days stage. Rani *et al.* (2004) in a field experiment conducted at Andhra Pradesh found that post emergence application of imazethapyr 75 g $ha^{-1}$ in soybean was found promising alternative to hand weeding practices and recorded 23 per cent higher yield over weedy check. Tiwari *et al.* (2004) reported that Imazethapyr 0.1 kg ha-1 as pre emergence gave effective weed control and increased grain yield in greengram at C.S.A. University of Agriculture and Technology, Kanpur as compared to manual weeding twice. Vyas and Jain, (2004) reported that two hand weedings 30 and 45 DAS tended to give significantly higher soybean yield on vertisols of Indore

Guriqbal Singh (2005) conducted a field trial at Ludhiana (Punjab) during 2003 in which the effects of pendimethalin (1.0 kg $ha-^{1}$) with or without hand weeding at 30 days after sowing, pendimethalin (0.45 kg $ha^{-1}$) + hand weeding at 30 DAS on the yield and yield components of soybean. They reported that the highest grain yield (4000 kg $ha^{1}$) was obtained with pendimethalin (1.0 kg $ha^{-1}$) + hand weeding at 30 DAS. Raman and Krishnamoorthy (2005) reported that pendimethalin at 1.0 kg $ha^{-1}$+one hand weeding at 20 DAS was the most effective method of weed control and resulted in the highest seed yield (921 kg $ha^{-1}$). Integration of one herbicide with one hand weeding provided better growth, yield attributes and consequently higher yield. Kohli *et al.* (2006) in mungbean reported that pendimethalin at 1.0 kg $ha^{-1}$+hand weeding at 35 DAS gave the highest grain yield (15.1 q $ha^{-1}$), net return (` 24095 $ha^{-1}$) and profit over weedy control (` 10595 $ha^{-1}$). Two hand weedings at 20 and 30 DAS gave the highest protein content (22.5). Kumar *et al.* (2006) at Hissar, Haryana reported that pendimethalin at 0.75 kg $ha^{-1}$ + hand weeding at 30

DAS gave the highest seed yield (889 kg $ha^{-1}$) while hand weeding at 20 and 40 DAS gave the highest number of pods per plant.

Sharma and Yadav (2006) reported that weed free, two hand weedings done at 20 and 40 DAS and pre-emergent pendimethalin at 0.75 kg ha-1 + hand weeding treatments were found equally effective but significantly superior in increasing the seed yield of greengram in comparison to weedy check. These treatments recorded 71.3, 61.3 and 54.0 per cent higher seed yield, respectively in comparison to weedy check. Singh *et al.* (2006) in a study at Kota reported that two hand weedings 30 and 45 DAS in soybean produced significantly higher pods $plant^{-1}$ (63.31), 1000-seed weight (131.39 g), seed yield (23.13 q $ha^{-1}$), and net returns (` 21653 $ha^{-1}$) over the weedy check. The lowest N and P uptake by weeds and maximum N and P uptake by the crop were recorded under two hand weedings. They further reported maximum weed control efficiency of 98.02 per cent at 70 DAS under this treatment.

Sasikala *et al.* (2007) reported that the imazethapyr 75 g $ha^{-1}$ as post-emergence was found an effective weed management practice over application of pendimethalin alone and weedy check and gave higher pod yield, haulm yield, harvest index, net returns and B: C ratio in groundnut. Singh *et al.* (2007) reported that one hand weeding 20 DAS in soybean resulted in significantly higher pods $plant^{-1}$ (30.2) and seed yield (10.65 q $ha^{-1}$) compared to weedy check (8.1 pods $plant^{-1}$ and 3.70 q $ha^{-1}$ seed yield, respectively). Rathi *et al.* (2008) at Kanpur, Uttar Pradesh, India reported that the maximum net return was obtained under two hand weedings, followed by pre-emergence application of pendimethalin at 0.5 kg $ha^{-1}$ supplemented with one hand weeding at 30 DAS. Sheoran *et al.* (2008) at Punjab in mungbean (cv. SML 668) reported that two hand weeding practiced at 25 and 40 days after sowing (DAS) resulted in the lowest weed population at harvest, which was at par with pre-emergence application of pendimethalin (0.56 kg $ha^{-1}$) + one hand weeding at 30 DAS.

Kaur *et al*. (2010) in mungbean recorded maximum plant height with pendimethalin at 0.45 kg $ha^{-1}$. Singh (2011) conducted a field experiments during summer seasons for four years (2002, 2003, 2004 and 2005) and during kharif seasons for three years (2002, 2003 and 2005) and showed that two hand weeding (25 and 40 DAS) recorded the highest grain yield in all the years except in 2003 when pendimethalin 0.45 kg $ha^{-1}$+ hand weeding at 25 DAS produced highest grain yield. Two hand weedings 25 and 40 DAS recorded the highest grain yield in summer and kharif seasons,which was followed by pendimethalin 0.45 kg $ha^{-1}$ + HW25 DAS. Pendimethalin 0.5 kg $ha^{-1}$ + hand weeding 30 DAS provided effective control of weeds and high grain yield of kharif season blackgram. Yadav et *al.* (2011) reported that highest grain yield was obtained with weed free check (1840 kg $ha^{-1}$) followed by two hand weeding (1720 kg $ha^{-1}$) and imazethapyr 100 g $ha^{-1}$ + hand weeding 40 DAS (1711 kg $ha^{-1}$) and it was significantly higher than all other treatments. In a field experiment at ARS, Sriganganagar herbicide imazethapy 40 g $ha^{-1}$ at 40 DAS was found effective against weeds in clusterbean (SKRAU, 2011).

Jadhav (2013) at Agricultural Research Station, Karad, Satara, Maharashtra reported higher yield component and yield of soybean under weed free treatment. Weed biomass was reduced significantly by the integrated weed management methods comprising quizalofop ethyl 0.05 kg $ha^{-1}$ + chloromuron-ethyl 0.009kg $ha^{-1}$ as post-emergence application at 15 DAS + hand weeding at 30 DAS. Herbicide imazethapyr 50-70 g $ha^{-1}$, imazethapyr+imazamox 60-80 g $ha^{-1}$, imazethapyr+pendimethalin 800-1000 g $ha^{-1}$ provide effective control in greengram at Hissar and Ludhiana (DWSR, 2013).

Upadhyay *et al*. (2013) conducted a field experiment during kharif of 2009-10 at research farm JNKVV, Jabalpur and resulted that all the yield attributing traits branches/plant, dry matter production, pods/plant and yield were found significantly superior under application of odyssey + adjuvant in soybean crop. Singh *et al*. (2014) conducted a field experiment at SKRAU, Bikaner during *kharif* 2013 and resulted that imazethapyr + imazamox 40 g $ha^{-1}$ and imazethapyr alone 40 g $ha^{-1}$ significantly increased the yield attributes, seed yield and net return of clusterbean and also statistically at par with pendimethalin 0.75 kg $ha^{-1}$ and two hand weedings. Tiwari *et al*. (2014) conducted a field experiment at research farm of IGAU, Raipur during *kharif* 2012 and concluded that application of imazethapyr 35% + imazamox 35% (odyssey 70 WG) at 75 g $ha^{-1}$ + hand weeding at 35 DAS was the most appropriate weed management practices for maximization of growth, yield attributes and seed yield of urdbean.

## 2.6 Effect of various weed management treatments on nutrient content and uptake

Chhokar *et al.* (1995) in a field experiment at Hissar reported that an application of pendimethalin @ 1.0 kg $ha^{1}$ followed by hand hoeing at 35 days after sowing resulted in the maximum protein yield in soybean.

In unweeded control, uptake of nutrient by crop was significantly lower, while the nutrient removed by weed was maximum (Kori *et al*., 1997). Kumar *et al.* (1998) at Ranchi revealed that highest removal of N, P and K by pigeonpea (202.4 N, 10.1 P and 73.1 K kg $ha^{-1}$) was recorded with the pendimethalin + hand-weeding treatment. Kumar *et al*. (2003) reported that different weed control treatments resulted in significantly higher uptake of nutrients by grain and straw in mungbean as compared to weedy check. The maximum uptake of N,P and K was recorded in weed free plot. It was followed in the order of pendimethalin at 1.5 kg ha$^{-1}$ + one hand weeding at 30 DAS, pendimethalin at 1.5 kg ha$^{-1}$ alone and one hand weeding at 30 DAS treatment. Kumar *et al*. (2005) at Hissar while evaluating different weed control treatments noted the lowest depletion of N and P by weeds in greengram due to two hand weedings at 20 and 40 DAS treatment that was closely followed by pendimethalin at 0.75 kg ha$^{-1}$ + hand weeding at 30 DAS. Contrarily after weed free treatment, they recorded significantly higher uptake of N and P by greengram with two hand weedings, pendimethalin at 0.75 kg ha$^{-1}$ + hand weeding at 30 DAS than control. However, nutrient concentration in weeds remained unaffected.

Kohli *et al.* (2006) at Hissar noted that pendimethalin at 1.0 kg ha$^{-1}$ + one hand weeding at 35 DAS resulted in significantly higher N and P uptake by greengram. While two hand weedings at 20 and 30 DAS recorded the maximum grain protein content. Yadav *et al.* (2011) at Hissar noted that two hand weedings at 20 and 40 DAS resulted in maximum uptake of N (133.8 kg ha$^{-1}$), $P_2O_5$ (32.5 kg ha$^{-1}$), $K_2O$ (135.1 kg ha$^{-1}$) by clusterbean while in weedy check plots N,P,K uptake by crop was 40.6, 9.8, 41.1 kg ha$^{-1}$ respectively.

Yadav *et al.* (2011) at Udaipur reported that all weed control treatments significantly reduced N, P and K uptake by monocot and dicot weeds as well as total uptake by the weeds compared to weedy check. The minimum total N, P and K uptake by weeds was observed in two hand weedings 20 and 40 DAS followed by imazethapyr 100 g ha$^{-1}$ 20 DAS+ hand weeding 40 DAS and quizalofop-ethyl 60 g/ha 20 DAS + hand weeding 40 DAS which were found at par with each other. While, weed free treatment, two hand weedings (20 and 40 DAS) and imazethapyr 100 g ha$^{-1}$ 20 DAS + hand weeding 40 DAS significantly increased N, P and K uptake by crop over weedy check.

Chhodavadia *et al*. (2013) at JAU, Junagadh (Gujrat) reported that there was vigorous growth of weed in unweeded check treatments resulted in higher uptake of N, P and K nutrients while treatments two hand weeding and two interculturing at 20 and 40 DAS recorded the least loss of nutrients by weeds in summer greengram. Kavita *et al* (2014) reported that nutrient (N, P and K) uptake by blackgram was found superior in weed free treatment due to less weed competition and it was followed by pendimethalin 1500 g ha$^{-1}$ PE and two hand weeding at 15 DAS and 30 DAS while nutrient uptake by weeds were observed highest in weedy check.

## 2.7 Effect of various weed management treatments on economics

Bhandari *et al.* (2004) at Amritsar (Punjab) observed that PE application of pendimethalin 2.0 kg ha$^{-1}$ gave significantly higher seed yield, Stover yield, gross return and net return in black gram as compared to pendimethalin 1.0 and 1.5 kg ha$^{-1}$ , pendimethalin 1.0 kg ha$^{-1}$ followed by hoeing 25 DAS, hoeing 25 DAS and weedy check. Maximum seed yield and gross return was obtained from weed free treatment. Rathi *et al.* (2004) at Kanpur revealed that lower dose of pendimethalin (0.5 kg ha$^{-1}$) followed by one hand weeding at 60 DAS demonstrated intended weed control (67.80 per cent WCE), enhanced higher grain yield (379 kg ha$^{-1}$) and fetched more net monetary return (` 3611 ha$^{-1}$) due to weed control.

Malliswari *et al.* (2008) at Tirupati (AP) in blackgram reported that net monetary return was higher under hand weeding carried out twice at branching and flowering followed by pre-emergence application of pendimethalin @ 1.5 kg ha$^{-1}$. Meena *et al.* (2011) conducted a field experiment to evaluate the efficacy of post emergence applications of imazethapyr on weed control and reported that application of imazethapyr 100 g ha$^{-1}$ gave significantly higher net return (` 14,237 ha$^{-1}$) and B: C ratio(1.68) of soybean followed by imazethapyr 150 g $ha^{-1}$ over weedy check and imazethapyr 50 g $ha^{-1}$.

Singh (2011) conducted a field experiments during summer seasons for four years and kharif seasons for three years and reported that gross returns were highest in case of 2 Hand weeding at 25 and 40 DAS during both the seasons. Net returns were the highest with pendimethalin 0.45 kg $ha^{-1}$+ hand weeding at 25 DAS, closely followed by pendimethalin 0.75 kg $ha^{-1}$ in summer season. Weedy check though involved the lowest cost of cultivation yet it provided the lowest net returns. Upadhyay *et al.* (2012) at Jabalpur reported early post-emergence applications of imazethapyr with adjuvant and ammonium sulphate (100 g + 750 ml + 1 kg $ha^{-1}$) recorded maximum net monetary returns (` 39,109 $ha^{-1}$) and B: C ratio (3.20). Kalhapure *et al.* (2013) at Rahuri reported that highest gross monetary returns (` 1,09,845 $ha^{-1}$) was recorded in treatment weed free check, maximum net monetary returns (` 61,460 $ha^{-1}$) and B:C ratio (2.42) were recorded in the treatment application of pendimethalin 1.5 kg $ha^{-1}$ as pre-emergence + imazethapyr 0.150 kg $ha^{-1}$ as post-emergence + one hand weeding at 40 DAS, which was found most economically feasible weed management practice for groundnut. Sangeetha *et al.* (2013) at Tamil Nadu reported that Imazethapyr at 100 g $ha^{-1}$ was found to be the economic method of weed management by giving higher net returns with grain yield in soybean.

## 2.8 Weed control efficiency of different treatments

Sandhu *et al.* (1993) while working at Ludhiana concluded that two hand weeding at 20 and 40 days after sowing were quite effective which recorded the highest weed control efficiency (95.3 per cent) in green gram. Kumar *et al.* (1998) observed that the lowest weed dry matter (54 g $m^2$), greatest weed control efficiency (80 per cent) and greatest weed suppression effect (73 per cent) were recorded for the pendimethalin (1 kg ha$^{-1}$) + hand weeding treatment. Hand weeding at 30 and 45 DAS was also very effective in soybean. Sukhadia *et al*. (2000) at Junagarh reported that weed-free (three hand weedings and interculturing) recorded the lowest weed density, their dry weight and the highest weed control efficiency (100 per cent), followed by integration of pendimethalin at 0.900 kg ha$^{-1}$ as pre-emergence with one hand weeding and interculturing at 40-45 days after sowing in pigeonpea crop. Srivastava and Srivastava (2004) observed that pendimethalin + hand weeding at 30 DAS, and hand weeding at 30 and 60 DAS recorded the highest weed control efficiency (80 per cent) and reduced the weed dry weight by 73.1 per cent and 64.7 per cent respectively. Shete *et al.* (2007) during a study at Maharashtra found the highest weed control efficiency with the application of imazethapyr 87.5 g ha$^{-1}$ followed by a dose of 75 g ha$^{-1}$ in soybean.

Yadav *et al.* (2010) at Meerut reported that in mungbean application of pendemethalin at 0.5 kg ha$^{-1}$ followed by one hand weeding at 30 DAS had highest weed control efficiency (69.65 and 67.35 per cent), respectively. Meena *et al.* (2011) conducted a field experiment to evaluate the efficacy of post emergence applications of imazethapyr of soybean and reported that maximum weed control efficiency of grasses (86.9 per cent), broad leaf (88.4 per cent) and sedges (73.0 per cent) was obtained with 2 hand weeding at 20 and 40 DAS closely followed by imazethapyr 150 g ha$^{-1}$. Singh (2011) conducted a field experiments during summer seasons for four years (2002, 2003, 2004 and 2005) and during *kharif* seasons for three years (2002, 2003 and 2005) and reported that two hand weedings (25 and 40 DAS) had the highest weed control efficiency (85.01 and 84.89 per cent) during both the seasons, which was closely followed by pendimethalin 0.45 kg ha$^{-1}$ + hand weeding 25 DAS (84.81 and 78.28 per cent) and pendimethalin 0.75 kg ha$^{-1}$ (79.12 and 77.52 per cent). Yadav *et al.* (2011) carried out a field experiment at Udaipur during *kharif* 2010 and reported that highest weed control efficiency was recorded under weed free check. Among other weed control treatments, weed control efficiency was highest under two hand weedings 20 and 40 DAS (90.9 per cent) followed by imazethapyr 100 g $ha^{-1}$ 20 DAS + hand weeding 40 DAS (89.4 per cent).

Upadhyay *et al.* (2012) carried out a field experiment was during rainy season of 2009-10 at Jabalpur and reported that weed-free treatment registered maximum weed control efficiency than all other treatments because of least dry matter production of the weeds over weedy checks. The next best treatment was imazethapyr + adjuvant + ammonium sulphate (100 g + 750 ml + 1 kg $ha^{-1}$). Ram *et al.* (2012) at Kota revealed that maximum and significantly higher weed control efficiency (89.17) was observed with hand weeding at 20 DAS followed by pendimethalin + imazethapyr 0.75 kg $ha^{-1}$ of mungbean.

Gupta *et al.* (2013) conducted an experiment on urdbean and reported that highest weed control efficiency and lowest weed biomass was recorded with two hand weedings at 20 and 40 DAS followed by application of imazethapyr 25 g $ha^{-1}$ (post-emergence) at 20 DAS. Sangeetha *et al.* (2013) reported that weed control efficiency could be enhanced 93-98 per cent due to higher dose of imazethapyr at 60 DAS in soybean. Tiwari *et al*. (2014) noticed that application of imazethapyr 35% + imazamox 35% (odyssey 70 WG) at 75 g/ha + hand weeding at 35 DAS gave significantly higher weed control efficiency (75.87 per cent) followed by pendimethalin (PE) + hand weeding at 25 DAS (75.53 per cent) in urdbean.

It can be summarized from the foregoing research reviews that the herbicide alone as well as herbicide with hand weeding is sufficient for controlling weeds effectively as well as providing weed free conditions for longer time. This can be possible when effective herbicides are supplemented with hand weeding and interculturing.

# 3. MATERIAL AND METHODS

A field experiment entitled "Integrated Weed Management in Greengram [*Vigna radiata* (L.) Wilczek.] in Arid Region" was conducted at Agronomy Farm of Agriculture Research Station, S.K. Rajasthan Agricultural University, Bikaner during *kharif* season of 2013. The details of experimental techniques, materials used and methods adopted for treatment evaluation during the course of investigation are described in this chapter.

## 3.1 Experimental site and location

The experiment was conducted on the farm of Agriculture Research Station, S.K. Rajasthan Agricultural University, Bikaner during the *kharif* season of 2013. It is situated in Bikaner district on national highway No. 15 at 7 km, north to Bikaner city. Geographical location of Bikaner is between $72.55^0$ to $73.42^0$ E longitude and $28.00^0$ to $28.16^0$ N latitude at an altitude of 234.70 metres above mean sea level. According to "Agro-ecological region map" brought out by the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Bikaner falls under Agro-ecological region No. 2 (MgE1) under Arid ecosystem (Hot Arid Eco-region with desert and saline soil), which is characterized by deep, sandy and coarse loamy, desert soils with low water holding capacity, hot and arid climate. The average annual evaporation of this region is 2810 mm. As per NARP, Bikaner falls in agroclimatic zone Ic (Hyper Arid Partially Irrigated North Western Plain Zone). According to National Planning Commission, Bikaner falls under Agro climatic zone XIV (Western Dry Region) of India.

## 3.2 Climate and weather condition

The climate of this zone is typically arid characterized by aridity of the atmosphere and salinity in the rhizosphere with extremes of temperature both in summers and winters. The annual average rainfall of Bikaner is about 263 mm. More than 80 per cent rainfall is received in the monsoon season (July-September) by the south-west monsoon. The mean maximum and minimum temperatures show a wide range of fluctuations during the summer and winter months. During summers the maximum temperature may go as high as $48^0$C, while in the winters it may fall as low as -$3^0$C. This region is prone to high wind velocity and soil erosion due to dusty winds that is also the major problem during the summers. Weather parameters play an important role in influencing the growth and development processes of the crops; hence, it is important to present climatic parameters. The mean weekly data for temperature, relative humidity, total rainfall, rainy days, wind velocity and evaporation recorded at the Meteorological Observatory of Agricultural Research Station, Bikaner for the period of the experimentation *w.e.f.* June, 2013 to November, 2013 are presented in table 3.1 and depicted in fig. 3.1.

The periodical mean weekly weather parameters for the period of the experimentation recorded from the meteorological observatory of Agricultural Research Station, S.K. Rajasthan Agricultural University, Bikaner, are presented in table 3.1 and depicted in fig. 3.1. Data in table 3.1 shows that lowest and highest maximum temperature of $33.3^0$C and $41.0^0$C were recorded in the $44^{th}$ and $26^{th}$ standard meteorological week, respectively. Likewise values of minimum temperature ($13.1^0$C & $28.0^0$C) were recorded in the $44^{th}$ and $26^{th}$ standard meteorological weeks, respectively. The maximum and minimum relative humidity ranged between 58 to 92 per cent and 17 to 70 per cent, respectively. Crop received 203.6 mm of rainfall in 15 rainy days during the growing season. Evaporation ranged from 6.0 to 11.8 mm per day during the crop growing period.

**Table No.3.1: Mean weekly meteorological data during crop season (*kharif,* 2013)**

| Standard Week | Duration | | Temperature ($^0C$) | | Relative Humidity (%) | | Total Rainfall (mm) | Rainy days | Wind velocity (km/hr) | Evaporation | BSSH |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | From | To | Max. | Min. | Max. | Min. | | | | (mm/day) | |
| 26 | 25-June | 01-Jul | 41.0 | 28.0 | 59.3 | 36.0 | 0.0 | 0 | 15.2 | 11.8 | 7.7 |
| 27 | 02-Jul | 08-Jul | 40.5 | 25.5 | 66.0 | 37.4 | 12.1 | 1 | 8.6 | 11.6 | 6.0 |
| 28 | 09-Jul | 15-Jul | 39.3 | 25.3 | 77.4 | 44.8 | 0.0 | 0 | 12.4 | 10.6 | 7.5 |
| 29 | 16-Jul | 22-Jul | 39.0 | 25.5 | 70.0 | 51.7 | 40.0 | 1 | 12.0 | 11.0 | 6.7 |
| 30 | 23-Jul | 29-Jul | 34.5 | 21.8 | 85.0 | 63.8 | 26.8 | 4 | 7.3 | 6.1 | 6.0 |
| 31 | 30-Jul | 5-Aug | 36.2 | 22.7 | 81.2 | 56.5 | 5.0 | 1 | 9.4 | 7.3 | 6.7 |
| 32 | 6-Aug | 12-Aug | 35.5 | 22.2 | 82.7 | 43.0 | 42.0 | 2 | 9.2 | 8.1 | 3.5 |
| 33 | 13-Aug | 19-Aug | 33.3 | 21.6 | 91.6 | 69.7 | 51.4 | 3 | 6.2 | 6.0 | 5.1 |
| 34 | 20-Aug | 26-Aug | 37.0 | 23.5 | 79.8 | 48.1 | 19.3 | 2 | 6.6 | 7.7 | 9.8 |
| 35 | 27-Aug | 2-Sep | 36.0 | 23.7 | 75.3 | 42.1 | 0.0 | 0 | 10.8 | 8.4 | 10.6 |
| 36 | 3-Sep | 9-Sep | 36.3 | 24.6 | 70.0 | 36.5 | 0.0 | 0 | 11.4 | 9.4 | 10.7 |
| 37 | 10-Sep | 16-Sep | 39.2 | 25.1 | 58.8 | 29.8 | 0.0 | 0 | 5.2 | 10.4 | 8.8 |
| 38 | 17-Sep | 23-Sep | 36.8 | 24.2 | 75.8 | 35.8 | 5.0 | 1 | 5.6 | 10.1 | 9.0 |
| 39 | 24-Sep | 30-Sep | 33.4 | 22.0 | 83.1 | 52.7 | 1.0 | 0 | 5.2 | 8.5 | 9.0 |
| 40 | 1-Oct | 7-Oct | 35.6 | 22.3 | 82.0 | 47.4 | 1.0 | 0 | 4.6 | 8.5 | 8.2 |
| 41 | 8-Oct | 14-Oct | 34.7 | 22.0 | 78.0 | 39.4 | 0.0 | 0 | 4.3 | 9.4 | 8.4 |
| 42 | 15-Oct | 21-Oct | 35.9 | 18.2 | 61.8 | 29.4 | 0.0 | 0 | 4.9 | 8.8 | 9.3 |
| 43 | 22-Oct | 28-Oct | 34.6 | 15.1 | 57.5 | 24.7 | 0.0 | 0 | 4.0 | 7.7 | 9.1 |
| 44 | 29-Oct | 4-Nov | 33.3 | 13.1 | 61.8 | 17.2 | 0.0 | 0 | 5.1 | 6.8 | 8.7 |

Source: Agromet Observatory, ARS, Bikaner

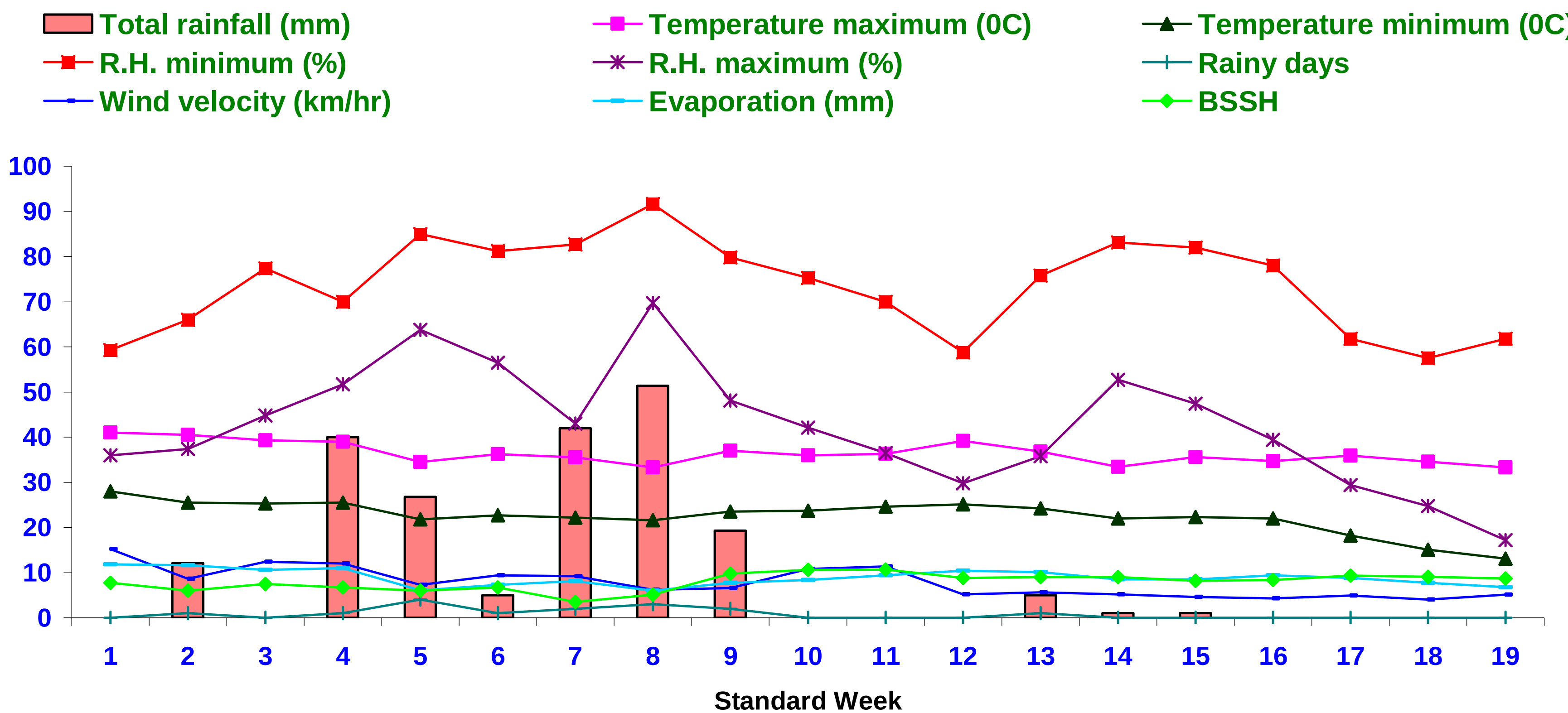



**Fig. 3.1 : Mean weekly meteorological data during crop season (*kharif,* 2013)**

## 3.3 Cropping history of experimental field

The cropping history of the experimental field for the last three years is given in table 3.2.

**Table 3.2: Cropping history of the experimental field**

| **Crop year** | **Season** | |
|---|---|---|
| | ***Kharif*** | ***Rabi*** |
| 2009-10 | Pearl millet | Chickpea |
| 2010-11 | Groundnut | Wheat |
| 2011-12 | Clusterbean | Barley |
| 2012-13 | Greengram * | Cumin |

* Experimental crop

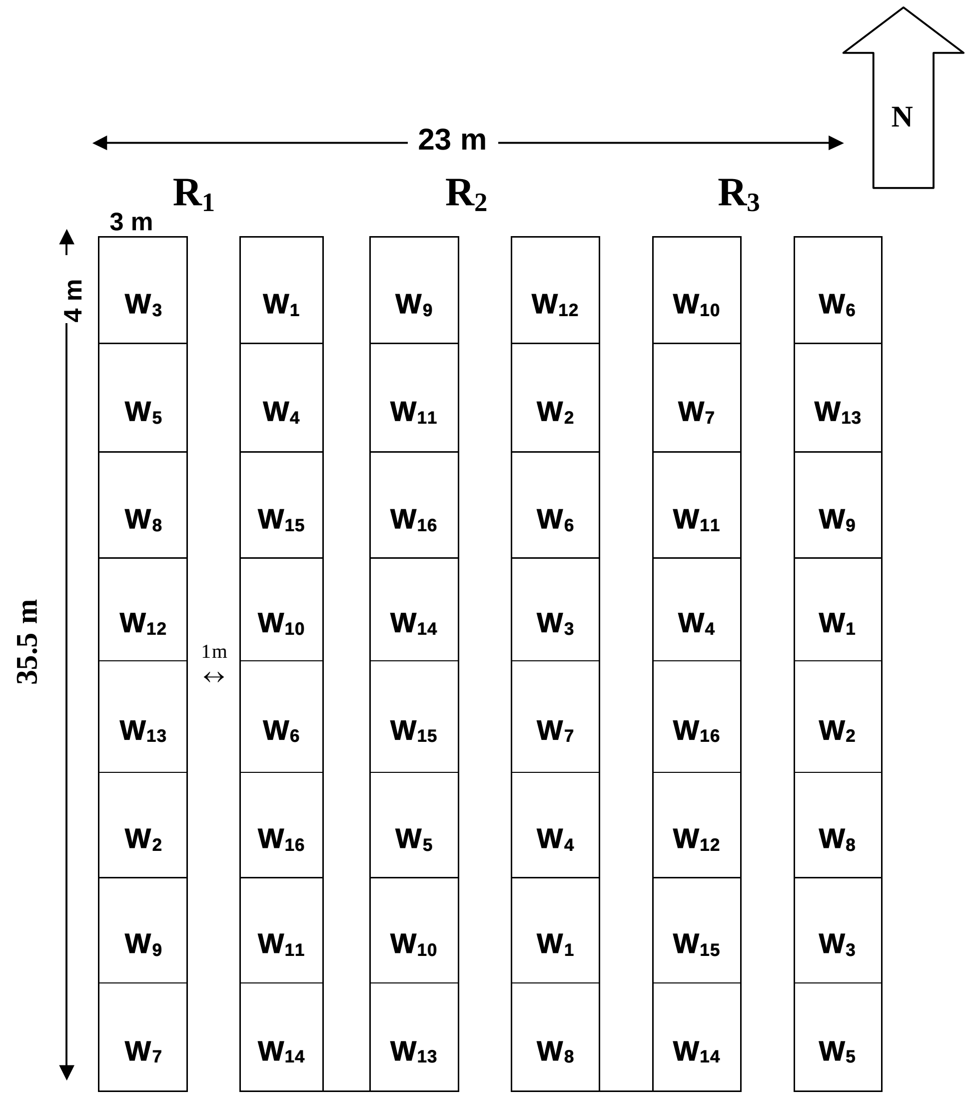
## 3.4 Soil of the experimental field

In order to know the physico-chemical properties of soil, samples were taken randomly from 0-30 cm depth from different spots of the experimental field and a representative composite sample was prepared by mixing all these samples together. This composite sample was analyzed to determine the physico-chemical properties of the soil are presented in table 3.3. The analysis revealed that the soil of the experimental field was loamy sand in texture, slightly alkaline in reaction, poor in organic carbon, low in available nitrogen but medium in available phosphorus and potassium.

## 3.5 Experimental details

### 3.5.1 Experimental design and layout

The experiment was laid out (fig.3.2) in a randomized block design and replicated thrice. The treatments were randomized with the help of random number table (Fisher, 1950).




| | | |
|---|---|---|
| Gross plot Size | = | 4.0 m x 3.0 m =12.0 $m^2$ |
| Replication | = | 3 |
| Net plot size | = | 3.40 m x 2.40 m=8.16 $m^2$ |
| Total number of plots | = | 48 |
| Total number of treatments | = | 16 |
| Path between replication | = | 1.00 m |
| Bund | = | 0.5m |

**Fig. 3.2: Plan of layout**

**Table 3.3: Physico-chemical characteristics of the experimental soil at 0-30 cm depth**

| Soil properties | Value at 0-30 cm depth | Methods of analysis with reference |
|---|---|---|
| **A. Mechanical Composition** | | |
| Sand (%) | 84.53 | Hydrometer method (Bouyoucos, 1962) |
| Silt (%) | 7.46 | |
| Clay (%) | 8.01 | |
| Texture | Loamy Sand | Triangular method (Brady, 1983) |
| **B. Physical properties** | | |
| Bulk density (Mg $m^{-3}$) | 1.54 | Method No. 38, USDA Handbook No. 60 (Richards, 1954) |
| Particle density (Mg $m^{-3}$) | 2.68 | Method No. 39, USDA Handbook No. 60 (Richards, 1954) |
| Field Capacity (%) | 7.90 | Method No. 30, USDA Handbook No. 60 (Richards, 1954) |
| Porosity (%) | 42.16 | Method No. 40, USDA Handbook No. 60 (Richards, 1954) |
| **C. Chemical properties** | | |
| Organic carbon (%) | 0.08 | Walkley and Black's rapid titration method (Jackson, 1973) |
| Available N (kg $ha^{-1}$) | 78.0 | Alkaline $KMnO_4$ method (Subbiah and Asija, 1956) |
| Available P ($P_2O_5$ kg $ha^{-1}$) | 22.0 | Olsen's method (Olsen *et al.*, 1954) |
| Available K ($K_2O$ kg $ha^{-1}$) | 210.0 | Flame photometric Method (Jackson, 1973) |
| EC ($dSm^{-1}$) (1:2 soil water suspension at 25ºC) | 0.16 | Method No. 4 USDA Handbook No.60 (Richards, 1954) |
| Soil pH (1:2 soil water suspension) | 8.22 | Method No. 21 b, USDA Handbook No. 60 (Richards, 1954) |

**Details of Layout-**

The plan of layout is shown in fig. 3.2 and details are as under

| | | | |
|---|---|---|---|
| i. | Season | : | *Kharif*, 2013 |
| ii. | Number of treatment combinations | : | 16 |
| iii. | Number of replications | : | 3 |
| iv. | Total number of plots | : | 16 x 3=48 |
| v. | Experimental design | : | RBD |
| vi. | Plot size | | |
| | (a) Gross | : | 4.0 x 3.0 $m^2$ =12.0 $m^2$ |
| | (b) Net | : | 3.40 x 2.40 $m^2$= 8.16$m^2$ |
| vii. | Test crop | : | Greengram |
| viii. | Variety | : | SML- 668 |
| ix. | Crop geometry | : | 30 cm x 10 cm |
| x. | Seed rate | : | 20 kg $ha^{-1}$ |
| xi. | Fertilizers | | |
| | (a) Nitrogen | : | 20 kg N $ha^{-1}$ through urea |
| | (b) Phosphorus | : | 40 kg $P_2O_5$ $ha^{-1}$ through SSP |
| | (c) Potash | : | 40 kg $K_2O$ $ha^{-1}$ through MOP |

### 3.5.2 Treatments

The experiment comprised with sixteen weed control treatments. Details of treatments along with the symbols used are given in table 3.4.

**Table 3.4: Treatments with their symbols**

| | Treatments | Symbols |
|---|---|---|
| i. | Weedy check | $W_1$ |
| ii. | Weed free | $W_2$ |
| iii. | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE | $W_3$ |
| iv. | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE + one hand weeding at 30 DAS | $W_4$ |
| v. | Imazethpyr @ 40 g ha$^{-1}$ at 20 DAS as PoE (at 3-4 leaf stage) | $W_5$ |
| vi. | Imazethpyr @ 50 g ha$^{-1}$ at 20 DAS as PoE (at 3-4 leaf stage) | $W_6$ |
| vii. | Imazethpyr @ 60 g ha$^{-1}$ at 20 DAS as PoE (at 3-4 leaf stage) | $W_7$ |
| viii. | Imazethpyr @ 40 g ha$^{-1}$ at 20 DAS as PoE (at 3-4 leaf stage)+ one hand weeding at 40 DAS | $W_8$ |
| ix. | Imazethpyr @ 50 g ha$^{-1}$ at 20 DAS as PoE (at 3-4 leaf stage)+ one hand weeding at 40 DAS | $W_9$ |
| x. | Imazethpyr @ 60 g ha$^{-1}$ at 20 DAS as PoE (at 3-4 leaf stage) + one hand weeding at 40 DAS | $W_{10}$ |
| xi. | Imazethapyr + imazemox @ 40 g ha$^{-1}$ at 20 DAS as PoE(at 3-4 leaf stage) | $W_{11}$ |
| xii. | Imazethapyr + imazemox @ 60 g ha$^{-1}$ at 20 DAS as PoE(at 3-4 leaf stage) | $W_{12}$ |
| xiii. | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr @ 40 g ha$^{-1}$ at 30 DAS as PoE | $W_{13}$ |
| xiv. | Imazethapyr + imazemox @ 40 g ha$^{-1}$ at 20 DAS as PoE (at 3-4 leaf stage)+ one hand weeding at 40 DAS | $W_{14}$ |
| xv. | Imazethapyr + Imazemox @ 60 g ha$^{-1}$ at 20 DAS as PoE (at 3-4 leaf stage) + one hand weeding at 40 DAS | $W_{15}$ |
| xvi. | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr + Imazemox @ 40 g ha$^{-1}$ at 30 DAS as PoE | $W_{16}$ |

### 3.6 Crop variety

SML-668 is a early maturing variety (75 – 85 days) with average yield of 1000-1133 kg $ha^{-1}$ and recommended for cultivation in low hills, sub tropical zone under irrigated condition in summer season. It can be exploited in summer season as contingent crop i.e. after harvesting ginger, potato etc. or as intercropping in sugarcane. It plant height ranges 45-71 cm, the plants grow erect and foliage colour is dark green. It bears long pods in bunches with 10-12 dull green bold seeds, growth habit is erect, semi determinate, flower colour yellow foliage colour dark green, number of primary branches 3-4, pod length 8-10 cm, 100 seed wt. 5.7 gm, days to 50% flowering 51-60 days, seed colour dull green, seed texture hard, hilum colour white, seed size bold, seed shape round to oval and protein 22.7 per cent. Pod bearing at the top of the plant. Pods are long and drooping nature. Colour of pods at maturity is dark brown. Pod husk/cover is thick. Seed septation in pods is distinct.

### 3.7 Details of crop raising

The details of different operations undertaken for raising the crop are given here under.

#### 3.7.1 Field preparation

After giving irrigation, the experimental field was prepared by ploughing twice with tractor drawn harrow and planking. Plots of 4.0 m x 3.0 m size were prepared according to the plan of lay out with the provision of irrigation with sprinkler.

#### 3.7.2 Fertilizer application

A uniform dose of nitrogen (20 kg $ha^{-1}$) , phosphorus (40 kg $ha^{-1}$) and potash (40 kg $ha^{-1}$) was applied as basal dose through Urea , single super phosphate and muriate of potash respectively, by drilling in furrows 30 cm apart at a depth of 8-10 cm.

### 3.7.3 Seed treatment

The seed was treated with carbendazim 2 g $kg^{-1}$ and streptocyclin 200 ppm solution to prevent seed born diseases.

### 3.7.4 Seed rate and sowing

Greengram variety SML 668 was used as a test crop with the seed rate of 20 kg $ha^{-1}$. Seed was sown with manual plough at a spacing of 30 cm x 10 cm.

### 3.7.5 Gap filling

In order to maintain the plant population, gap filling was done manually 7 days after sowing.

### 3.7.6 Thinning

Thinning was done manually at 15 days after sowing maintaining the plant to plant spacing of 10 cm for uniform plant population.

### 3.7.7 Weed management

As per treatment, pendimethalin was applied after the sowing of crop while imazethapyr and imazethapyr + imazamox were applied 25 DAS (at 3-4 leaf stage). These herbicides were sprayed with knapsack sprayer using 500 litres of water per hectare. In the weed free plots two hoeing were done at 20 & 40 DAS and the weeds were removed when they appeared. In pendimethalin+one hand weeding treated plots the hoeing was done at 30 DAS as well as in imazethapyr+one hand weeding and imazethapyr + imazamox+one hand weeding treated plots the hoeing was done at 40 DAS. In pendimethalin + imazethapyr and pendimethalin + imazethapyr + imazamox treated plots imazethapyr and imazethapyr + imazamox spray was done at 40DAS.

The list of herbicides and their formulations used has been given in table 3.5.

**Table 3.5: Details of herbicides used**

| S.No. | Common Name | Trade Name | Chemical Name |
|---|---|---|---|
| 1 | Pendimethalin | Stomp (30 EC) | N-(1-ethylproyl)-3,4-dimethyl-2, 6- dinitrobenzenamine |
| 2 | Imazethapyr | Pursuit (10 SL) | 2[4,5-dihydro-4-methyl-4(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-ethyl-3-pyridine carboxylic acid |
| 3 | Imazethapyr +Imazamox | Odyssey (35%+35%) | 2[4,5-dihydro-4-methyl-4(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-ethyl-3-pyridine carboxylic acid+2[4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl]-5-methoxymethylnicotinic acid |

### 3.7.8 Plant protection

There was no diseases and insects attack in the test crop.

### 3.7.9 Irrigation

Pre sowing irrigation was given to prepare field and sowing of crop. Later on one irrigation was applied to the crop during the dry spell. The respective dates of irrigation to crop are presented in chronological record.

### 3.7.10 Harvesting

To assess the biological, seed and straw yields, the net area of 3.4 x 2.4 $m^2$ was harvested separately from each plot by sickles, tied in bundles and tagged. These tagged bundles were left for sun drying in the plots. After complete drying, the bundles were weighed using physical balance and weight of each bundle was recorded in kg per plot and converted to kg ha $^{-1}$ as biological yield.

### 3.7.11 Threshing and winnowing

The dry weight of each bundle was recorded on cloth bag and then threshing was done manually by beating and trampling the pods of each plot separately and seeds were collected in numbered bags. After winnowing, cleaned seeds were weighted to record seed yield in kg per plot. The straw yield was computed by subtracting the seed yield from biological yield.

### 3.8 Chronological record

The chronological record of crop raising is given in table 3.6.

**Table 3.6: Chronological record of crop raising**

| S. No. | Particulars | Date | Remarks |
|---|---|---|---|
| 1 | Pre-sowing irrigation | 15.07.2013 | Sprinkler |
| 2 | Ploughing and planking | 16.07.2013 | Tractor drawn harrow and planker |
| 3 | Layout of experimental field | 17.07.2013 | Manually |
| 4 | Fertilizer application | 18.07.2013 | Kera |
| 5 | Sowing of seeds | 18.07.2013 | Kera |
| 6 | Pendimethalin (PE) | 18.07.2013 | Knapsack sprayer |
| 7 | Gap filling | 25.07.2013 | Manually |
| 8 | Thinning | 02.08.2013 | Manually |
| 9 | Imazethapyr and | 12.08.2013 | Knapsack sprayer |
| | imazethapyr+imazamox spray | 27.08.2013 | Knapsack sprayer |
| 10 | Hand weeding | | |
| | 1st | 08.08.2013 | Manually |
| | 2nd | 18.08.2013 | Manually (with PE herbicide) |
| | 3rd | 28.08.2013 | Manually (with PE herbicide) |
| 11 | Irrigation | 16.09.2013 | Sprinkler |
| 10. | Harvesting | 08.10.2013 | Manually |
| 11. | Threshing and winnowing | 02.11.2013 | Manually |

## 3.9 Treatment evaluation

The methodology used for evaluating the different treatments in terms of growth, yield and quality of crop have been given here under:

### 3.9.1 Weed studies

#### 3.9.1.1 Weed survey

Visual observations on major weed flora appeared in the experimental fields were recorded time to time.

#### 3.9.1.2 Weed density

List of dominant weed species observed during the course of investigation are presented in table 3.7. In each plot, broad leaved and grassy weeds were counted from two randomly selected area of 0.25 $m^2$ using 0.5 m X 0.5 m quadrate at 30, 60 DAS and at harvest and converted into one square meter. The mean data were subjected to square root transformation ($\sqrt{x + 0.5}$) to normalize their distribution where 'x' is the original data (Gomez and Gomez, 1984).

**Table 3.7: Weed flora of experimental site**

| S. No. | Botanical name | Common name | Growth habit |
|---|---|---|---|
| 1. | *Aerva tomentosa* L. | Javanese wool plant | Perennial |
| 2. | *Amaranthus spinosus* L. | Spiny Amaranthus | Annual |
| 3. | *Aristida depressa* L. | Three awn | Annual |
| 4. | *Cenchrus biflorus* L. | Sandbur | Annual |
| 5. | *Corchorus tridense* L. | Wild jute | Annual |
| 6. | *Digera arvensis* L. | Digera | Annual |
| 7. | *Eleusine verticillata* L. | Goosegrass | Annual |
| 8. | *Eragrostis tennela* L. | Kusagrass | Annual |
| 9. | *Euphorbia hirta* L. | Garden spurge | Annual |
| 10. | *Gisekia poiedious* L. | Suleri | Annual |
| 11. | *Portulaca oleracea* L. | Common Purslane | Annual |
| 12. | *Trianthema portulacastrum* L. | Horse purslane | Annual |
| 13. | *Tribulus terrestris* L. | Puncture vine | Biennial |

### 3.9.1.3 Weed dry weight

The weeds under 0.25 $m^2$ area were removed from randomly selected area at 30 and 60 DAS and classified as broad leaved and grassy weeds. These were dried at $65^o$ C temperature in oven for 48 hours and weighed to obtain mean weed dry weight and at harvest all weeds of net plot were harvested and categorized as broad leaved and grassy weeds before drying and weighing.

### 3.9.1.4 Nutrient uptake by weeds

Representative samples of weed dry matter taken from each plot as per treatments were processed and subjected to chemical analysis for their N, P and K content with standard methods. Nitrogen was estimated by Nesseler's reagent colorimetric method, phosphorus by 'Vando molybdate phosphate yellow colour method' whereas, potassium by Flame photometric method. The depletion of these nutrients by weeds at different growth stages was estimated by using the following formula:

$$\text{N/P/K depletion(kg ha}^{-1}\text{)} = \frac{\text{N/P/K content in weeds} \times \text{Weed dry matter of reference stage (kg ha}^{-1}\text{)}}{100}$$

### 3.9.1.5 Weed control efficiency (%) (WCE)

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

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

### 3.9.1.6 Weed index (%)

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

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

Where, $X$ = Yield from weed free plot (kg $ha^{-1}$)
$Y$ = Yield from treated plot (kg $ha^{-1}$)

### 3.9.2 Crop studies

#### 3.9.2.1 Growth parameters

For evaluating growth characters, five plants were randomly selected in each plot from the sampling rows and tagged permanently.

##### 3.9.2.1.1 Plant stand

Number of plants $plot^{-1}$ was counted 20 DAS and at harvest and converted in number of plants $ha^{-1}$.

##### 3.9.2.1.2 Plant height

The height of five permanently tagged plants from each plot was measured from the base to the apex of the main shoot with the help of metre scale at 30, 60 DAS and at harvest and the average of the five plants was recorded as mean plant height (cm).

##### 3.9.2.1.3 Number of branches

The number of branches per plant of the same five plants was recorded at harvest and average was worked out.

##### 3.9.2.1.4 Dry matter accumulation

To find out the effect of different treatments on dry matter accumulation of crop, five plants randomly uprooted from outer rows of each plot at 30, 60 and at harvest. After removing the root portion, the above ground parts of plants were first sun dried in paper bags for some days and finally in an electric oven at $70^0$C for 24 hours. After complete drying, the material was weighed on balance and the weight was recorded. The average weight was worked out and was used as dry matter (g $plant^{-1}$).

#### 3.9.2.1.5 Dry weight of nodules per plant

At 50 DAS, five plants were safely uprooted at random from each plot without disturbing the roots and their nodules. After thorough washing in flowing water and roots along with nodules dried in shades and the dry weight of nodules (mg) were taken.

### 3.9.2.2 Yield and yield attributes

#### 3.9.2.2.1 Number of pods per plant

The pods of five randomly selected and tagged plants were counted and average number of pod per plant was worked out and recorded as number of pods per plant.

#### 3.9.2.2.2 Number of seeds per pod

The seeds per pod of ten randomly selected and tagged plants were counted and average number of seed per pod was worked out and recorded as number of seeds per pod.

#### 3.9.2.2.3 Test weight

One thousand seeds were counted by seed counter from each sample drawn from the produce of each plot and their weight (g) was recorded.

#### 3.9.2.2.4 Seed yield

After threshing and winnowing, the weight of seed from each net plot area was recorded in kg $plot^{-1}$ and was converted as kg $ha^{-1}$.

### 3.9.2.2.5 Straw yield

The straw yield (kg $plot^{-1}$) was obtained by subtracting the seed yield from biological yield per net plot recorded earlier and then converted in terms of kg $ha^{-1}$.

### 3.9.2.2.6 Biological yield

The harvested material from net area of each plot was thoroughly sun dried. After drying, the produce of individual net plot area was weighed with the help of a spring balance and weight recorded in kg $plot^{-1}$. Later, biological yield per plot was converted in terms of kg $ha^{-1}$.

### 3.9.2.2.7 Harvest index

The harvest index was worked out by dividing the seed yield (economic yield) by seed + straw yield (biological yield) obtained from net plot area and multiplied by 100 to express it in per cent (Singh and Stoskhopf, 1971).

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

### 3.9.2.3 Quality character

### 3.9.2.3.1 Protein content

The protein content of seed was estimated by multiplying nitrogen content of seed with conversion factor of 6.25 (A.O.A.C., 1960).

### 3.9.2.4 Nutrient content and uptake

### 3.9.2.4.1 Plant nutrient analysis

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

**Table 3.8: Methods of plant analysis**

| S.No | Determination | Methods | References |
|---|---|---|---|
| 1. | Nitrogen content | Estimation from digested aliquot of digestion I colour was developed with Nessler's reagent and recorded on colorimeter with green filter | Snell and Snell (1949) |
| 2. | Phosphorus content | Estimated from digested aliquot of digestion II colorimetrically (spectrophotometer 106) using Vanado-molybdo-phosphoric yellow colour method | Jackson (1973) |
| 3. | Potassium content | Estimated from digested aliquot of digestion II using flame photometer 129 | Bhargava and Raghupathi (1993) |
| 4. | Protein content | N (%) x 6.25 | A.O.A.C (1960) |

## Method of plant analysis

## Wet digestion I

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

**Wet digestion II**

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

**3.9.2.5.2 Nutrient uptake**

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

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Per cent nutrient content in seed} \times \text{Seed yield (kg ha}^{-1}\text{)} + \text{Per cent nutrient content in straw} \times \text{Straw yield (kg ha}^{-1}\text{)}}{100}$$

## 3.10 Economics of treatment

### 3.10.1 Net returns (` ha$^{-1}$)

To find out the more profitable treatment, economics of different treatments were worked out in terms of net returns (` ha$^{-1}$) on the basis of the prevailing market rate so that the most remunerative treatment could be recommended.

Net return (` ha$^{-1}$) = Gross return (` ha$^{-1}$) - Cost of cultivation (` ha$^{-1}$)

### 3.10.2 Benefit: cost ratio

Benefit: cost ratio for each treatment was calculated to ascertain economic viability of the treatment using the following formula:

$$\text{B : C ratio} = \frac{\text{Gross returns (` ha}^{-1}\text{)}}{\text{Cost of cultivation (` ha}^{-1}\text{)}}$$

## 3.11 Statistical analysis

### 3.11.1 Analysis of variance and test of significance

The experimental data recorded for growth, yield and other characters were statistically analyzed with the help of fisher's analysis of variance technique (Fisher, 1950).The data of weed density were subjected to square root transformation ($\sqrt{x+0.5}$) to normalize their distribution as per Gomez and Gomez (1984).While presenting the results of weed density and dry matter and nutrient uptake by weeds, the columns of data where weed did not exist due to employment of weed free treatments, have been left blank and the statistical analysis was done after subtracting respective degrees of freedom of weed competition periods. The critical differences for the treatment comparison were worked out, wherever, the "F" test was found significant at 5 per cent level of significance. To elucidate effects, summary tables along with S.Em± and C.D. (P= 0.05) were prepared and are given in chapter "Experimental Results" and their analysis of variance are given in the appendices at the end.

### 4.11.2 Correlation and regression studies

To asses the relationship, correlation and regression coefficients between seed yield (Y) and the independent variables (X) such as weed dry matter, crop dry matter, yield attributes and N, P and K uptake by weeds and crop were worked out using the procedure given by Snedecor and Cochran (1968). The regression equations were also fitted and tested for significance.

# 4. EXPERIMENTAL RESULTS

The results of the field experiment entitled "Integrated Weed Management in Greengram [*Vigna radiata* (L.) Wilczek] in Arid region" conducted at Instructional Farm, Agriculture Research Station, SKRAU, Bikaner, during *kharif* 2013 are being presented in this chapter. Data were statistically analysed to test the significance of the results. Analysis of variance for these data has been furnished in Appendices I to XX at the end.

## 4. 1 Weed studies

### 4.1.1 Weed survey

Weed flora of experimental field consisted of *Amaranthus spinosus* L., *Digera arvensis* L., Tri*anthema portulacastrum* L. , *Gisekia poredious* L., *Euphorbia hirta* L., *Aristida depressa* L., *Portulaca oleracea* L., *Cenchrus biflorus* L., *Cleome viscosa* L., *Tribulus terrestris* L., *Corchorus tridense* L., *Cyperus rotundus* L., *Eleusine verticillata* L., *Eragrastris tennela* L. and *Aerva tomentosa* L.

### 4.1.2 Weed density

#### 4.1.2.1 Weed density 30 DAS

An examination of data (table 4.1) reveals that all the weed control treatments significantly reduced density of broad leaved, grassy and total weeds over weedy check. Data further reveal that weed free treatment recorded lowest broad leaved, grassy and total weeds compared to rest of the weed control treatments.

Treatments imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE and imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS were found next best treatments to weed free. Among herbicidal weed control treatments, application of pendimethalin 0.75 kg $ha^{-1}$ alone, pendimethalin 0.75 kg $ha^{-1}$ + hand weeding at 30 DAS,

**Table 4.1. Effect of weed control treatments on weed density at 30 DAS of greengram**

| Treatments | | Weed density (No. $m^{-2}$) | | |
|---|---|---|---|---|
| | | Broad leaved | Grassy | Total |
| $W_1$ | Weedy check | 6.11 (36.84) | 5.37 (28.34) | 8.10 (65.18) |
| $W_2$ | Weed free | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 2.83 (7.56) | 0.81 (0.16) | 2.86 (7.72) |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 2.82 (7.56) | 0.81 (0.16) | 2.85 (7.72) |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 1.59 (2.12) | 1.76 (2.62) | 2.28 (4.74) |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 1.59 (2.07) | 1.74 (2.58) | 2.27 (4.64) |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 1.59 (2.03) | 1.72 (2.50) | 2.23 (4.53) |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 1.61 (2.10) | 1.75 (2.64) | 2.28 (4.75) |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 1.60 (2.06) | 1.75 (2.56) | 2.26 (4.62) |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 1.59 (2.04) | 1.71 (2.48) | 2.24 (4.51) |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 0.98 (0.46) | 1.22 (1.00) | 1.40 (1.46) |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 0.95 (0.40) | 0.75 (0.07) | 0.99 (0.47) |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 2.84 (7.56) | 0.81 (0.16) | 2.87 (7.71) |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.98 (0.47) | 1.23 (1.02) | 1.41 (1.49) |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.95 (0.41) | 0.76 (0.08) | 0.99 (0.49) |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 2.84 (7.56) | 0.81 (0.16) | 2.87 (7.72) |
| | S.Em.$\pm$ | 0.10 | 0.09 | 0.12 |
| | C.D. at 5% | 0.30 | 0.27 | 0.33 |

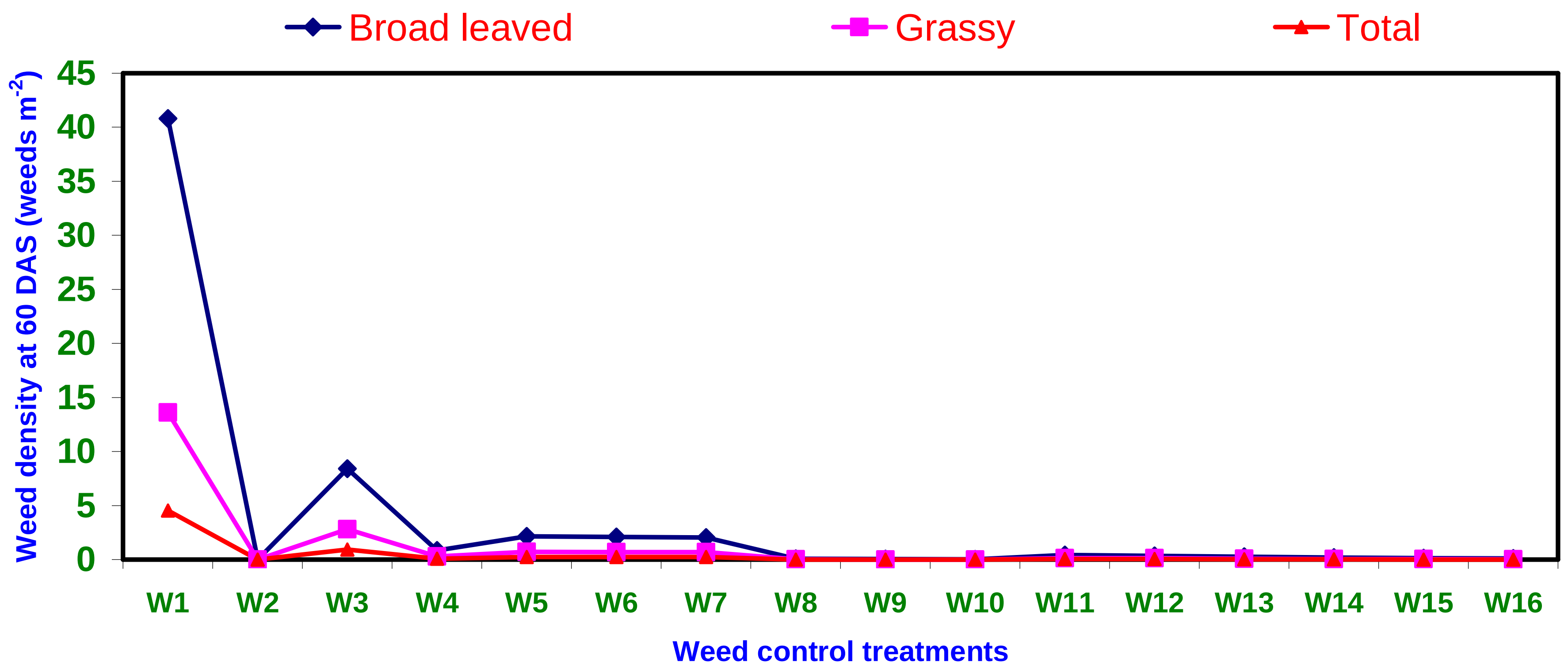



**Fig. 4.1. Effect of weed control treatments on weed density at 30 DAS of green gram**

pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE and pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE were found at par with each other and these treatments significantly reduced the density of total weeds (2.86, 2.85, 2.87 and 2.87 weeds $m^{-2}$, respectively) in comparison to weedy check (8.10 weeds $m^{-2}$).

**4.1.2.2 Weed density 60 DAS**

A perusal of data (table 4.2) indicates that all the weed control treatments significantly reduced density of broad leaved, grassy and total weeds over weedy check. Weed free treatment recorded the lowest density of weeds (negligible, hypothetically 0) compared to weedy check wherein density of broad leaved (6.42 weeds $m^{-2}$), grassy (6.12 weeds $m^{-2}$) and total weeds (8.84 weeds $m^{-2}$) were recorded highest with weedy check.

Among all weed control treatments, the next best treatments were pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE, which remained statistically at par with each other and weed free.

The per cent reduction in total weed dry weight due to weed free treatment, pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE,

**Table 4.2. Effect of weed control treatments on weed density at 60 DAS of greengram**

| Treatments | | Weed density (No. $m^{-2}$) | | |
|---|---|---|---|---|
| | | Broad leaved | Grassy | Total |
| $W_1$ | Weedy check | 6.42 (40.80) | 6.12 (36.99) | 8.84 (77.79) |
| $W_2$ | Weed free | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 2.98 (8.42) | 0.8 (0.15) | 3.00 (8.56) |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 1.16 (0.85) | 0.77 (0.09) | 1.20 (0.94) |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 1.63 (2.15) | 1.76 (2.65) | 2.29 (4.80) |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 1.61 (2.09) | 1.76 (2.60) | 2.28 (4.69) |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 1.60 (2.05) | 1.73 (2.51) | 2.24 (4.56) |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.76 (0.08) | 1.32 (1.24) | 1.35 (1.32) |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.73 (0.04) | 1.29 (1.15) | 1.30 (1.19) |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.72 (0.02) | 1.26 (1.10) | 1.27 (1.12) |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 0.96 (0.42) | 0.76 (0.08) | 1.00 (0.50) |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 0.92 (0.35) | 0.74 (0.04) | 0.94 (0.39) |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 0.88 (0.27) | 0.76 (0.08) | 0.92 (0.35) |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.82 (0.18) | 0.81 (0.15) | 0.91 (0.33) |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.79 (0.12) | 0.74 (0.05) | 0.82 (0.17) |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 0.77 (0.10) | 0.72 (0.02) | 0.78 (0.12) |
| | S.Em.$\pm$ | 0.08 | 0.07 | 0.09 |
| | C.D. at 5% | 0.23 | 0.20 | 0.25 |

imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS, imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE, imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE, imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE and pendimethalin @ 0.75 kg $ha^{-1}$ as PE were 100, 99.85, 99.78, 99.58, 99.55, 99.50, 99.36, 98.79, 98.56, 98.47, 98.30, 94.14, 93.97, 93.83 and 89.00, respectively compared to weedy check.

#### 4.1.2.3 Weed density at harvest

An examination of data (table 4.3) reveals that all the weed control treatments significantly reduced density of broad leaved, grassy and total weeds over weedy check. Data further reveal that weed free treatment recorded lowest density of all type weeds compared to rest of the weed control treatments.

Significantly lower number of total weeds were recorded under weed free treatment which was remained at par with pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS and imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS. Data also show that higher doses of imazethapyr and imazethapyr+imazamox herbicide could not result in significant reduction in weed density compared to their lower doses.

The per cent reduction in total weed dry weight due to weed free treatment, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr +

**Table 4.3. Effect of weed control treatments on weed density at harvest of greengram**

| Treatments | | Weed density (No. $m^{-2}$) | | |
|---|---|---|---|---|
| | | Broad leaved | Grassy | Total |
| $W_1$ | Weedy check | 5.80 (33.2) | 5.74 (32.6) | 8.14 (65.80) |
| $W_2$ | Weed free | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 2.79 (7.31) | 0.78 (0.11) | 2.81 (7.42) |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 1.00 (0.50) | 0.77 (0.09) | 1.04 (0.59) |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 1.24 (1.05) | 1.59 (2.10) | 1.90 (3.15) |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 1.23 (1.02) | 1.58 (2.07) | 1.88 (3.09) |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 1.22 (1.00) | 1.58 (2.00) | 1.87 (3.00) |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.75 (0.06) | 1.07 (0.65) | 1.10 (0.71) |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.72 (0.02) | 0.99 (0.48) | 1.00 (0.50) |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.71 (0.01) | 1.16 (0.85) | 1.17 (0.86) |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 0.95 (0.40) | 0.72 (0.02) | 0.96 (0.43) |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 0.90 (0.31) | 0.72 (0.01) | 0.91 (0.32) |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 0.87 (0.25) | 0.74 (0.05) | 0.90 (0.31) |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.77 (0.09) | 0.77 (0.1) | 0.83 (0.19) |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.72 (0.02) | 0.74 (0.04) | 0.75 (0.06) |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 0.74 (0.05) | 0.72 (0.01) | 0.75 (0.06) |
| | S.Em.$\pm$ | 0.05 | 0.09 | 0.06 |
| | C.D. at 5% | 0.14 | 0.26 | 0.17 |

imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE, imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE, imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS, imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE, imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE, imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE and pendimethalin @ 0.75 kg $ha^{-1}$ as PE were 100, 99.91, 99.91, 99.71, 99.53, 99.51, 99.35, 99.24, 99.10, 98.92, 98.69, 95.44, 95.00, 95.21 and 88.72, respectively compared to weedy check.

### 4.1.3 Weed dry weight

#### 4.1.3.1 Dry weight at 30 DAS

An appraisal of data presented in table 4.4 explicit that all the weed control treatments significantly reduced weed dry weight over weedy check. Data further reveal that weed free treatment recorded the lowest dry weight of broad leaved, grassy and total weeds compared to all other weed control treatments.

Among herbicidal weed control treatments, the lowest weed density was observed with imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE and this treatment was significantly reduced the dry weight of weeds compared to weedy check. It is also noticed that application of imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE and imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS were found also superior over imazethapyr + imazamox @ 40 g $ha^{-1}$

**Table 4.4. Effect of weed control treatments on weed dry weight at 30 DAS of green gram**

| Treatments | | Dry weight (g $m^{-2}$) | | |
|---|---|---|---|---|
| | | Broad leaved | Grassy | Total |
| $W_1$ | Weedy check | 37.58 | 7.66 | 45.24 |
| $W_2$ | Weed free | 0.00 | 0.00 | 0.00 |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 8.17 | 0.12 | 8.29 |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 8.22 | 0.13 | 8.35 |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 2.39 | 0.78 | 3.16 |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 2.43 | 0.85 | 3.29 |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 2.54 | 0.87 | 3.41 |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 2.50 | 0.85 | 3.35 |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 2.48 | 0.83 | 3.32 |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 2.58 | 0.90 | 3.48 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 0.75 | 0.31 | 1.06 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 0.64 | 0.02 | 0.66 |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 8.16 | 0.06 | 8.22 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.84 | 0.31 | 1.15 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.76 | 0.03 | 0.79 |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 8.15 | 0.07 | 8.22 |
| | S.Em.$\pm$ | 0.33 | 0.06 | 0.23 |
| | C.D. at 5% | 0.94 | 0.17 | 0.65 |

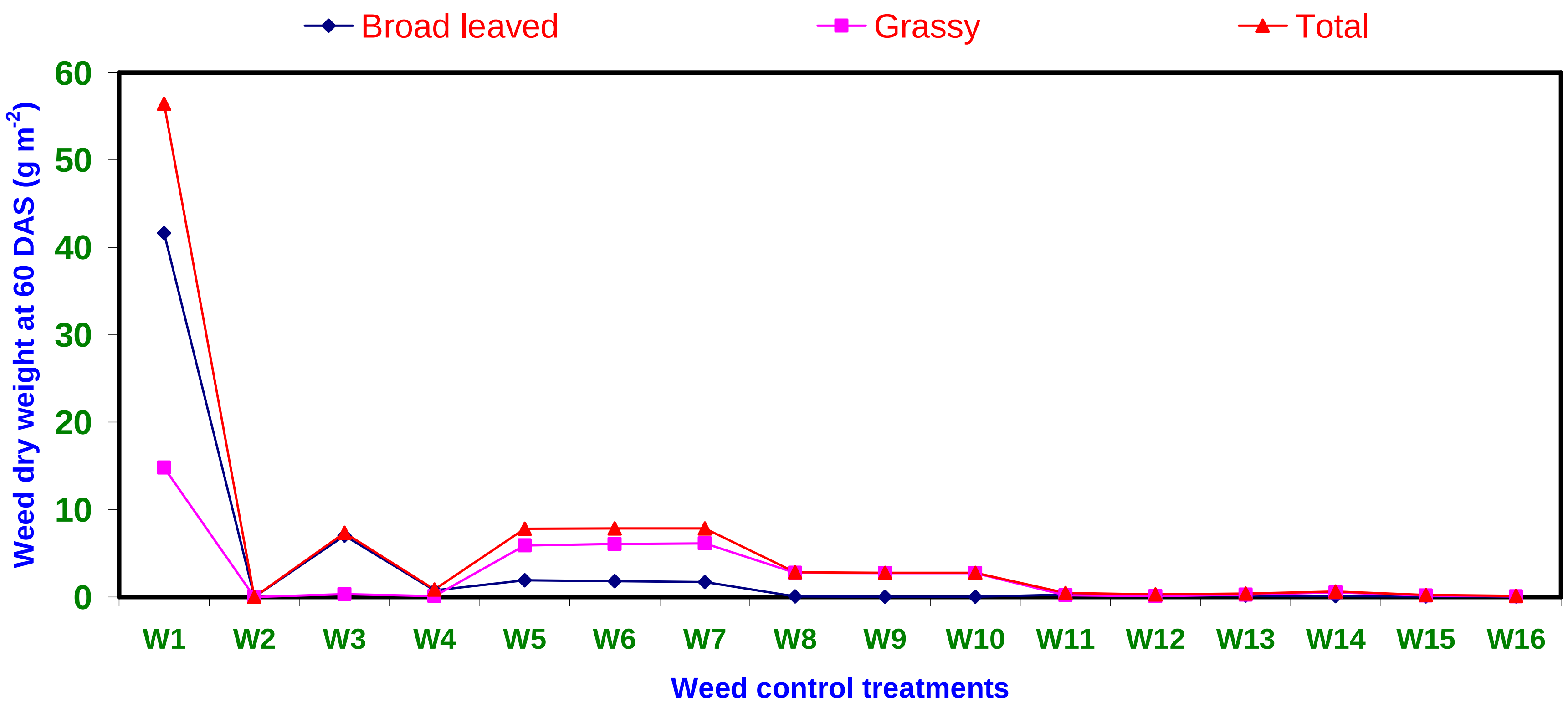



**Fig. 4.2 : Effect of weed control treatments on weed dry weight at 60 DAS of green gram**

at 20 DAS as PoE and imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS with respect to broad leaved and total weeds, at the same time it is also observed that all the levels of imazethapyr alone or integrated with one hand weeding are inferior to the other weed control treatments in controlling grassy weeds. It is also evident from data that higher doses of imazethapyr and imazethapyr + imazamox herbicide could not result in significant reduction in weed dry weight compared to their lower doses. The per cent reduction in total weed dry weight due to weed free treatment, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE and imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS were 100, 98.54, 98.25, 97.66 and 97.46, respectively compared to weedy check.

### 4.1.3.2 Dry weight at 60 DAS

An assessment of data (table 4.5) indicates that all the weed control treatments significantly reduced the dry weight of broad leaved, grassy and total weeds over weedy check. Weed free treatment recorded the nil dry weight of broad leaved, grassy and total weeds compared to weedy check where in dry weight of broad leaved, grassy and total weeds were recorded highest with the values of 41.65, 14.79 and 56.45 g $m^{-2}$, respectively.

Among herbicidal weed control treatments, application of pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox

**Table 4.5. Effect of weed control treatments on weed dry weight at 60 DAS of green gram**

| Treatments | | Dry weight (g $m^{-2}$) | | |
|---|---|---|---|---|
| | | Broad leaved | Grassy | Total |
| $W_1$ | Weedy check | 41.65 | 14.79 | 56.45 |
| $W_2$ | Weed free | 0.00 | 0.00 | 0.00 |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 7.02 | 0.33 | 7.35 |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 0.77 | 0.09 | 0.86 |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 1.92 | 5.89 | 7.81 |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 1.81 | 6.05 | 7.86 |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 1.71 | 6.12 | 7.83 |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.07 | 2.76 | 2.83 |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.04 | 2.73 | 2.77 |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.02 | 2.75 | 2.77 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 0.25 | 0.21 | 0.45 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 0.20 | 0.11 | 0.31 |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 0.15 | 0.27 | 0.41 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.10 | 0.52 | 0.63 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.07 | 0.17 | 0.23 |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 0.05 | 0.07 | 0.12 |
| | S.Em.$\pm$ | 0.24 | 0.12 | 0.18 |
| | C.D. at 5% | 0.71 | 0.34 | 0.52 |

@ 40 g $ha^{-1}$ at 20 DAS as PoE were found at par with weed free treatment and these treatments significantly reduced the dry weight of weeds compared to weedy check. These herbicides treatments are at par with imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS and pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS. The per cent reduction in total weed dry weight due to weed free treatment, pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE were 100, 99.79, 99.59, 99.45, 99.27 and 99.20, respectively compared to weedy check.

#### 4.1.3.3 Dry weight at harvest

A critical examination of data presented in table 4.6 explicit that all the weed control treatments significantly reduced dry weight of broad leaved, grassy and total weeds over weedy check. The nihil dry weight of broad leaved, grassy and total weeds was recorded under weed free treatment, while the respective values for these parameters under weedy check were 33.88, 13.04 and 46.92 g $m^{-2}$.

Among herbicidal weed control treatments, application of pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE, imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as

**Table 4.6. Effect of weed control treatments on weed dry weight at harvest of green gram**

| Treatments | | Dry weight (g $m^{-2}$) | | |
|---|---|---|---|---|
| | | Broad leaved | Grassy | Total |
| $W_1$ | Weedy check | 33.88 | 13.04 | 46.92 |
| $W_2$ | Weed free | 0.00 | 0.00 | 0.00 |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 6.09 | 0.24 | 6.33 |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 0.45 | 0.09 | 0.54 |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 0.93 | 4.66 | 5.60 |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 0.88 | 4.82 | 5.70 |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 0.84 | 4.88 | 5.72 |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.05 | 1.44 | 1.49 |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.02 | 1.14 | 1.15 |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.01 | 2.13 | 2.13 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 0.24 | 0.05 | 0.29 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 0.18 | 0.03 | 0.21 |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 0.14 | 0.16 | 0.30 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.05 | 0.34 | 0.39 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.02 | 0.13 | 0.15 |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 0.03 | 0.04 | 0.06 |
| | S.Em.± | 0.19 | 0.10 | 0.16 |
| | C.D. at 5% | 0.54 | 0.28 | 0.46 |

PoE + one hand weeding at 40 DAS were found at par with weed free treatment and these treatments significantly reduced the dry weight of weeds compared to weedy check. These herbicides treatments are at par with pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS. The per cent reduction in total weed dry weight due to weed free treatment, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE, imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS were 100, 99.87, 99.68, 99.55, 99.38, 99.36 and 99.17, respectively compared to weedy check.

### 4.1.4 Weed control efficiency

An examination of data presented in table 4.7 reveals that weed control efficiency at 60 DAS based on total weed density fluctuated to a great extent under the influence of various weed control treatments. In general, all weed control treatments efficiently controlled broad leaved as well as grassy weeds.

The highest weed control efficiency was recorded under weed free treatment (100%) followed by pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS and pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE with the respective values of 99.85, 99.78, 99.58 and 99.53 per cent, respectively. Among the

**Table 4.7 : Effect of weed control treatments on weed control efficiency and weed index in greengram**

| | Treatments | Weed control efficiency (%) | Weed index (%) |
|---|---|---|---|
| $W_1$ | Weedy check | - | 50.56 |
| $W_2$ | Weed free | 100.00 | - |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 89.00 | 14.06 |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 98.79 | 2.40 |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 93.83 | 19.09 |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 93.97 | 16.45 |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 94.14 | 16.77 |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 98.30 | 12.14 |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 98.47 | 10.30 |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 98.56 | 9.82 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 99.36 | 15.42 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 99.50 | 14.62 |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 99.55 | 2.88 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 99.58 | 7.51 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 99.78 | 6.07 |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 99.85 | 4.79 |

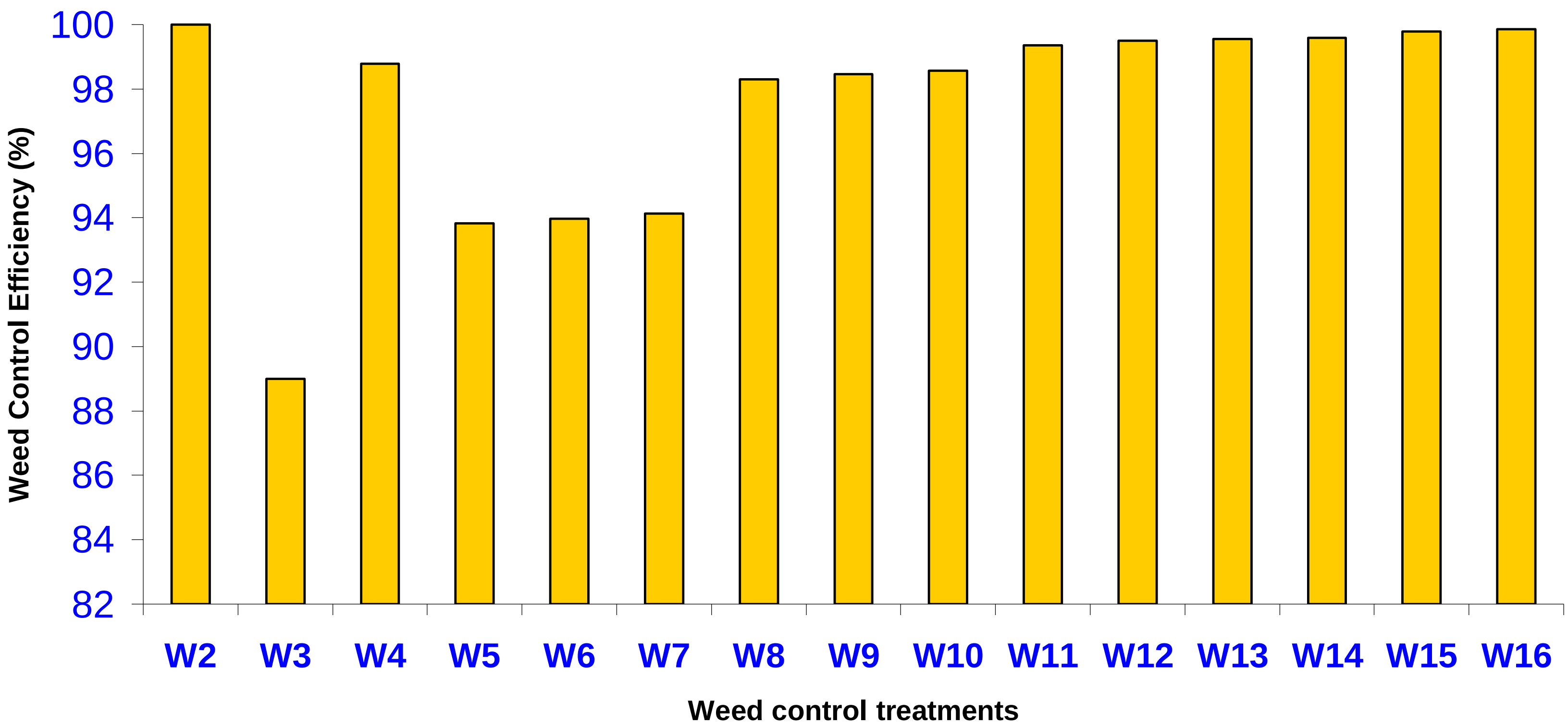



**Fig. 4.3 : Effect of weed control treatments on weed control efficiency in greengram**

herbicides the lowest total weed control efficiency of 89.00 per cent was recorded with application of pendimethalin @ 0.75 kg $ha^{-1}$ as PE.

### 4.1.5 Weed index

An appraisal of data (table 4.7) reveals that highest weed index was recorded under weedy check (50.56%). Among the herbicides the highest weed index of (19.09%) was recorded with application of imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE.

Data further indicate that the lowest weed index was recorded under pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS (2.40%) followed by pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE (2.88%) and pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE (4.79%).

## 4.2 Crop Studies

### 4.2.1 Growth attributes

#### 4.2.1.1 Plant stand

A perusal of data (table 4.8) reveals that all weed control measures caused non-significant effect on the plant stand at both the stages of greengram at 20 DAS and at harvest.

#### 4.2.1.2 Plant height

A critical examination of data (table 4.9) indicates that all the weed control treatments significantly affected the plant height at 60 DAS and at harvest as compared to weedy check but in 30 DAS, plant height was found non significant among all the weed control treatments. At 60 DAS,

**Table 4.8 : Effect of weed control treatments on plant stand of greengram**

| Treatments | | Plant stand (lac $ha^{-1}$) | |
|---|---|---|---|
| | | 20 DAS | At harvest |
| $W_1$ | Weedy check | 3.08 | 2.93 |
| $W_2$ | Weed free | 3.20 | 3.00 |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 3.18 | 2.99 |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 3.19 | 2.99 |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 3.10 | 2.94 |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 3.10 | 2.94 |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 3.11 | 2.94 |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 3.15 | 2.96 |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 3.16 | 2.97 |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 3.16 | 2.97 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 3.12 | 2.95 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 3.13 | 2.95 |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 3.14 | 2.95 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 3.17 | 2.98 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 3.17 | 2.98 |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 3.18 | 2.99 |
| S.Em.$\pm$ | | 0.12 | 0.15 |
| C.D. at 5% | | NS | NS |

DAS= Days after sowing
NS= Non-significant

**Table 4.9 : Effect of weed control treatments on plant height of greengram**

| Treatments | | Plant height (cm) | | |
|---|---|---|---|---|
| | | 30 DAS | 60 DAS | At harvest |
| $W_1$ | Weedy check | 27.04 | 46.25 | 46.60 |
| $W_2$ | Weed free | 29.85 | 54.25 | 65.25 |
| $W_3$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE | 29.36 | 53.97 | 64.50 |
| $W_4$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE + one hand weeding at 30 DAS | 26.40 | 54.09 | 64.70 |
| $W_5$ | Imazethapyr @ 40 g ha$^{-1}$ at 20 DAS as PoE | 28.03 | 52.66 | 59.10 |
| $W_6$ | Imazethapyr @ 50 g ha$^{-1}$ at 20 DAS as PoE | 28.23 | 52.83 | 59.20 |
| $W_7$ | Imazethapyr @ 60 g ha$^{-1}$ at 20 DAS as PoE | 30.53 | 52.85 | 59.60 |
| $W_8$ | Imazethapyr @ 40 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 30.81 | 53.24 | 61.00 |
| $W_9$ | Imazethapyr @ 50 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 31.87 | 53.28 | 61.40 |
| $W_{10}$ | Imazethapyr @ 60 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 27.90 | 53.37 | 61.50 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g ha$^{-1}$ at 20 DAS as PoE | 31.69 | 52.90 | 60.20 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE | 27.52 | 52.94 | 60.50 |
| $W_{13}$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr @ 40 g ha$^{-1}$ at 30 DAS as PoE | 32.21 | 53.03 | 60.70 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 28.86 | 53.59 | 62.10 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 32.63 | 53.67 | 62.30 |
| $W_{16}$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE +imazethapyr + imazamox @ 40 g ha$^{-1}$ at 30 DAS as PoE | 29.61 | 53.81 | 63.40 |
| | S.Em.$\pm$ | 1.47 | 1.28 | 2.56 |
| | C.D. at 5% | NS | 3.71 | 7.40 |

DAS= Days after sowing

the maximum plant height was recorded under weed free treatment (54.25 cm), which was found statistically at par with rest of treatments except weedy check. The minimum plant height (46.25 cm) was recorded under weedy check.

Data further indicate that the maximum plant height at harvest was recorded under weed free treatment (65.25 cm) but it was found statistically at par with rest of the weed control treatments and minimum plant height (46.60 cm) was recorded under weedy check. The increase in plant height with weed free treatment was 40.02 per cent over weedy check.

#### 4.2.1.3 Branches plant$^{-1}$

An assessment of data (table 4.10) reveals that weedy and weed free treatments have significant effect on number of branches plant$^{-1}$ at harvest. The maximum number of branches (4.21) was obtained in weed free treatment, which was significantly higher over weedy check, however, all weed control treatments were statistically at par with weed free treatment. The minimum branches plant$^{-1}$ was observed in weedy check (2.97). The increased branches per plant with weed free, pendimethalin @ 0.75 kg ha$^{-1}$ as PE + one hand weeding at 30 DAS, pendimethalin @ 0.75 kg ha$^{-1}$ as PE, pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr + imazamox @ 40 g ha$^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS were 41.75, 40.40, 40.07, 38.72 and 38.05 per cent, respectively over weedy check.

#### 4.2.1.4 Dry weight of nodules plant$^{-1}$

An assessment of data (table 4.10) reveals that all the weed control treatments brought about significant effect on dry weight of nodules

**Table 4.10 : Effect of weed control treatments on branches plant$^{-1}$ and dry weight of nodules of greengram**

| Treatments | | Branches plant$^{-1}$ | Dry weight of nodules at 50 DAS (mg plant$^{-1}$) |
|---|---|---|---|
| $W_1$ | Weedy check | 2.97 | 20.23 |
| $W_2$ | Weed free | 4.21 | 29.52 |
| $W_3$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE | 4.16 | 25.50 |
| $W_4$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE + one hand weeding at 30 DAS | 4.17 | 27.37 |
| $W_5$ | Imazethapyr @ 40 g ha$^{-1}$ at 20 DAS as PoE | 3.77 | 25.65 |
| $W_6$ | Imazethapyr @ 50 g ha$^{-1}$ at 20 DAS as PoE | 3.80 | 26.17 |
| $W_7$ | Imazethapyr @ 60 g ha$^{-1}$ at 20 DAS as PoE | 3.81 | 26.43 |
| $W_8$ | Imazethapyr @ 40 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 3.98 | 26.47 |
| $W_9$ | Imazethapyr @ 50 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 4.01 | 26.52 |
| $W_{10}$ | Imazethapyr @ 60 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 4.03 | 27.03 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g ha$^{-1}$ at 20 DAS as PoE | 3.87 | 27.69 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE | 3.90 | 27.85 |
| $W_{13}$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr @ 40 g ha$^{-1}$ at 30 DAS as PoE | 3.93 | 25.83 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 4.06 | 28.09 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 4.10 | 28.23 |
| $W_{16}$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr + imazamox @ 40 g ha$^{-1}$ at 30 DAS as PoE | 4.12 | 27.21 |
| | S.Em.$\pm$ | 0.17 | 1.06 |
| | C.D. at 5% | 0.50 | 3.05 |

DAS= Days after sowing

plant$^{-1}$**.** The dry weight of nodules plant$^{-1}$ at 50 DAS was recorded highest 29.52 mg g$^{-1}$ and lowest 20.23 mg g$^{-1}$ with weed free treatment and weedy check, respectively.

### 4.2.1.5 Dry matter accumulation

#### 4.2.1.5.1 Dry matter accumulation 30 DAS

An assessment of data (table 4.11) elucidates that all the weed control treatments caused significantly effect on plant dry matter (g plant$^{-1}$) over weedy check. Data further reveal that the maximum dry matter accumulation at 30 DAS (0.32 g plant$^{-1}$) was found with weed free, which was significantly higher with weedy check, however all the weed control treatments were found at par with each other. The minimum dry matter accumulation was recorded in weedy check.

#### 4.2.1.5.2 Dry matter accumulation 60 DAS

A perusal of data (table 4.11) indicates that all the weed control treatments significantly increased dry matter accumulation of greengram as compared to weedy check (3.26 g plant$^{-1}$). The highest plant dry matter (6.28 g plant$^{-1}$) was recorded under weed free treatment but it was found statistically at par with all weed control treatments. The increase in plant dry matter with weed free treatment, pendimethalin @ 0.75 kg ha$^{-1}$ as PE + one hand weeding at 30 DAS, pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr @ 40 g ha$^{-1}$ at 30 DAS as PoE, pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr + imazamox @ 40 g ha$^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS were 92.64, 90.18, 87.73, 84.66 and 81.90 per cent, respectively over weedy check.

**Table 4.11 : Effect of weed control treatments on dry matter accumulation of greengram**

| Treatments | | Dry matter accumulation (g plant$^{-1}$) | | |
|---|---|---|---|---|
| | | 30 DAS | 60 DAS | At harvest |
| $W_1$ | Weedy check | 0.19 | 3.26 | 7.90 |
| $W_2$ | Weed free | 0.32 | 6.28 | 14.79 |
| $W_3$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE | 0.31 | 5.32 | 13.22 |
| $W_4$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE + one hand weeding at 30 DAS | 0.32 | 6.20 | 14.54 |
| $W_5$ | Imazethapyr @ 40 g ha$^{-1}$ at 20 DAS as PoE | 0.27 | 4.98 | 12.79 |
| $W_6$ | Imazethapyr @ 50 g ha$^{-1}$ at 20 DAS as PoE | 0.27 | 5.01 | 13.16 |
| $W_7$ | Imazethapyr @ 60 g ha$^{-1}$ at 20 DAS as PoE | 0.28 | 5.07 | 12.96 |
| $W_8$ | Imazethapyr @ 40 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.29 | 5.41 | 13.44 |
| $W_9$ | Imazethapyr @ 50 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.29 | 5.55 | 13.83 |
| $W_{10}$ | Imazethapyr @ 60 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.29 | 5.62 | 14.10 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g ha$^{-1}$ at 20 DAS as PoE | 0.28 | 5.10 | 13.35 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE | 0.28 | 5.24 | 13.25 |
| $W_{13}$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr @ 40 g ha$^{-1}$ at 30 DAS as PoE | 0.29 | 6.15 | 14.45 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.30 | 5.82 | 14.10 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.30 | 5.93 | 14.20 |
| $W_{16}$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE +imazethapyr + imazamox @ 40 g ha$^{-1}$ at 30 DAS as PoE | 0.30 | 6.02 | 14.28 |
| | S.Em.$\pm$ | 0.02 | 0.48 | 0.91 |
| | C.D. at 5% | 0.05 | 1.38 | 2.62 |

DAS= Days after sowing

#### 4.2.1.5.3 Dry matter accumulation at harvest

A critical examination of data (table 4.11) reveals that all the weed control treatments significantly increased dry matter accumulation of greengram compared to weedy check (7.90 g plant$^{-1}$). Data show that highest plant dry matter (14.79 g plant$^{-1}$) was recorded under weed free treatment but it was found statistically at par with all other treatments except weedy check.

Among herbicides, the performance of pendimethalin 0.75 kg ha$^{-1}$ as PE was found superior in enhancing dry matter accumulation of greengram closely followed by each dose imazethapyr and imazethapyr+ imazamox. Integration of each herbicide with one hand weeding was also recorded increase in plant dry matter accumulation compared to their application alone. The increase in plant dry matter accumulation with weed free treatment, pendimethalin 0.75 kg ha$^{-1}$ + hand weeding at 30 DAS, pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr @ 40 g ha$^{-1}$ at 30 DAS as PoE, pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr + imazamox @ 40 g ha$^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS were 87.22, 84.05, 82.91, 80.76 and 79.75 per cent, respectively over weedy check.

### 4.2.2 Yield attributes and Yield

#### 4.2.2.1 Pods plant$^{-1}$

An appraisal of data (table 4.12) reflects that all weed control treatments significantly increased number of pods plant$^{-1}$ over weedy check (19.23). The number of pods plant$^{-1}$ was found statistically at par with all other remaining treatments except weedy check.

**Table 4.12 : Effect of weed control treatments on yield attributes of greengram**

| Treatments | | Pods plant$^{-1}$ (No.) | Seeds pod$^{-1}$ (No.) | Test weight (g) |
|---|---|---|---|---|
| $W_1$ | Weedy check | 19.23 | 4.52 | 24.50 |
| $W_2$ | Weed free | 27.76 | 5.94 | 25.49 |
| $W_3$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE | 26.10 | 5.61 | 25.34 |
| $W_4$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE + one hand weeding at 30 DAS | 27.52 | 5.89 | 25.38 |
| $W_5$ | Imazethapyr @ 40 g ha$^{-1}$ at 20 DAS as PoE | 25.40 | 5.50 | 24.75 |
| $W_6$ | Imazethapyr @ 50 g ha$^{-1}$ at 20 DAS as PoE | 25.50 | 5.65 | 24.87 |
| $W_7$ | Imazethapyr @ 60 g ha$^{-1}$ at 20 DAS as PoE | 25.70 | 5.57 | 24.90 |
| $W_8$ | Imazethapyr @ 40 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 26.40 | 5.65 | 25.06 |
| $W_9$ | Imazethapyr @ 50 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 26.57 | 5.69 | 25.12 |
| $W_{10}$ | Imazethapyr @ 60 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 26.60 | 5.71 | 25.15 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g ha$^{-1}$ at 20 DAS as PoE | 25.90 | 5.59 | 24.95 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE | 26.04 | 5.60 | 24.98 |
| $W_{13}$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr @ 40 g ha$^{-1}$ at 30 DAS as PoE | 27.47 | 5.87 | 25.00 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 26.98 | 5.75 | 25.23 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 27.07 | 5.81 | 25.24 |
| $W_{16}$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE +imazethapyr + imazamox @ 40 g ha$^{-1}$ at 30 DAS as PoE | 27.15 | 5.83 | 25.30 |
| | S.Em.$\pm$ | 1.12 | 0.17 | 0.74 |
| | C.D. at 5% | 3.24 | 0.50 | NS |

Data further reveal that among the all weed control treatments the decreasing trend of increase in number of pods plant$^{-1}$ with weed free treatment, pendimethalin 0.75 kg ha$^{-1}$ + hand weeding at 30 DAS, pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr @ 40 g ha$^{-1}$ at 30 DAS as PoE, pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr + imazamox @ 40 g ha$^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS were recorded 44.36, 43.11, 42.85, 41.19 and 40.77 per cent, respectively compared to weedy check.

### 4.2.2.2 Seeds pod$^{-1}$

A critical examination of data (table 4.12) reveals that all the weed control treatments significantly increased number of seeds pod$^{-1}$ over weedy check (4.52). Weed free treatment recorded highest number of seeds pod$^{-1}$ (5.94) which was found statistically at par with all remaining treatments except weedy check. Among the herbicides the trend of increase in number of seeds pod$^{-1}$ under weed free treatment, pendimethalin 0.75 kg ha$^{-1}$ + hand weeding at 30 DAS, pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr @ 40 g ha$^{-1}$ at 30 DAS as PoE, pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr + imazamox @ 40 g ha$^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS were 31.42, 30.31, 29.87, 28.98 and 28.54 per cent, respectively compared to weedy check.

### 4.2.2.3 Test weight

An assessment of data (table 4.12) elucidates that all the weed control treatments caused non-significantly effect on test weight. The maximum test weight was 25.49 g with weed free treatment and minimum was 24.50 g with weedy check.

### 4.2.2.4 Seed yield

An examination of data (table 4.13) indicates that all the weed control treatments had significant increase in seed yield of greengram over weedy check (619 kg $ha^{-1}$). The highest seed yield (1252 kg $ha^{-1}$) was recorded with weed free treatment which was found statistically at par with all other treatments except weedy check.

Among herbicide weed control treatments, the highest seed yield was obtained under with pendimethalin 0.75 kg $ha^{-1}$ + hand weeding at 30 DAS followed by pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS. Integration of each herbicide with one hand weeding also effectively increased the seed yield compared to herbicides applied alone. The increase in seed yield due to weed free treatment, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, pendimethalin @ 0.75 kg $ha^{-1}$ as PE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE, imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE, imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE, imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE and imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE were 102.26, 97.42, 96.45, 92.57, 89.98, 87.08, 82.39, 81.42, 77.71, 73.83,

**Table 4.13 : Effect of weed control treatments on yields and harvest index of greengram**

| | Treatments | Seed yield (kg ha$^{-1}$) | Straw yield (kg ha$^{-1}$) | Biological yield (kg ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|---|---|
| $W_1$ | Weedy check | 619 | 1691 | 2310 | 26.80 |
| $W_2$ | Weed free | 1252 | 3180 | 4432 | 28.25 |
| $W_3$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE | 1076 | 2822 | 3898 | 27.50 |
| $W_4$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE + one hand weeding at 30 DAS | 1222 | 3111 | 4333 | 28.20 |
| $W_5$ | Imazethapyr @ 40 g ha$^{-1}$ at 20 DAS as PoE | 1013 | 2736 | 3749 | 27.00 |
| $W_6$ | Imazethapyr @ 50 g ha$^{-1}$ at 20 DAS as PoE | 1046 | 2812 | 3858 | 27.10 |
| $W_7$ | Imazethapyr @ 60 g ha$^{-1}$ at 20 DAS as PoE | 1042 | 2762 | 3804 | 27.20 |
| $W_8$ | Imazethapyr @ 40 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 1100 | 2899 | 3999 | 27.50 |
| $W_9$ | Imazethapyr @ 50 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 1123 | 2947 | 4069 | 27.60 |
| $W_{10}$ | Imazethapyr @ 60 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 1129 | 2946 | 4075 | 27.70 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g ha$^{-1}$ at 20 DAS as PoE | 1059 | 2816 | 3875 | 27.30 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE | 1069 | 2832 | 3901 | 27.40 |
| $W_{13}$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr @ 40 g ha$^{-1}$ at 30 DAS as PoE | 1216 | 3114 | 4330 | 28.10 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 1158 | 3006 | 4164 | 27.80 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 1176 | 3032 | 4208 | 27.90 |
| $W_{16}$ | Pendimethalin @ 0.75 kg ha$^{-1}$ as PE +imazethapyr + imazamox @ 40 g ha$^{-1}$ at 30 DAS as PoE | 1192 | 3077 | 4269 | 28.00 |
| | S.Em.$\pm$ | 84 | 201 | 273 | 0.74 |
| | C.D. at 5% | 241 | 580 | 790 | NS |

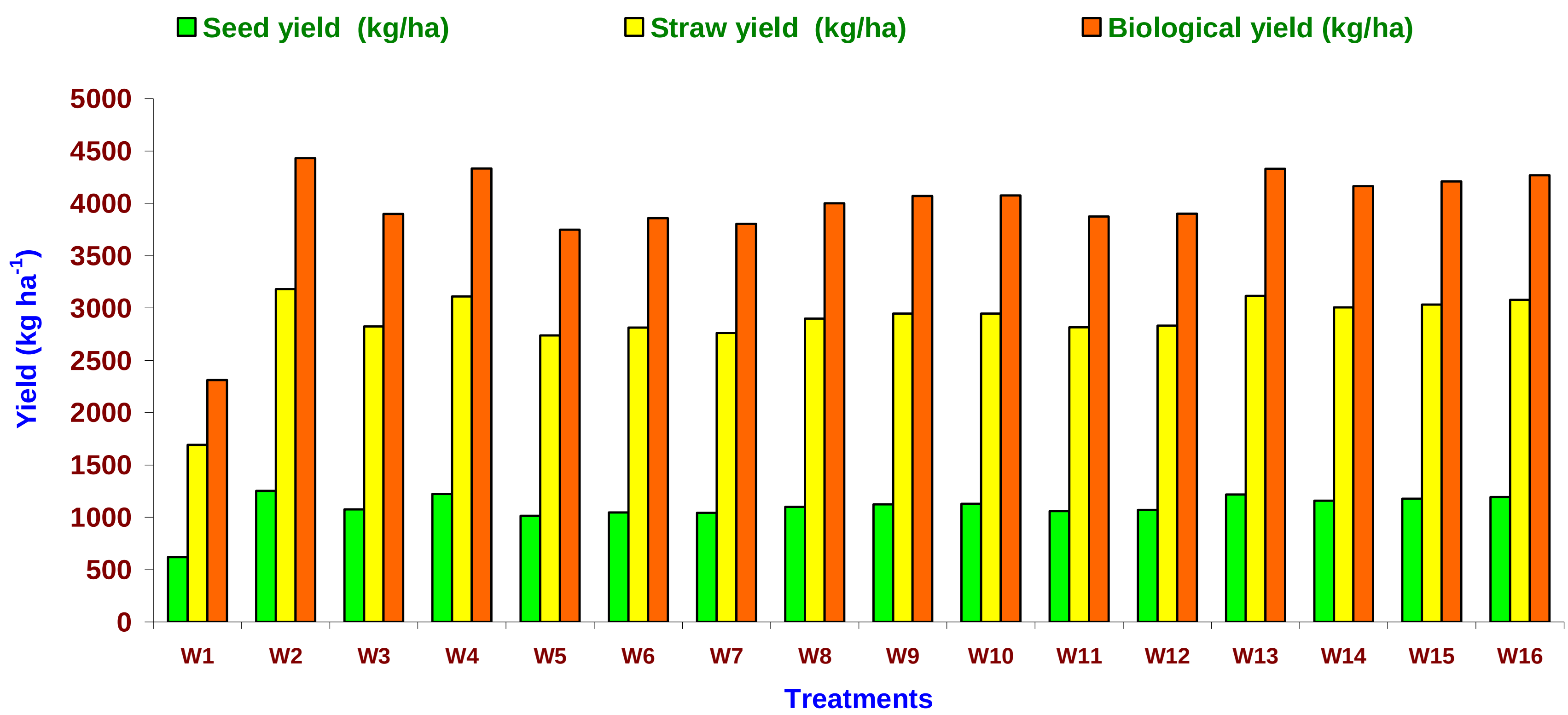



**Fig. 4.4 : Effect of weed control treatments on seed, straw and biological yields of green gram**

72.70, 71.08, 68.98, 68.34 and 63.65 per cent, respectively over weedy check.

### 4.2.2.5 Straw yield

A perusal of data (table 4.13) shows that straw yield differed significantly due to different weed control treatments. The highest straw yield was recorded under treatment weed free (3180 kg $ha^{-1}$). However, it remained statistically at par with all other treatments except weedy check. Weedy check recorded lowest straw yield (1691 kg $ha^{-1}$)

Among herbicide weed control treatments, the highest straw yield was obtained with pendimethalin 0.75 kg $ha^{-1}$ + hand weeding at 30 DAS followed by pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS. Integration of each herbicide with one hand weeding also effectively increased the straw yield compared to herbicides applied alone. The increase in straw yield due to weed free treatment, pendimethalin 0.75 kg $ha^{-1}$ + hand weeding at 30 DAS, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS was 88.05, 83.97, 84.15, 81.96 and 79.30 per cent, respectively over weedy check.

### 4.2.2.6 Biological yield

The results in table 4.13 showed that differed weed control treatments exerted their significant effect on the biological yield. The highest biological yield was recorded with treatment weed free (4432 kg ha$^{-1}$), which was found statistically at par with all other treatments except weedy check. The lowest biological yield was observed under weedy check (2310 kg ha$^{-1}$).

Among herbicide weed control treatments, the highest biological yield was obtained with pendimethalin 0.75 kg ha$^{-1}$ + hand weeding at 30 DAS followed by pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr @ 40 g ha$^{-1}$ at 30 DAS as PoE, pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr + imazamox @ 40 g ha$^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS. Integration of each herbicide with one hand weeding also effectively increased the biological yield compared to herbicides applied alone. The increase in biological yield due to weed free treatment, pendimethalin 0.75 kg ha$^{-1}$ alone, pendimethalin 0.75 kg ha$^{-1}$ + hand weeding at 30 DASand imazethapyr 60 g ha$^{-1}$+ hand weeding at 40 DAS at 40 DAS was 90.69, 83.49, 86.95 and 76.11 per cent, respectively over weedy check.

#### 4.2.2.7 Harvest index

It is explicit from data (table 4.13) that all weed control treatments did not exert their significance on harvest index.

### 4.2.3 Nutrient content and uptake studies

#### 4.2.3.1 Nutrient content in crop

##### 4.2.3.1.1 Nitrogen content

A perusal of data (table 4.14) reveals that nitrogen content in seed and straw of greengram recorded under the influence of all weed control treatments did not vary significantly.

**Table 4.14 : Effect of weed control treatments on nitrogen content of greengram**

| Treatments | | Nitrogen content of seed (%) | Nitrogen content of straw (%) |
|---|---|---|---|
| $W_1$ | Weedy check | 3.25 | 1.47 |
| $W_2$ | Weed free | 3.57 | 1.65 |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 3.35 | 1.54 |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 3.53 | 1.64 |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 3.28 | 1.50 |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 3.29 | 1.51 |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 3.30 | 1.52 |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 3.39 | 1.55 |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 3.40 | 1.57 |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 3.42 | 1.58 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 3.33 | 1.53 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 3.34 | 1.54 |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 3.52 | 1.63 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 3.46 | 1.61 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 3.47 | 1.61 |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 3.47 | 1.62 |
| | S.Em.$\pm$ | 0.10 | 0.06 |
| | C.D. at 5% | NS | NS |

#### 4.2.3.1.2 Phosphorus content

An assessment of data (table 4.15) indicates that all the weed control treatments did not have any significant effect on phosphorus content of seed and straw of greengram.

#### 4.2.3.1.3 Potassium content

An assessment of data (table 4.16) indicates that all the weed control treatments did not have any significant effect on potassium content of seed and straw of greengram.

### 4.2.3.2 Nutrient uptake by crop

#### 4.2.3.2.1 Nitrogen uptake

An appraisal of data (table 4.17) shows that all the weed control treatments recorded significant increase in nitrogen uptake by seed, straw as well as total N uptake by the crop compared to weedy check. The highest seed, straw as well as total N uptake (44.69, 52.46 and 97.16 kg $ha^{-1}$ respectively) was recorded under weed free treatment. The total N uptake by crop was statistically at par with all other weed control treatments except weedy check, imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE, imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE and imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE.

Data further reflect that among herbicide weed control treatments, the highest nitrogen uptake by crop with pendimethalin 0.75 kg $ha^{-1}$ + hand weeding at 30 DAS followed by pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand

**Table 4.15 : Effect of weed control treatments on phosphorus content of greengram**

| | Treatments | Phosphorus content of seed (%) | Phosphorus content of straw (%) |
|---|---|---|---|
| $W_1$ | Weedy check | 0.462 | 0.187 |
| $W_2$ | Weed free | 0.488 | 0.203 |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 0.469 | 0.194 |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 0.479 | 0.201 |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 0.465 | 0.188 |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 0.465 | 0.190 |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 0.466 | 0.190 |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.470 | 0.195 |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.470 | 0.195 |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.472 | 0.196 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 0.468 | 0.192 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 0.468 | 0.193 |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 0.478 | 0.202 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.474 | 0.198 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.475 | 0.199 |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 0.477 | 0.199 |
| | S.Em.± | 0.013 | 0.008 |
| | C.D. at 5% | NS | NS |

**Table 4.16 : Effect of weed control treatments on potassium content of greengram**

| | Treatments | Potassium content of seed (%) | Potassium content of straw (%) |
|---|---|---|---|
| $W_1$ | Weedy check | 1.17 | 2.31 |
| $W_2$ | Weed free | 1.33 | 2.45 |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 1.23 | 2.36 |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 1.31 | 2.43 |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 1.18 | 2.33 |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 1.19 | 2.34 |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 1.20 | 2.34 |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 1.25 | 2.37 |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 1.25 | 2.38 |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 1.26 | 2.39 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 1.20 | 2.35 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 1.21 | 2.35 |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 1.30 | 2.42 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 1.28 | 2.40 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 1.29 | 2.40 |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 1.29 | 2.41 |
| | S.Em.$\pm$ | 0.04 | 0.07 |
| | C.D. at 5% | NS | NS |

**Table 4.17 : Effect of weed control treatments on nitrogen uptake by crop**

| Treatments | | Nitrogen uptake ($kg\ ha^{-1}$) | | |
|---|---|---|---|---|
| | | Seed | Straw | Total |
| $W_1$ | Weedy check | 20.12 | 24.85 | 44.97 |
| $W_2$ | Weed free | 44.69 | 52.46 | 97.16 |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 35.97 | 43.48 | 79.46 |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 43.14 | 51.04 | 94.18 |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 33.09 | 41.07 | 74.16 |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 34.44 | 42.48 | 76.92 |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 34.37 | 42.04 | 76.40 |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 37.24 | 44.56 | 81.80 |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 38.17 | 46.11 | 84.28 |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 38.61 | 46.62 | 85.23 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 35.27 | 43.11 | 78.38 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 35.72 | 43.59 | 79.31 |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 42.78 | 51.22 | 94.00 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 40.30 | 48.31 | 88.61 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 41.29 | 49.13 | 90.42 |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 41.33 | 49.80 | 91.14 |
| | S.Em.$\pm$ | 3.24 | 3.78 | 6.60 |
| | C.D. at 5% | 9.36 | 10.92 | 19.07 |

weeding at 40 DAS. Integration of each herbicide with one hand weeding recorded also increase in nitrogen uptake by seed, straw and total N uptake by the crop compared to application of herbicides alone. Data further reveal that pendimethalin 0.75 kg $ha^{-1}$ + hand weeding at 30 DAS, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS were tended to increase total P uptake by the crop by 116.06, 109.43, 109.03,102.67 and 101.07 per cent, respectively over weedy check.

#### 4.2.3.2.2 Phosphorus uptake

The data presented in table 4.18 indicated that the crop was significantly influenced by different weed control treatments. The treatment weed free recorded significantly higher phosphorus uptake by seed, straw and total (6.11, 6.45 and 12.56 kg $ha^{-1}$). However, total phosphorus uptake remained at par with rest of the treatments under study except weedy check, imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE and imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE.

Among the herbicides, among herbicide weed control treatments, the highest phosphorus uptake by crop with pendimethalin 0.75 kg $ha^{-1}$ + hand weeding at 30 DAS followed by pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS. Integration of each herbicide with one hand weeding recorded also increase in nitrogen uptake by seed, straw and total phosphorus uptake by the crop compared to application of herbicides alone. Data further reveal that pendimethalin 0.75 kg $ha^{-1}$ + hand weeding

**Table 4.18: Effect of weed control treatments on phosphorus uptake by crop**

| | Treatments | Phosphorus uptake ($kg\ ha^{-1}$) | | |
|---|---|---|---|---|
| | | Seed | Straw | Total |
| $W_1$ | Weedy check | 2.86 | 3.16 | 6.02 |
| $W_2$ | Weed free | 6.11 | 6.45 | 12.56 |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 5.06 | 5.47 | 10.53 |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 5.85 | 6.25 | 12.10 |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 4.69 | 5.17 | 9.86 |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 4.87 | 5.35 | 10.21 |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 4.86 | 5.24 | 10.10 |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 5.18 | 5.66 | 10.84 |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 5.28 | 5.74 | 11.02 |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 5.33 | 5.79 | 11.12 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 4.90 | 5.41 | 10.31 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 5.01 | 5.47 | 10.47 |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 5.81 | 6.35 | 12.16 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 5.48 | 5.96 | 11.44 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 5.56 | 6.08 | 11.63 |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 5.69 | 6.13 | 11.82 |
| | S.Em.$\pm$ | 0.38 | 0.52 | 0.82 |
| | C.D. at 5% | 1.08 | 1.50 | 2.36 |

at 30 DAS, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS were tended to increase total P uptake by the crop by 108.64, 101.00, 101.99, 96.35 and 93.19 per cent, respectively over weedy check.

#### 4.2.3.2.3 Potassium uptake

An appraisal of data (table 4.19) shows that all the weed control treatments recorded significant increase in potassium uptake by seed, straw as well as total K uptake by the crop compared to weedy check. The highest seed, straw as well as total K uptake (7.24, 39.07 and 46.31 kg $ha^{-1}$, respectively) was recorded under weed free treatment. The total K uptake was found statistically at par with all other treatments except weedy check, imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE and imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE.

Among herbicide weed control treatments, the highest phosphorus uptake by crop with pendimethalin 0.75 kg $ha^{-1}$ + hand weeding at 30 DAS followed by pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS. Integration of each herbicide with one hand weeding recorded also increase in nitrogen uptake by seed, straw and total phosphorus uptake by the crop compared to application of herbicides alone. Data further reveal that pendimethalin 0.75 kg $ha^{-1}$ + hand weeding at 30 DAS, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 60 g $ha^{-1}$

**Table 4.19 : Effect of weed control treatments on potassium uptake by crop**

| | Treatments | Potassium uptake ($kg\ ha^{-1}$) | | |
|---|---|---|---|---|
| | | Seed | Straw | Total |
| $W_1$ | Weedy check | 7.24 | 39.07 | 46.31 |
| $W_2$ | Weed free | 16.65 | 77.91 | 94.56 |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 13.18 | 66.58 | 79.75 |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 16.00 | 75.59 | 91.59 |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 11.96 | 63.88 | 75.84 |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 12.46 | 65.87 | 78.33 |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 12.56 | 64.63 | 77.19 |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 13.78 | 68.23 | 82.01 |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 14.04 | 70.09 | 84.13 |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 14.23 | 70.50 | 84.73 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 12.63 | 66.26 | 78.90 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 12.93 | 66.53 | 79.46 |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 15.81 | 75.14 | 90.95 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 14.89 | 72.01 | 86.91 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 15.22 | 72.62 | 87.83 |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 15.37 | 73.91 | 89.28 |
| | S.Em.$\pm$ | 1.15 | 4.83 | 5.77 |
| | C.D. at 5% | 3.33 | 13.96 | 16.67 |

at 20 DAS as PoE + one hand weeding at 40 DAS were tended to increase total P uptake by the crop by 104.19, 97.78, 96.39, 92.79 and 89.66 per cent, respectively over weedy check.

### 4.2.3.3 Nutrient uptake by weeds

#### 4.2.3.3.1 Nitrogen uptake by weeds

An appraisal of data (table 4.20) reveals that all weed control treatments significantly reduced N uptake by broad leaved and grassy weeds as well as total N uptake by the weeds except weedy check. The nix N uptake by weeds was observed in weed free treatment, which was statistically at par with pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE and imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS and per cent reduction of total N uptake was 100, 99.87, 99.73, 99.55, 99.40, 99.37 and 99.24 per cent over weedy check (61.95 kg $ha^{-1}$).

#### 4.2.3.3.2 Phosphorus uptake by weeds

An appraisal of data (table 4.21) reveals that all weed control treatments significantly reduced P uptake by broad leaved and grassy weeds as well as total P uptake by the weeds except weedy check. Data shows that P uptake by weeds was observed in weed free treatment was nil, which remained at par with pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE,

**Table 4.20 : Effect of weed control treatments on nitrogen uptake by weeds**

| | Treatments | Nitrogen uptake ($kg\ ha^{-1}$) | | |
|---|---|---|---|---|
| | | **Broad leaved** | **Grassy** | **Total** |
| $W_1$ | Weedy check | 46.75 | 15.20 | 61.95 |
| $W_2$ | Weed free | 0.00 | 0.00 | 0.00 |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 8.40 | 0.28 | 8.68 |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 0.62 | 0.10 | 0.73 |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 1.29 | 5.44 | 6.73 |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 1.22 | 5.62 | 6.84 |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 1.16 | 5.69 | 6.85 |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.07 | 1.69 | 1.76 |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.02 | 1.33 | 1.36 |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.01 | 2.55 | 2.55 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 0.33 | 0.06 | 0.39 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 0.24 | 0.04 | 0.28 |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 0.18 | 0.19 | 0.37 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.07 | 0.40 | 0.47 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.02 | 0.15 | 0.17 |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 0.04 | 0.05 | 0.08 |
| | S.Em.$\pm$ | 0.26 | 0.11 | 0.22 |
| | C.D. at 5% | 0.75 | 0.33 | 0.62 |

**Table 4.21 : Effect of weed control treatments on phosphorus uptake by weeds**

| | Treatments | Phosphorus uptake ($kg\ ha^{-1}$) | | |
|---|---|---|---|---|
| | | Broad leaved | Grassy | Total |
| $W_1$ | Weedy check | 9.05 | 3.02 | 12.07 |
| $W_2$ | Weed free | 0.00 | 0.00 | 0.00 |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 1.62 | 0.05 | 1.68 |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 0.12 | 0.02 | 0.14 |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 0.25 | 1.08 | 1.33 |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 0.24 | 1.12 | 1.36 |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 0.22 | 1.01 | 1.24 |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.01 | 0.35 | 0.37 |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.01 | 0.28 | 0.29 |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.01 | 0.54 | 0.54 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 0.06 | 0.01 | 0.08 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 0.05 | 0.01 | 0.05 |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 0.04 | 0.04 | 0.07 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.01 | 0.08 | 0.10 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.01 | 0.03 | 0.04 |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 0.01 | 0.01 | 0.02 |
| | S.Em.$\pm$ | 0.05 | 0.02 | 0.04 |
| | C.D. at 5% | 0.14 | 0.06 | 0.12 |

pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE and imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS. The highest P uptake was observed under weedy check (12.07 kg $ha^{-1}$).

#### 4.2.3.3.3 Potassium uptake by weeds

An appraisal of data (table 4.22) reveals that all weed control treatments significantly reduced K uptake by broad leaved and grassy weeds as well as total K uptake by the weeds except weedy check. Data further reveal that zero K uptake by weeds was observed in weed free treatment. Next to weed free treatment total K uptake by the weeds was pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE and imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, which was statistically at par with weed free treatment. The highest potassium uptake was recorded under weedy check (51.30 kg $ha^{-1}$).

### 4.2.4 Quality

#### 4.2.4.1 Protein content

A perusal of data (table 4.23) reveals that protein content in seed of greengram recorded under the influence of all weed control treatments did not vary significantly.

**Table 4.22 : Effect of weed control treatments on potassium uptake by weeds**

| | Treatments | Potassium uptake ($kg\ ha^{-1}$) | | |
|---|---|---|---|---|
| | | Broad leaved | Grassy | Total |
| $W_1$ | Weedy check | 38.45 | 12.85 | 51.30 |
| $W_2$ | Weed free | 0.00 | 0.00 | 0.00 |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 6.78 | 0.23 | 7.01 |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 0.51 | 0.09 | 0.59 |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 1.05 | 4.55 | 5.60 |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 0.96 | 4.70 | 5.66 |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 0.91 | 4.22 | 5.13 |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.06 | 1.47 | 1.53 |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.04 | 1.17 | 1.21 |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.03 | 2.26 | 2.29 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 0.27 | 0.05 | 0.32 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 0.19 | 0.03 | 0.22 |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 0.15 | 0.16 | 0.31 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.06 | 0.34 | 0.40 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 0.04 | 0.13 | 0.17 |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 0.03 | 0.04 | 0.07 |
| | S.Em.$\pm$ | 0.13 | 0.10 | 0.22 |
| | C.D. at 5% | 0.38 | 0.30 | 0.64 |

**Table 4.23: Effect of weed control treatments on protein content of seed**

| Treatments | | Protein content in seed (%) |
|---|---|---|
| $W_1$ | Weedy check | 20.31 |
| $W_2$ | Weed free | 22.31 |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 20.94 |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 22.06 |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 20.50 |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 20.56 |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 20.63 |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 21.19 |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 21.25 |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 21.38 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 20.81 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 20.88 |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 22.00 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 21.63 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 21.69 |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 21.69 |
| | S.Em.$\pm$ | 0.58 |
| | C.D. at 5% | NS |

## 4.2.5 Economics

### 4.2.5.1 Net returns

Economic evaluation of different weed management treatments in greengram presented in table 4.24 indicates that the maximum net returns of ` 50102 $ha^{-1}$ was obtained with weed free treatment which was followed by ` 48108 $ha^{-1}$ with pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE. Data further reveal that among the weed control treatments except weedy check, minimum net return ` 37823 $ha^{-1}$ under imazethapyr 40 g $ha^{-1}$.

### 4.2.5.2 B:C ratio

Data presented in table 4.24 revealed that maximum benefit: cost ratio was obtained with weed free treatment (3.05) and the lowest benefit: cost ratio of 1.70 was recorded under weedy check. Data further reveal that among the weed control treatments except weedy check, minimum B: C ratio 2.67 was obtained with imazethapyr 40 g $ha^{-1}$.

## 4.3 Correlation and regression

Simple correlation and regression were worked out between seed yield, pods $plant^{-1}$, seeds $pod^{-1}$ and total N, P, K uptake. The correlation coefficient has been given in table 4.25.

Correlation coefficient study reveals that the yield was significantly and positively correlated with plant height, dry matter at harvest, pods $plant^{-1}$, seeds $pod^{-1}$, total N, P, K uptake. The corresponding values for correlation coefficient were 0.939, 0.989, 0.990, 0.990, 0.994, 0.998 and 0.999, respectively.

**Table 4.24 : Effect of weed control treatments on net returns and B:C ratio of greengram**

| | Treatments | Net returns (Rs. $ha^{-1}$) | B:C ratio |
|---|---|---|---|
| $W_1$ | Weedy check | 15188 | 1.70 |
| $W_2$ | Weed free | 50102 | 3.05 |
| $W_3$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE | 40704 | 2.74 |
| $W_4$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS | 47987 | 2.94 |
| $W_5$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE | 37823 | 2.67 |
| $W_6$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE | 39688 | 2.74 |
| $W_7$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE | 39318 | 2.72 |
| $W_8$ | Imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 41616 | 2.74 |
| $W_9$ | Imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 42884 | 2.78 |
| $W_{10}$ | Imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 43133 | 2.78 |
| $W_{11}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE | 40686 | 2.81 |
| $W_{12}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE | 41169 | 2.82 |
| $W_{13}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE | 48108 | 2.98 |
| $W_{14}$ | Imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 45191 | 2.90 |
| $W_{15}$ | Imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS | 46140 | 2.93 |
| $W_{16}$ | Pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE | 46864 | 2.94 |
| | S.Em.± | 3602 | 0.183 |
| | C.D. at 5% | 10404 | 0.53 |

The regression equation (table 4.25) showed that every unit increase in plant height, dry matter accumulation, pods $plant^{-1}$, seeds $pod^{-1}$, total nitrogen uptake, total phosphorus uptake and total potassium uptake increased the seed yield 0.02, 0.01, 0.01, 0.002, 0.08, 0.01 and 0.07 kg $ha^{-1}$, respectively.

**Table 4.25: Correlation coefficient and regression equation between dependent (y) and independent variables (x)**

| S.No. | Dependent (y) variables | Independent (x) Variables | r | Regression equation Y = a + b x |
|---|---|---|---|---|
| 1. | Seed yield (kg ha$^{-1}$) | Plant height (cm) | 0.938* | Y= 30.932 + 0.0273x |
| 2. | Seed yield (kg ha$^{-1}$) | DMA at harvest (g) | 0.989* | Y= 1.6012 + 0.0108x |
| 3. | Seed yield (kg ha$^{-1}$) | Pods plant$^{-1}$ | 0.990* | Y= 11.444+ 0.0134x |
| 4. | Seed yield (kg ha$^{-1}$) | Seeds pod$^{-1}$ | 0.990* | Y= 3.228 + 0.0022x |
| 5. | Seed yield (kg ha$^{-1}$) | Total N uptake by crop (kg ha$^{-1}$) | 0.994* | Y= - 9.1649 + 0.0836x |
| 6. | Seed yield (kg ha$^{-1}$) | Total P uptake by crop (kg ha$^{-1}$) | 0.998* | Y= - 0.5046 + 0.0103x |
| 7. | Seed yield (kg ha$^{-1}$) | Total K uptake by crop (kg ha$^{-1}$) | 0.999* | Y= - 0.9302 + 0.0756x |
| 8. | Seed yield (kg ha$^{-1}$) | Total weed density at harvest (No. m$^{-2}$) | -0.895* | Y= 135.93 - 0.1182x |
| 9. | Seed yield (kg ha$^{-1}$) | Total weed dry weight at harvest (g m$^{-2}$) | -0.922* | Y= 84.258 - 0.0727x |
| 10. | Seed yield (kg ha$^{-1}$) | Total N uptake by weeds (kg ha$^{-1}$) | -0.919* | Y= 110.77-0.0957x |
| 11. | Seed yield (kg ha$^{-1}$) | Total P uptake by weeds (kg ha$^{-1}$) | -0.918* | Y= 21.566-0.0186x |
| 12. | Seed yield (kg ha$^{-1}$) | Total K uptake by weeds (kg ha$^{-1}$) | -0.918* | Y= 18.976-0.0164x |
| 13. | Total weed density at harvest (No. m$^{-2}$) | Total weed dry weight at harvest (g m$^{-2}$) | 0.993* | Y= 0.9591+0.7226x |
| 14. | Total weed dry weight at harvest (g m$^{-2}$) | DMA at harvest (g) | -0.961* | Y= 14.038-0.133x |

* Significant at 1 % level of significance

# 5. DISCUSSION

During the course of presenting the results of field investigation entitled “Integrated Weed Management in Greengram [*Vigna radiata* (L.) Wilczek.] in Arid region” in preceding chapter, many significant variations in the criteria used for treatment evaluation were obtained under the influence of different treatments. In the present chapter, efforts have been made to ascertain cause and effect of relationship among the various parameters found significant on greengram productivity were studied and the important data pertaining to the effects of different treatments have also been presented in this chapter through suitable graph. Wherever felt necessary, experimental findings or observation of other workers on the same crop or family have been cited to support the results of present experiment.

## 5.1 Effects of weed control measures

### 5.1.1. Effect on weed density and dry weight

The results revealed that all the weed management treatments significantly reduced the density of both broad leaved and grassy weeds (table 4.1, 4.2, 4.3 and fig. 4.1) and their dry weight (table 4.4, 4.5, 4.6 and fig. 4.2) at all the stages of observations compared to weedy check.

At 30 DAS, weed free treatment recorded significantly lowest number of total weeds and dry weight followed by imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS and imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE and which were at par with each other in weed density. While treatment weedy check registered significantly higher number of total weeds. This might be due to effective control of weeds either by manual weeding or herbicides or integrated approach. Moreover, dense crop canopy might have smothering effect on weeds. At 30 DAS more reduction in both density and dry weight of grassy weeds with application of imazethapyr+imazamox was might be due to the more effectiveness of imazamox against grassy weeds.

At 60 DAS as well as at harvest, weed free treatment was found effectively superior to rest of the treatments and at par with pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE and imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE in controlling the density and dry weight of weeds and among herbicides the performance of herbicidal (all levels of imazethapyr and pendimethalin) treatment along with one hand weeding were found superior over application of herbicide alone with respect to both density and dry weight of broad leaved, grassy and total weeds. In case of application of imazethapyr + imazamox at all levels shows equal effect on weed density and weed dry weight with or without hand weeding (table 4.1 to 4.6).

Data for weed density in undisturbed environment of weedy check indicated that in general, density of broad leaved weeds was more dominating at 30, 60 days and harvest stage of observations representing their square root transformed values as 6.11, 6.42 and 5.80 per 0.25 $m^{-2}$, respectively as against the total weed density of 8.10, 8.84 and 8.14 (table 4.1, 4.2 and 4.3) under weedy check. The dry weight of broad leaved weeds (table 4.4, 4.5 and 4.6) also indicated the same trend as that of weeds density at 30, 60 DAS and at harvest.

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

Weed density (table 4.1, 4.2, 4.3 and fig. 4.1 ) and weed dry weight (table 4.2 and fig. 4.2) indicated that pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE and imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE performed very well in controlling all the categories of weeds.

Pendimethalin is a versatile pre-emergence herbicide, rapidly absorbed by germinating weeds and inhibit both cell division and cell elongation in the root and shoot meristems of the susceptible plants. The growth is inhibited directly following absorbing through hypocotyls and shoot region. The plants die shortly after germination or emergence from the soil (Gupta, 2008). The present results are in close accordance with finding of Singh *et al*. (1995), Malik *et al.* (2005), Kohli *et al.* (2006), Yadav *et al.* (2011).

Imazethapyr and imazethapyr+imazamox are selective and applied as post emergence with a view to control late emerging weeds. It inhibits the plastid enzyme acetolactate syntheses (ALS) in plants which catalyses the first step in the biosynthesis of essential branched chain amino acids (Valine, leucine, isoleucine). The ALS inhibitors thus stop cell division and reduce carbohydrate translocation in the susceptible plants. Saltoni *et al.* (2004) have suggested that imazethapyr and imazethapyr+imazamox are imidazolinones herbicide, which are absorbed both by the roots and the shoots. These can effectively control a broad spectrum of weeds. Results corroborate with the findings of Rao and Rao (2003), Rani *et al.* (2004) and Sasikala *et al.* (2007).

### 5.1.2 Nutrients uptake by weeds

The data in table 4.20, 4.21, 4.22 reveal that N, P and K uptake by weeds almost followed the footsteps of weed biomass in trend. It was found that all weed control treatments significantly reduced the N, P and K uptake both by the individual weed categories and total weeds at harvest. The nil uptake of N, P and K by weeds was recorded with weed free which was at par with pendimethalin @ 0.75 kg ha$^{-1}$ as PE +imazethapyr + imazamox @ 40 g ha$^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 40 g ha$^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr @ 40 g ha$^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g ha$^{-1}$ at 20 DAS as PoE and imazethapyr + imazamox @ 40 g ha$^{-1}$ at 20 DAS as PoE during the experimentation. Nutrient uptake is the product of per cent nutrient content and biomass, thus similarity in the trend of uptake and total weed biomass production was an expected outcome. It can also be explained in the light of the facts that these treatments controlled the weeds effectively, might have made more nutrients available to crop and consequently encouraged higher concentration of nutrients and more yield and thereby higher uptake of nutrients by crop. Reduced nutrient uptake by weeds under the influence of different weed control measures had been also reported by Chhokar *et al*. (1995), Gaikwad and Pawar (2003), Chhodavadia *et al.* (2013) and Kavita *et al.* (2014).

### 5.1.3 Weed control efficiency and weed index

A perusal of data presented in table 4.7 indicates that besides weed free treatment, treatments pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS and imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS recorded lower weed index 4.79, 6.07, 7.51 and 9.82 and higher weed control efficiency 99.85, 99.78, 99.58 and 98.56 per cent. This might be due to elimination of weeds by manual weeding and interculturing or by herbicides. The integrated effect on dry weight of weeds and seed yield under these treatments might have been responsible for excellent weed indices. These findings are akin to report of Bhandari *et al.* (2004).

### 5.1.2. Effect on crop

#### 5.1.2.1 Growth parameters

All weed management practices adopted during the experimentation resulted in significant increase in growth parameters like plant height, branches per plant, dry weight of nodules at 50 DAS and periodical dry matter production (table 4.9, 4.10 and 4.11) of greengram at successive stages *viz.*, 30, 60 DAS and at harvest compared to weedy check. Dry matter accumulation of greengram is determined by the ability of greengram canopy to absorb incidence photosynthetic phyton flux density (PPFD) which is a function of canopy extinction coefficient and shading of greengram canopy by weeds in crop weed mixtures. The maximum dry matter accumulation was observed with weed free treatment which was at par with rest of the herbicidal treatments and proved their superiority over weedy check. This was attributed to their higher weed control efficiency (table 4.7) which proved favourable environment for growth of the crop. This can be further explained in terms of negative correlation between total weed dry weight and crop dry matter at harvest with the respective values of r = - 0.961 (table 4.25). Results so obtained are in close conformity with the finding of Gupta *et al.* (1991), Reager *et al.* (2003), Kumar *et al.* (2006) and Singh *et al.* (2014).

The higher values of growth parameters i.e plant height, number of branches per plant and dry weight of nodules at 50 DAS under treatments weed free, which was at par with other weed control treatments except weedy check were mainly ascribed to better control of weeds through hand weeding and interculturing along with herbicides application as evidence by weed density (table 4.1, 4.2 and 4.3) and dry weight of weeds (table 4.4, 4.5 and 4.6). This might have resulted in better availability of moisture and nutrients to the crop in absence of weeds. Moreover increased nutrient and water uptake by crop, which could be increased photosynthate which supply more carbohydrates, resulted in increase cell division and elongation of cells resulted to increase plant height and number of branches.

The lowest values of growth parameters *viz.,* plant height, dry weight of nodules and number of branches per plant under treatment weedy check might be due to severe competition by weeds for resources, which made the crop plant inefficient to take up more moisture, nutrients and ultimately growth was adversely affected due to less supply of carbohydrates. Similar findings was observed by Panwar *et al.* (1982), Singh and Chaudhary (1992), Shaikh *et al.* (2002) and Malliswari *et al.* (2008).

### 5.1.2.2 Yield attributes and yield

The yield attributing characters *viz*. pods plant$^{-1}$ and seeds pod$^{-1}$ were significantly improved under various weed control treatments as compared to weedy check (table 4.12) and the effect was more pronounced with weed free treatment closely followed by rest of the weed control treatments. This was attributed to minimum infestation of weeds (table 4.1, 4.2 and 4.3) together with lesser competition for other growth resources i.e. light, space, water and nutrients. Thus, reduced crop-weed competition resulted into overall improvement in crop growth as reflected by plant height and dry matter accumulation (table 4.9 and 4.11) consequently resulted into better development of reproductive structure and translocation of photosynthates to the sink. The results corroborate with the findings of Singh *et al.* (1994), Kumar *et al*. (2003), Singh *et al.* (2006) and Yadav *et al.* (2014).

It is evident from results (table 4.13) that significant superiority of weed free treatment over all weed control methods significantly enhanced yield components *viz.,* pods plant$^{-1}$ and seeds pod$^{-1}$ with concomitant increased in seed, straw and biological yield. The extents of increase in seed, straw and biological yield of greengram were by 102.26, 88.05 and 90.69 per cent under weed free treatment respectively compared to weedy check.

It is an established fact that least crop weed competition during critical phase of crop growth exerts an important regulation function on complex process of yield formation due to better availability of water, space and nutrients to the crop plant. It also helps in improving aeration and nutrient uptake by plant resulting in higher metabolic activity (Lalitha Bai and Sinha, 1993). In preceding section it was, well emphasized that reduced crop-weed competition under weed free treatment as well as other herbicides, markedly influenced 'source' by virtue of higher photosynthetic and metabolic activity which in turn improved growth of crop and consequently yield components. The adverse effect of weed competition under present investigation is clearly reflected under weedy check, wherein dense population of weeds reduced crop growth *viz.*, dry matter accumulation compared to weed free treatment as well as other treatments. Thus ultimately reduced yield components i.e., pods plant$^{-1}$ and seeds pods$^{-1}$. Nutrient stress caused by weeds might have also affected the seed bearing capacity of each pod. Not only this, but even normally stable components like test weight was also adversely affected by weeds under weedy check (table 4.12). Thus, the weeds were able to adversely affect vegetative as well as reproductive parts of crop plant ultimately crop yield.

The reduced crop weed competition caused significant increase in growth characters and yield ultimately led to higher seed yield of greengram. The significant improvement in seed yield as a result of weed free treatment and all herbicidal weed control treatments could be ascribed to the fact that yield of crop depends on several yield components which are interrelated. Under present investigation existence of high positive correlation between pods plant$^{-1}$ and seed pods$^{-1}$ on seed yield (r=0.990 and 0.990, respectively) also validate the aforesaid statement. Similarly, total weed dry weight at harvest was also negatively correlated with seed yield (r= -0.922) (table 4.25). Under weedy situation, at early crop growth stage a greater part of resources present in soil and environment are depleted by weeds for their growth. The crop plant thus, faced stress which ultimately affected their growth, development and yield. Similar results were also reported by Bhadoria et al. (2000), Raskar and Bhoi (2002), Sumachandrika *et al.* (2003) and Upadhayay *et al.* (2013).

Alike seed yield, straw yield was also significantly increased under various treatments of weed management during the experimentation over weedy check. Increase in straw yield might be due to the direct influence of various weed management treatments on the suppression of weeds. Thus, crop weed competition resulted into increased plant height, dry matter accumulation (table 4.9 and 4.11) and nutrient uptake. The results so obtained for straw corroborate with the findings of Kumar *et al*. (2003), Mishra and Chandrabhanu (2006) and Tiwari *et al*. (2014).

Biological yield is a function of seed and straw yield. Thus, significant increase in biological yield with various weed management treatments could be ascribed to the increased seed and straw yield (table 4.10).

Among herbicides, pendimethalin proved efficient for controlling weeds which was found marginally superior to imazethapyr and imazethapyr + imazamox in terms of seed and biological yield (table 4.10). This seems to be on account of its activity due to continuous retention of moisture in soil by rainfall during beginning of crop season (table 3.1) because it was applied as surface application instead of incorporation. The results corroborate with the findings of Sumachandrika *et al*. (2003), Guriqbal (2005) and Yadav *et al.* (2011).

### 5.1.2.3 Nutrient content and uptake

All the weed control measures tended to improve the uptake of nitrogen, phosphorus and potassium by seed and straw significantly compared to weedy check (table 4.17, 4.18 and 4.19). The highest N, P and K uptake by the crop was recorded with weed free treatment closely followed by all other weed control treatments which might be ascribed to higher yield with these treatments (table 4.13). As nutrient uptake by crop is primarily a function of yield and nutrient content. Thus, higher uptake by crop may be due to decreased crop weed competition had concurrently increased in nutrient availability, better crop growth and higher crop biomass production coupled with more nutrient content. In persent study, strong positive correlation was documented between seed yield and their N, P and K uptake with the corrosponding ’r’ values as 0.994, 0.998 and 0.999 respectively, further substantiate the fact. These results are in agreement with the findings of Gaikwad and Pawar (2003), Singh *et al*. (2006) and Kavita *et al*. (2014).

### 5.1.2.4 Economics

A perusal data presented in table 4.24 revealed that maximum net returns of ` 50102 $ha^{-1}$ was realized under the weed free treatment and it was closely followed by pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr @ 40 g ha$^{-1}$ at 30 DAS as PoE, pendimethalin @ 0.75 kg ha$^{-1}$ as PE + one hand weeding at 30 DAS and pendimethalin @ 0.75 kg ha$^{-1}$ as PE +imazethapyr + imazamox @ 40 g ha$^{-1}$ at 30 DAS as PoE which recorded net return of ` 48108, 47987 and 46864 ha$^{-1}$, respectively. The higher seed yield recorded with this treatment might be responsible for higher net returns.

The maximum B:C ratio (3.05) was accrued under weed free treatment followed by weed free and pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr @ 40 g ha$^{-1}$ at 30 DAS as PoE values. These findings are in close vicinity with those reported by Sukhadia *et al.* (2000), Sardana *et al.* (2006), Upadhyay *et al.* (2012), Kalhapure *et al.* (2013) and Yadav *et al.* (2014).

# 6. SUMMARY AND CONCLUSION

The results of field experiment entitled "Integrated Weed Management in Greengram [*Vigna radiata* (L.) Wilczek] in Arid Region" were presented and discussed in the preceeding chapter are summarized below:

## 6.1 Effect of weed control measures

### 6.1.1 Weed studies

#### 6.1.1.1 Weed growth

- In weedy check plots, greengram was heavily infested with mixed flora of broad leaved and grassy weeds chiefly consisted of *Amaranthus spinosus* L., *Digera arvensis* L., Tri*anthema portulacastrum* L., *Gisekia poredious* L., *Euphorbia hirta* L., *Aristida depressa* L., *Portulaca oleracea* L., *Cenchrus biflorus* L., *Cleome viscosa* L., *Tribulus terrestris* L., *Corchorus tridense* L., *Cyperus rotundus* L., *Eleusine verticillata* L., *Eragrastris tennela* L. and *Aerva tomentosa* L..
- Weed free treatment recorded the none weed density at 60 DAS. It accounted for 88.94, 88.40 and 91.97 per cent reduction in the density of broad leaved, grassy and total weeds than that of weedy check respectively.
- All the weed control treatments significantly reduced dry weight of broad leaved, grassy and total weeds at harvest over weedy check. The nil dry weight of broad leaved, grassy and total weeds was recorded under weed free treatment, while the respective values for these parameters under weedy check were 33.88, 13.04 and 46.92 g $m^{-2}$.
- At 60 DAS, maximum weed control efficiency was observed with weed free treatment (100%) followed by pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE and imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE +

one hand weeding at 40 DAS, with the respective values of 99.85 and 99.78. Among the herbicides the lowest total weed control efficiency of 93.83 per cent was recorded with application of imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE.

- The lowest weed index was recorded under pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS (2.40%).

**6.1.1.2 Nutrient uptake**

- Significant decrease in total N, P and K uptake by weeds were recorded due to all weed management practices over weedy check. The nil uptake of N, P and K by weeds was recorded with weed free which was at par with pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE and imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE.

### 6.1.2 Crop

### 6.1.2.1 Growth attributes

- All weed control measures caused non-significant effect on the plant stand at 20 DAS and at harvest compared to weedy check and all other treatments.
- All weed management practices were found effective in enhancing plant height at 60 DAS as well as at harvest, branches per plant at harvest and dry weight of nodules at 50 DAS of greengram and it was highest with weed free treatment compared to weedy check.
- The dry matter accumulation by the crop was significantly increased with all the weed management treatments over weedy check with 30, 60 DAS and at harvest. The maximum dry matter accumulation at 30, 60 DAS and at harvest were with weed free treatment with

the corresponding increase of 68.42, 92.64 and 87.22 per cent compared to weedy check.

#### 6.1.2.2 Yield attributes and yield

- Yield attributing characters *viz*. pods plant$^{-1}$ and seeds pod$^{-1}$ were favorably and significantly influenced by all weed management practices compared to weedy check but test weight was not affected by all weed control treatments. Among all weed control treatments, weed free treatment recorded highest which was found statistically at par with all remaining treatments except weedy check.
- All weed management practices significantly enhanced seed yield over weedy check. There was no significant difference between seed yield with all of the treatments except weedy check. Weed free treatment produced the highest seed yield (1252 kg ha$^{-1}$ ) followed by pendimethalin 0.75 kg ha$^{-1}$ + one hand weeding 30 DAS (1222 kg ha$^{-1}$) while it was minimum under weedy check (619 kg ha$^{-1}$).
- The straw yield during experimentation was significantly increased with all the treatments of weed control. The highest straw yield obtained with weed free treatment (3180 kg ha$^{-1}$) was closely followed by pendimethalin @ 0.75 kg ha$^{-1}$ as PE + imazethapyr @ 40 g ha$^{-1}$ at 30 DAS as PoE with per cent increase of 88.05 and 84.15, respectively over weedy check (1691 kg ha$^{-1}$).
- The biological yield increased significantly by various weed control treatments. Among treatments, weed free treatment (4432 kg ha$^{-1}$) gave better results being at par with other remaining treatments except weedy check.
- The harvest index was not affected by all weed control treatments.

#### 6.1.2.3 Nutrient content, uptake and quality

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

- All weed control treatments significantly increased N, P and K uptake by seed and straw of greengram over weedy check. Weed free treatment resulted in significantly highest total uptake of N (97.16 kg $ha^{-1}$), P (12.56 kg $ha^{-1}$) and K (94.56 kg $ha^{-1}$) by the crop compared to weedy check (44.97, 12.56 and 94.56 kg $ha^{-1}$), respectively.
- Protein content of seed in greengram was not affected with any weed management practices.

### 6.1.2.4 Economics

- The maximum net returns (` 50102 $ha^{-1}$) and B:C ratio (3.05) were obtained with weed free treatment followed by ` 48108 $ha^{-1}$ and 2.98 with Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE.

## CONCLUSION

It is concluded that all weed control treatments are almost equally important in controlling weeds and improving crop yield. Weed free treatment was superior most with respect to yield (1252 kg $ha^{-1}$), yield attributes, quality, net profit (` 50102 $ha^{-1}$) and B: C ratio (3.05). The next best treatment was Pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE with respect to net returns (` 48108 $ha^{-1}$) and B:C ratio (2.98)

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

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# Integrated Weed Management in Greengram [*Vigna radiata* (L.) Wilczek.] in Arid Region

**Komal Kataria*** **(Scholar)**

**Dr. S.P. Singh**** **(Major Advisor)**

**ABSTRACT**

A field experiment entitled "Integrated Weed Management in Greengram [*Vigna radiata* (L.) Wilczek.] in Arid Region" was conducted at Agronomy Farm of Agriculture Research Station, S.K. Rajasthan Agricultural University, Bikaner during *kharif* season of 2013. Sixteen weed control treatments *viz.,* weedy check, weed free, pendimethalin @ 0.75 kg $ha^{-1}$ as PE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + one hand weeding at 30 DAS, imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE, imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE, imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE, imazethapyr @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr @ 50 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE, pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE, imazethapyr + imazamox @ 40 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS, imazethapyr + imazamox @ 60 g $ha^{-1}$ at 20 DAS as PoE + one hand weeding at 40 DAS and pendimethalin @ 0.75 kg $ha^{-1}$ as PE +imazethapyr + imazamox @ 40 g $ha^{-1}$ at 30 DAS as PoE were conducted in randomized block design with three replications.

The results revealed that weed free treatment brought about the maximum reduction in weed density, weed dry weight and nutrient uptake by weeds at harvest. The higher weed control efficiency was also obtained in this treatment which resulted in improvement of growth parameters viz., plant height, branches $plant^{-1}$, dry matter accumulation and yield attributing characters i.e. pods $plant^{-1}$, seeds $pod^{-1}$, and consequently increased the seed yield, net returns and B: C ratio compared to weedy check. Amongst the herbicidal treatments, maximum seed yield was obtained with pendimethalin 0.75 kg $ha^{-1}$ + one hand weeding 30 DAS (1222 kg $ha^{-1}$) while maximum net returns and B:C ratio was obtained with pendimethalin @ 0.75 kg $ha^{-1}$ as PE + imazethapyr @ 40 g $ha^{-1}$ at 30 DAS as PoE.

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# Appendices

**Appendix – I**

**Analysis of variance (MSS) for weed control treatments on weed density at 30 DAS of green gram**

| Analysis of variance | df | Weed density (No. $m^{-2}$) | | |
|---|---|---|---|---|
| | | Broad leaved | Grassy | Total |
| Replications | 2 | 0.001 | 0.001 | 0.0003 |
| Treatments | 15 | 5.31** | 3.81** | 8.45** |
| Error | 30 | 0.033 | 0.026 | 0.04 |

**significant at 1 per cent level of significance

**Appendix – II**

**Analysis of variance (MSS) for weed control treatments on weed density at 60 DAS of green gram**

| Analysis of variance | df | Weed density (No. $m^{-2}$) | | |
|---|---|---|---|---|
| | | Broad leaved | Grassy | Total |
| Replications | 2 | 0.036 | 0.024 | 0.024 |
| Treatments | 15 | 6.27** | 5.28** | 11.76** |
| Error | 30 | 0.019 | 0.014 | 0.025 |

**significant at 1 per cent level of significance

**Appendix – III**

**Analysis of variance (MSS) for weed control treatments on weed density at harvest of green gram**

| Analysis of variance | df | Weed density (No. $m^{-2}$) | | |
|---|---|---|---|---|
| | | Broad leaved | Grassy | Total |
| Replications | 2 | 0.007 | 0.01 | 0.001 |
| Treatments | 15 | 5.06** | 4.59** | 9.95** |
| Error | 30 | 0.007 | 0.024 | 0.011 |

**significant at 1 per cent level of significance

**Appendix – IV**

**Analysis of variance (MSS) for weed control treatments on weed dry weight at 30 DAS of green gram**

| Analysis of variance | df | Weed dry weight (g $m^{-2}$) | | |
|---|---|---|---|---|
| | | Broad leaved | Grassy | Total |
| Replications | 2 | 0.601 | 0.003 | 0.09 |
| Treatments | 15 | 246.51** | 10.27** | 348.04** |
| Error | 30 | 0.321 | 0.011 | 0.153 |

**significant at 1 per cent level of significance

**Appendix – V**

**Analysis of variance (MSS) for weed control treatments on weed dry weight at 60 DAS of green gram**

| Analysis of variance | df | Weed dry weight (g $m^{-2}$) | | |
|---|---|---|---|---|
| | | Broad leaved | Grassy | Total |
| Replications | 2 | 0.044 | 0.064 | 0.072 |
| Treatments | 15 | 320.02** | 47.18** | 568.12** |
| Error | 30 | 0.18 | 0.042 | 0.096 |

**significant at 1 per cent level of significance

**Appendix – VI**

**Analysis of variance (MSS) for weed control treatments on weed dry weight at harveest of green gram**

| Analysis of variance | df | Weed dry weight (g $m^{-2}$) | | |
|---|---|---|---|---|
| | | Broad leaved | Grassy | Total |
| Replications | 2 | 0.078 | 0.01 | 0.034 |
| Treatments | 15 | 213.54** | 35.62** | 395.32** |
| Error | 30 | 0.105 | 0.028 | 0.072 |

**significant at 1 per cent level of significance

**Appendix – VII**

**Analysis of variance (MSS) for weed control treatments on plant stand of greengram**

| Analysis of variance | df | Plant stand (lac $ha^{-1}$) | |
|---|---|---|---|
| | | 20 DAS | At harvest |
| Replications | 2 | 0.01 | 0.04 |
| Treatments | 15 | 0.004 | 0.001 |
| Error | 30 | 0.04 | 0.07 |

**Appendix – VIII**

**Analysis of variance (MSS) for weed control treatments on plant height of greengram**

| Analysis of variance | df | Plant height (cm) | | |
|---|---|---|---|---|
| | | 30 DAS | 60 DAS | At harvest |
| Replications | 2 | 8.7 | 1.38 | 0.05 |
| Treatments | 15 | 11.36 | 10.21* | 53.85* |
| Error | 30 | 6.42 | 4.95 | 19.68 |

*significant at 5 per cent level of significance

**Appendix – IX**

**Analysis of variance (MSS) for weed control treatments on branches plant$^{-1}$ and dry weight of nodules of greengram**

| Analysis of variance | df | Branches plant$^{-1}$ | Dry weight of nodules at 50 DAS (mg plant$^{-1}$) |
|---|---|---|---|
| Replications | 2 | 0.01 | 6.37 |
| Treatments | 15 | 0.25** | 12.16** |
| Error | 30 | 0.09 | 3.34 |

**significant at 1 per cent level of significance

**Appendix – X**

**Analysis of variance (MSS) for weed control treatments on dry matter accumulation of greengram**

| Analysis of variance | df | Dry matter accumulation (g plant$^{-1}$) | | |
|---|---|---|---|---|
| | | 30 DAS | 60 DAS | At harvest |
| Replications | 2 | 0.0001 | 0.97 | 0.59 |
| Treatments | 15 | 0.0028* | 1.6* | 7.58** |
| Error | 30 | 0.0013 | 0.68 | 2.47 |

*and **significant at 5 and 1 per cent level of significance, respectively

**Appendix – XI**

**Analysis of variance (MSS) for weed control treatments on yield attributes of greengram**

| Analysis of variance | df | Pods plant$^{-1}$ (No.) | Seeds pod$^{-1}$ (No.) | Test weight (g) |
|---|---|---|---|---|
| Replications | 2 | 0.19 | 0.10 | 0.02 |
| Treatments | 15 | 11.65** | 0.32** | 0.2 |
| Error | 30 | 3.77 | 0.09 | 1.66 |

**significant at 1 per cent level of significance

**Appendix – XII**

**Analysis of variance (MSS) for weed control treatments on yields and harvest index of greengram**

| Analysis of variance | df | Seed yield (kg ha$^{-1}$) | Straw yield (kg ha$^{-1}$) | Biological yield (kg ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|---|---|
| Replications | 2 | 11772.25 | 81696.83 | 121682.76 | 1.12 |
| Treatments | 15 | 63623.4** | 348414.36** | 707938.96** | 0.58 |
| Error | 30 | 20917.58 | 121012.1 | 224352.44 | 1.62 |

**significant at 1 per cent level of significance

**Appendix – XIII**

**Analysis of variance (MSS) for weed control treatments on nitrogen, phosphorus and potassium content of greengram**

| Analysis of variance | df | Nitrogen content (%) | | Phosphorus content (%) | | Potassium content (%) | |
|---|---|---|---|---|---|---|---|
| | | Seed | Straw | Seed | Straw | Seed | Straw |
| Replications | 2 | 0.01 | 0.0005 | 0.0001 | 0.00002 | 0.003 | 0.002 |
| Treatments | 15 | 0.03 | 0.01 | 0.0001 | 0.0001 | 0.008 | 0.005 |
| Error | 30 | 0.03 | 0.01 | 0.0005 | 0.0002 | 0.005 | 0.014 |

**Appendix – XIV**

**Analysis of variance (MSS) for weed control treatments on nitrogen uptake by crop**

| Analysis of variance | df | Nitrogen uptake (kg ha$^{-1}$) | | |
|---|---|---|---|---|
| | | Seed | Straw | Total |
| Replications | 2 | 14.31 | 16.64 | 60.36 |
| Treatments | 15 | 100.09** | 126.06** | 450.16** |
| Error | 30 | 31.48 | 42.91 | 130.79 |

*and **significant at 5 and 1 per cent level of significance, respectively

**Appendix – XV**

**Analysis of variance (MSS) for weed control treatments on phosphorus uptake by crop**

| Analysis of variance | df | Phosphorus uptake (kg ha$^{-1}$) | | |
|---|---|---|---|---|
| | | Seed | Straw | Total |
| Replications | 2 | 0.3 | 0.44 | 1.48 |
| Treatments | 15 | 1.63** | 1.76* | 6.77** |
| Error | 30 | 0.42 | 0.81 | 2 |

*significant at 5 per cent level of significance

**Appendix – XVI**

**Analysis of variance (MSS) for weed control treatments on potassium uptake by crop**

| Analysis of variance | df | Potassium uptake (kg ha$^{-1}$) | | |
|---|---|---|---|---|
| | | Seed | Straw | Total |
| Replications | 2 | 2.05 | 30.06 | 46.4 |
| Treatments | 15 | 14.99** | 233.39** | 364.25** |
| Error | 30 | 3.99 | 70.04 | 99.88 |

**significant at 1 per cent level of significance

**Appendix – XVII**

**Analysis of variance (MSS) for weed control treatments on nitrogen uptake by weeds**

| Analysis of variance | df | Nitrogen uptake (kg ha$^{-1}$) | | |
|---|---|---|---|---|
| | | Broad leaved | Grassy | Total |
| Replications | 2 | 0.149 | 0.016 | 0.076 |
| Treatments | 15 | 406.67** | 48.4** | 689.98** |
| Error | 30 | 0.2 | 0.038 | 0.14 |

**significant at 1 per cent level of significance

**Appendix – XVIII**

**Analysis of variance (MSS) for weed control treatments on phosphorus uptake by weeds**

| Analysis of variance | df | Phosphorus uptake (kg ha$^{-1}$) | | |
|---|---|---|---|---|
| | | Broad leaved | Grassy | Total |
| Replications | 2 | 0.006 | 0.0006 | 0.003 |
| Treatments | 15 | 15.22** | 1.89** | 26.15** |
| Error | 30 | 0.007 | 0.0015 | 0.005 |

**significant at 1 per cent level of significance

**Appendix – XIX**

**Analysis of variance (MSS) for weed control treatments on potassium uptake by weeds**

| Analysis of variance | df | Potassium uptake (kg ha$^{-1}$) | | |
|---|---|---|---|---|
| | | Broad leaved | Grassy | Total |
| Replications | 2 | 0.033 | 0.00463 | 0.033 |
| Treatments | 15 | 274.83** | 33.88** | 472.33** |
| Error | 30 | 0.05 | 0.03 | 0.15 |

**significant at 1 per cent level of significance

**Appendix – XX**

**Analysis of variance (MSS) for weed control treatments on protein content, net returns and B:C ratio of greengram**

| Analysis of variance | df | Protein content in seed (%) | Net returns (Rs. ha$^{-1}$) | B:C ratio |
|---|---|---|---|---|
| Replications | 2 | 0.43 | 26151497.23 | 0.05 |
| Treatments | 15 | 1.12 | 188626582.4** | 0.28** |
| Error | 30 | 1.01 | 38926852.16 | 0.1 |

**significant at 1 per cent level of significance

**Appendix-XXI**

**Cost of cultivation of greengram**

| S.No. | Particulars of operation | Cost ( ` ha-1) | Inputs | Rate/unit (`) |
|---|---|---|---|---|
| 1. | Field preparation | | | |
| | i. Ploughing by disc plough (one before onset of monsoon) | 1500.00 | Tractor drawn disc harrow | ` 1500.00 ha$^{-1}$ |
| | ii. Ploughing by harrow (after onset of monsoon) and planking | 1200.00 | Tractor drawn disc harrow | ` 1200.00 ha$^{-1}$ |
| | iii. Layout and preparation of beds | 664.00 | Tractor charges for lifting and sowing | 1200.00 ` ha$^{-1}$ |
| 2. | Seed (20 kg ha-1) | 1800.00 | Seed rate | ` 90.00 kg$^{-1}$ |
| 3. | Seed treatment | 60.00 | 40 g | ` 1.5 g$^{-1}$ |
| 4. | N-Urea | 313.20 | Urea | ` 7.2 kg$^{-1}$ |
| 5. | SSP | 1500.00 | SSP | ` 6 kg$^{-1}$ |
| 6. | MOP | 1176.00 | MOP | ` 17.64 kg$^{-1}$ |
| 7. | Application charges | 166.00 | 1 Labour | 166 labour$^{-1}$ |
| 8. | Sowing charges (5 labour) | 830.00 | 1 L chloro-pyriphos | 300 ` L$^{-1}$ |
| 9. | Irrigation (including labour) | 2300.00 | Irrigation charges | 1150 ` irrigation$^{-1}$ |
| 10. | Intercultural operations (8 labours) | 1328.00 | | |
| 11. | Plant protection (3 liter ha$^{-1}$) | 900.00 | | |
| 12. | Harvesting (14 labour) | 2324.00 | | |
| 13. | Threshing and winnowing (14 labours) | 2324.00 | | |
| 14. | Tractor charges | 2400.00 | | |
| 15. | Miscellaneous | 1000.80 | | |
| | **Total** | **21786.00** | | |

**Appendix-XXII**

**Comparative economics of various treatments**

| S.No. | Treatments | Common cost of cultivation (` ha$^{-1}$) | Treatment cost (` ha$^{-1}$) | Total cost (` ha$^{-1}$) | Yield (kg ha$^{-1}$) | | Gross returns (` ha$^{-1}$) | Net returns (` ha$^{-1}$) | B : C ratio |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Seed | Straw | | | |
| 1. | W1 | 21786.00 | 0.00 | 21786.00 | 619 | 1691 | 36974.04 | 15188.04 | 1.70 |
| 2. | W2 | 21786.00 | 2656.00 | 24442.00 | 1252 | 3180 | 74544.06 | 50102.06 | 3.05 |
| 3. | W3 | 21786.00 | 1664.00 | 23450.00 | 1076 | 2822 | 64153.58 | 40703.58 | 2.74 |
| 4. | W4 | 21786.00 | 2992.00 | 24778.00 | 1222 | 3111 | 72764.56 | 47986.56 | 2.94 |
| 5. | W5 | 21786.00 | 868.00 | 22654.00 | 1013 | 2736 | 60476.88 | 37822.88 | 2.67 |
| 6. | W6 | 21786.00 | 960.00 | 22746.00 | 1046 | 2812 | 62433.58 | 39687.58 | 2.74 |
| 7. | W7 | 21786.00 | 1052.00 | 22838.00 | 1042 | 2762 | 62156.26 | 39318.26 | 2.72 |
| 8. | W8 | 21786.00 | 2196.00 | 23982.00 | 1100 | 2899 | 65598.87 | 41616.87 | 2.74 |
| 9. | W9 | 21786.00 | 2288.00 | 24074.00 | 1123 | 2947 | 66957.50 | 42883.50 | 2.78 |
| 10. | W10 | 21786.00 | 2380.00 | 24166.00 | 1129 | 2946 | 67299.09 | 43133.09 | 2.78 |
| 11. | W11 | 21786.00 | 707.00 | 22493.00 | 1059 | 2816 | 63178.85 | 40685.85 | 2.81 |
| 12. | W12 | 21786.00 | 810.00 | 22596.00 | 1069 | 2832 | 63764.64 | 41168.64 | 2.82 |
| 13. | W13 | 21786.00 | 2532.00 | 24318.00 | 1216 | 3114 | 72426.32 | 48108.32 | 2.98 |
| 14. | W14 | 21786.00 | 2035.00 | 23821.00 | 1158 | 3006 | 69011.91 | 45190.91 | 2.90 |
| 15. | W15 | 21786.00 | 2138.00 | 23924.00 | 1176 | 3032 | 70063.72 | 46139.72 | 2.93 |
| 16. | W16 | 21786.00 | 2371.00 | 24157.00 | 1192 | 3077 | 71021.27 | 46864.27 | 2.94 |

Cost of imazethapyr+imazamox : ` 904/ 175g, pendimethalin : ` 466/300 g, Imazathapyr : ` 230/25 g
Sale price of green gram seed : ` 57 kg$^{-1}$, straw : ` 1 kg$^{-1}$