# Effect of Weed Control Measures in Pearl millet - Legumes Intercropping System in Arid Western Rajasthan

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**Hari Singh**


## Thesis

*Master of Science in Agriculture*

**(Agronomy)**

**2015**


**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**

**Hari Singh**

**2015**

# Swami Keshwanand
# Rajasthan Agricultural University, Bikaner
# College of Agriculture, Bikaner

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This is to certify that the thesis entitled **“Effect of Weed Control Measures in Pearlmillet - Legumes Intercropping System in Arid Western Rajasthan”** submitted for the degree of **Master of Science in Agriculture** in the subject of **Agronomy** embodies bonafide research work carried out by Mr**. Hari Singh** 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 17/ 06 / 2015.

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This is to certify that **Mr. Hari Singh** of the Department of Agronomy, College of Agriculture, Bikaner (Rajasthan) has made all corrections/modifications in the thesis entitled **"Effect of Weed Control Measures in Pearlmillet - Legumes Intercropping System in Arid Western Rajasthan"** which were suggested by the external examiner and the advisory committee in the oral examination held on _________. The final copies of the thesis duly bound corrected were submitted on ___________ and forwarded herewith for approval.

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# ACKNOWLEDGEMENT

The pride of place in this galaxy belongs to esteemed major advisor **Dr. M.L. Reager,** Assistant professor, Department of Agronomy, Krishi Vigyan Kendra, Bikaner for his engrossing guidance, incessant encouragement, constructive suggestions propitious assistance, keen and sustained interest, kind and gracious patronage during the entire course of investigation and preparation of this manuscript.

I am highly obliged and grateful to all the members of Advisory Committee Dr. K.K. Jain, Professor, Department of Agronomy, Dr. S.K. Johri, Associate Professor, Department of Agricultural Statistics and Dr. L.S. Bareth, Professor, Department of Extension education, ( Nominee Dean PGS), College of Agriculture, Bikaner for their generous gesture and critical suggestions during the course of investigation.

I again record my thanks to Dr. N.S. Yadava, Professor and Head, Department of Agronomy, College of Agriculture, Bikaner for their moral support, helpful criticism and for providing necessary facilities during the course of investigation.

I also take this opportunity to express my cordial thanks to Dr. I.J. Gulati, Dean, College of Agriculture, Bikaner for providing assistance and necessary facilities during the course of investigation.

I wish to express my deep sense of gratitude to Dr. R. S. Yadav, Dr. P.S. Shekhawat, Dr. S.M. Kumawat, Dr. S.R. Bhunia, Dr. P.S. Rathore, Professor Department of Agronomy, College of Agriculture, Bikaner, Dr. S.P. Singh, and Dr. R.C. Bairwa Asstt. Professor Department of Agronomy, College of Agriculture, Bikaner.

I extend a lot of thanks to Sh. Bhawani singh Technical Asstt., Department of Agronomy and special thanks to Sh. Ganpat ji, Farm Manager, COA, Bikaner and Sh. Shanker lal and Pyare lal, Labour for rendering the help during the course of investigation.

Words fail to convey my sincere thanks to my seniors Sharve Dr. Amit Kumawat, Amit Yadav, Anil Khichar, Rupa ram, Ramdhan, Shish Ram, Bajarang lal, Arjun lal, *Rajesh rana, Kamal, Suresh bairwa, Babu lal, Ramesh sanp, Sunil pipliwal, Surender, Gangaram, Komal, Sonal, Rinku, Mukesh Yadav, Raju singh, Deepak jat, Sushila khangarot, Versha gupta, Balram, Rupesh meena, Bhawana sharhan, Soma vishnoi, Pawan, Friends Arif, Jitendra, Arjun, Vimal, Gajanand, Hansraj, Ghanshyam, Kamal, Bablesh, Dara Singh, Suman, Ravi, Avinash, Kuldeep, Pushkar, Pancham, Shubham, Kedar ram, Subhash, Uttam, Rajendra, Rakesh, Lokesh, Dinesh, Vivek, Hari and my loving juniors Mr. Anil, Vikas, Sisupal, Naresh, Mahaveer, Ram pratap, Ramniwas, Ravi and also other department seniors and juniors for their moral support, love, joyful company and sustained encouragement provided during the study sustained encouragement provided during the study.*

*I have no adequate words to express my sense of profuse regards and affection to my worthy Grandfather Sh. Kajor Mal, Grandmother Bidami Devi, parents Sh. Bhopal ram and Smt. Vidya Devi, my brother Sh. Mahipal singh, Sister kamlesh, Sister in law Sunita and my nephew Anita, Raman, Lucky, Deepika deserve appreciation for their incessant love, affection and encouragement, which brought the present task to completion.*

*Last but not the least I express my sincere faith in "god"* ***Shree Khatu Shyam ji*** *who made all the circumstances favourable and peaceful for me.*

**Place: Bikaner**

**Date** **(HARI SINGH)**

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**Abbreviations**

| | | |
|---|---|---|
| % | - | Per cent |
| $^0$C | - | Degree Celsius |
| @ | - | At the rate of |
| $^0$E | - | Degree East |
| AICPMIP | - | All India Coordinated Pearlmillet Improvement Project |
| B:C. | - | Benefit cost ratio |
| C.D. | - | Critical difference |
| CB | - | Cluster bean |
| cm | - | Centimeter |
| CV | - | Coefficient of variation |
| d.f. | - | Degree of freedom |
| DAP | - | Diammonium phosphate |
| DAS | - | Days after sowing |
| dS $m^{-1}$ | - | Deci- simens per meter |
| E.C. | - | Electrical conductivity |
| etc. | - | (et. cetera) and other similar things) |
| *et al.* | - | (et al. al. alii or et al. al. alia) other people or things) |
| Fig. | - | Figure |
| g | - | Gram |
| Ha | - | Hectare |
| Hrs | - | Hours |
| HI | - | Harvest index |
| i.e. | - | (id est) That is |
| ICAR | - | Indian Council of Agricultural Research |
| K | - | Potassium |
| Kg $ha^{-1}$ | - | Kilogram per hectare |
| Km/hr | - | Kilometers per hour |
| LER | - | Land equivalent ratio |
| MB | - | Mothbean |

| | | |
|---|---|---|
| M | - | Meter |
| Max. | - | Maximum |
| $m^2$ | - | Square meter |
| Mg | - | Milligram |
| Mg $m^3$ | - | Mega gram per cubic meter |
| Min | - | Minimum |
| mm $day^{-1}$ | - | Millimeter per day |
| m ha | - | Million hectare |
| M ton | | Million Tonne |
| N | - | Nitrogen |
| NARP | - | National Agricultural Research Project |
| NBSS & LUP | - | National Bureau of Soil Survey & Land Use Planning |
| $^0$N | - | Degree North |
| No. | - | Number |
| NS | - | Non-significant |
| PM | - | Pearlmillet |
| PET | - | Potential evapotranspiration |
| PMEY | - | Pearlmillet equivalent yield |
| q $ha^{-1}$ | - | Quintal per hectare |
| R.H. | - | Relative humidity |
| Rep. | - | Replication |
| Rs. $ha^{-1}$ | - | Rupee per hectare |
| S.Em$\pm$ | - | Standard error of mean |
| S.No. | - | Serial Number |
| USDA | - | United States Department of Agriculture |
| *Viz.* | - | (Videlicet) namely |
| WCE | - | Weed control efficiency |
| WSE | - | Weed smothering efficiency |

# 1. INTRODUCTION

Northwestern Rajasthan is characterized by typical arid climate where vegetation condition is primarily dependent on the unpredictable (though seasonal) influence of climatic conditions. Mixed cropping by virtue of its merits has traditionally been practiced as an insurance against aberrant weather conditions and natural calamities like droughts, which appear more frequently in this region. Crop-mixtures, in general, outperform monocultures both in terms of productivity and weed suppression but in order to ensure their benefits to be persistent and consistent through time, more scientific way-out in the form of intercropping needs to be evaluated by involving crops which are complimentary and compatible to each other in terms of growth rhythm and climatic requirements so that dynamic relationship between species of diverse morphology can fully be utilized for efficient utilization of resources in the hungry-thirsty soils of this region.

Legume use in intercropping system is valued not only for its ability to substitute for fertilizer nitrogen use but to improve canopy apparent photosynthesis also, which is one of the primary metabolic processes determining plant growth and yields. Therefore, intercropping of cereals and legumes appears to be one of the feasible approaches for increasing the yields in this region, but in harnessing maximum economic yields from component crops, elimination of causes responsible for yield losses is also very important and need be addressed properly. Among such causes, weed infestation is one, which is of prime importance in intercropping systems because a number of weed species infests both the crops during their growth season. But hitherto, most of the studies on crop-weed competition are related to sole crop only and such studies are scanty on intercropping systems.

Pearl millet and legume intercropping system is promising for this region and legumes compatible with pearl millet as intercrops, are mainly cluster bean and moth bean. All the component crops of the system have their own importance in livelihood of farmers of the region.

Pearl millet [*Pennisetum glaucum* (L.) Br Emend stuntz.] popularly known as bajra is an important coarse grain cereal of this region. It is a dual purpose (grain and fodder) crop very well adapted to agroclimatic conditions of this region. Grains contain 11-12% protein, 5-6% fat, 67% carbohydrate and are also rich in minerals (phosphorus and iron) and vitamins (carotene, riboflavin and niacin). India is the largest producer of pearl millet with an annual production of 10.05 m tons from an area of 8.69 m ha and productivity of 1156 kg $ha^{-1}$ (Annual Report, AICPMIP, 2014). Rajasthan ranks first in area (4.41 m ha) and production (4.11 m tons). However, average productivity is 933 kg $ha^{-1}$ which is still low compared to the national average. (www.rajasthankrishi.gov.in, 2014). In Rajasthan, pearl millet cultivation is mainly confined to the arid (62% of total area) and semi-arid (12.60% of total area) regions.

Among the leguminous crops compatible with pearl millet as intercrops, cluster bean [*Cyamopsis tetragonoloba (L.) Taub.*] is one, which is the crop of dry and warm habitat. It is grown for different purposes such as seed, vegetables, green fodder, etc. Its seeds contain 28-33% gum, which is an important product of commercial value. The multi adaptive and adjusting nature of this crop has enabled it to become a crucial part of all types cropping and farming systems of the arid regions. With the increased availability of new cultivars of pearl millet and cluster bean differing widely in plant type and maturity periods, considerable scope exists to develop more productive pearl millet + cluster bean intercropping system to increase and stabilize the yield of these crop in this region.

Moth bean [*Vigna aconitifolia* (Jacq.) Marchall] is another important leguminous crop of arid and semi arid regions, which fits well in intercropping system with pearl millet because of its shorter life span, besides other advantages. It is also known as moth and dew bean. It is an indispensable component of dry land farming system of arid and semi-arid regions because it is the most drought tolerant crop among *Kharif* pulses. Moth bean contain about 20.5% easily digestible protein being relatively rich in lysine and tryptophan, the essential amino acids, in which cereals are deficient. It offers a variety of edible products such as dried seeds, mature and immature green pods for vegetable and snacks. Moth bean has deep and extensive root system with profuse vegetative growth and dense foliage, thus acts as a protective cover against soil erosion, smothers weeds and conserves soil moisture for a longer period. The duration of crop is very short; hence it is most suitable for low rainfall areas of western Rajasthan (Yadav, 2005). Recent increase in its demand is quite explainable as it is the crop, which has made Bikaner as a major *papad* and *bhujia* producing hub in the world. All these reasons make moth bean an economic crop of the area. Rajasthan is a leading producer of moth bean, contributing about 86 % area (9.2 lakh ha) and 79 % production (2.6 lakh ton) in the country. Despite all, the productivity of moth bean in Rajasthan is very low (288 kg/ha) (www.rajasthankrishi.gov.in, 2014) mainly because of the fact that it is cultivated largely on marginal or sub marginal lands of poor fertility status.

As pointed out earlier, weed infestation is considered as one of the most important constraint that limits yields in intercropping system. Pearl millet and legume intercropping, being a rainy season system, suffers badly due to severe competition by mixed weed flora. Weeds adversely affect crop production because they compete with the crop plants for nutrient, moisture, light and space. In pearl millet, weeds account for 16 to 94 per cent reduction in yield (Umrani *et al., 1980*). Thus, weed control has become crucial for quality product and higher yields. Conventional methods of weed control being weather dependent, laborious, time consuming and costly due to high cost of labour and mechanical means being less efficient in controlling weeds compare to use of herbicides, there is need to explore suitable herbicide (s), which may be effective and economically viable for both monoculture and intercropping. In recent years, pendimethalin has performed well in leguminous and cereals crops as pre-emergence herbicide. It 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 option left with them. In view of paucity of information on weed management especially the application of post-emergence herbicides an attempt has been made to test imazethapyr as a post-emergence herbicides, as these have shown encouraging results in other leguminous crops. Numerous reports on weed control in sole pearl millet are available (Singh and Yadav, 1994 and Ram *et al*., 2004) but information on control of weeds in pearl millet and legume intercropping system in arid zone is lacking, particularly on herbicidal weed control. So there is a need to test chemical as well as other methods of weed control for pearl millet and legume intercropping system. Taking cognizance of the facts mentioned above the present investigation entitled "Effect of Weed Control Measures in Pearl millet–Legumes Intercropping System in Arid Western Rajasthan" was conducted with the following objectives:

1. To study the effect of different weed control measures and intercrops on intensity and dry matter of weeds.

2. To study the effect of different weed control measures and intercrops on growth and yield of pearl millet and legumes.

3. To find out the effect of different weed control measures and intercrops on nutrients content and uptake by crops.

4. To find out the efficiency and economics of different weed control measures in pearl millet and legumes.

5. To find out the interaction effect of intercropping system and weed control measures, if any.

# 2. REVIEW OF LITERATURE

In this chapter, an attempt has been made to collate the experiment findings related to the present study entitled "Effect of Weed Control Measures in Pearl millet – Legumes Intercropping System in Arid Western Rajasthan". As regards intercropping studies involving cereals and legumes, a large number of reports were available but there is severe dearth of published literature on the use of herbicides in pearl millet and legume intercropping system as this aspect has seldom been studied in the past. Therefore, reports on others crops have also been included in this chapter to elucidate the major trends.

## 2.1 Effect of intercropping system

### 2.1.1 Weed growth

Singh *et al.* (2005) conducted a field experiment at Udaipur to study the effect of planting pattern and weed control methods on weeds and productivity of maize and soybean. Based on two year study, they reported that intercropping of maize with soybean, irrespective of their row ratio, effectively reduced the weed density and dry weight of weeds at 50 DAS compared to their pure cropping.

Ram *et al.* (2005) conducted an experiment on loamy sand soil of Jobner (Jaipur) to evaluate the effect of integrated weed management and intercropping systems and reported that lowest weed population (117/m$^2$) and dry weight (975 kg/ha) were recorded under pearl millet + cowpea followed by pearl millet + green gram while maximum under sole pearl millet at harvest. (Bilalis *et al*., 2008) also reported significantly less weed dry matter under intercropping systems (oat-pea or cereal-legume) as compared to pure stands. However, different cereal-legume intercropping systems remained statistically at par in this respect. Weed population was reduced in brinjal-groundnut intercropping also as compared to sole crop (Srikrishnah *et al*., 2008). Bilalisa *et al.* (2010) reported that intercropping maize and legumes considerably reduced the weed density compared to maize as sole.

Issa Piri *et al.(* 2011) also found that total dry matter of weeds recorded from the sole crop of millet and bean was higher than that recorded under intercropping, because millet had greater growth rate than bean when they were grown in mixture together. They noticed that millet occupied the upper part of the canopy and cast shadow on bean, while, bean in the lower part of the canopy cast shadow on the soil and led to suppression of weeds in this system. Workayehu and Wortmann (2011) reported 30% less weed infestation in intercrop as compared to sole crop of bean but differences across the years were inconsistent. Weed biomass was also 13% less with maize + bean intercropping compared to sole-cropped maize. Overall, intercropping suppressed weeds and was more productive and economical than sole crop production.

Kiroriwal *et al.* (2012) reported that the density and dry weight of weeds were reduced significantly in pearl millet + moth bean and pearl millet + cluster bean inter-cropping system as compared to sole crop of pearl millet. Kiroriwal and Yadav (2013) conducted a field experiment at Bikaner and concluded that Pearl millet intercropped with cluster bean and moth bean significantly reduced the density and dry matter of individual and total weeds as compared to sole pearl millet. Tenaw Workayehu (2014) also reported more biomass in sole bean compared with other cropping systems. The weeding frequency and cropping system interaction was not found significant for weed biomass.

### 2.1.2 Growth, yield attributes and yield

Yadav and Yadav (2000) at Jodhpur observed that the choice of the cropping system significantly affect seed yield of each component crop of the system. Maximum grain yield of 2056 kg $ha^{-1}$ obtained in sole crop of pearl millet was significantly superior to mixed cropping treatments. The seed yield of cluster bean was reduced by 38-67% in mixed stands. Further, mixed cropping of pearl millet + cluster bean in 1:2 ratio gave significantly higher pearl millet equivalent yield. However, Pandey *et al*. (2003) reported that maize based intercropping system reduced the values of yield attributes and grain yield of maize than sole crop of maize but significant reduction in cob length, kernels/row, grain/cob and grain yield was recorded only with seasame, turmeric and forage moth intercropping system at Pusa, Samastipur.

Ram *et al*. (2003) observed that plant height of pearl millet recorded under sole pearl millet was at par with that recorded under pearl millet + cluster bean but it was significantly higher when compared with pearl millet intercropped with cowpea and green gram. However, Singh and Agrawal (2004) observed that yield attributes of pearl millet viz., length of ear, grain weight/ear and 1,000- grain weight were not influenced by intercropping system.

Yadav *et al*. (2005) reported that the highest dry matter production of moth bean and cluster bean with pearl millet intercropping was obtained under 5:1 and 6:1 planting system and was at par with 4:1 and 5:1 planting system. They also reported that the highest grain yield of moth bean and cluster bean with pearl millet intercropping was obtained under 5:1 and 6:2 planting system and was at par with 4:1 and 5:1 planting system at Bikaner.

Yadav and Jat (2005) reported that the row ratio of 2:1 moth bean : Pearl millet being at par with 3:1 produced significantly higher grain and straw yield of moth bean in intercropping system than other ratios. Significantly higher pearl millet grain yield was recorded with 1:3 (moth bean: pearl millet) row ratio but it was at par with 1:2 (moth bean: pearl millet) row ratio. The highest fodder yield of pearl millet was recorded with 1:3 ratio among all other ratios tested. They further reported that out of three moth bean varieties namely RMO-40. Jwala and IPCMO-912 intercropped in 1:2, 2:1, 2:2, 1:3 and 3:1 row ratio with pearl millet, the short duration variety RMO-40 recorded significantly higher grain yield in intercropping with pearl millet than Jwala and IPCMO-912. In terms of fodder yield, however, IPCMO-912 being at par with long duration variety Jwala was significantly superior to RMO-40 in intercropping system at Fatehpur (Rajasthan).

Results of a field experiment was conducted at Hissar showed that sole pearlmillet, clusterbean, mungbean, cowpea and blackgram gave significantly higher grain and stover yields over inter and strip-cropping (Kumar *et al.,* 2006). Rana *et al*. (2006) reported that maize paired row (40/80 cm) +1 row of mung bean recorded significantly higher cobs/plant, cob length, grain/cob, grain weight/cob as compared to sole maize.

Chauhan *et al*. (2008) reported that the grain yield of cluster bean decreased in intercropping system when compared with the yield obtained from pure stand whereas cluster bean equivalent yield was higher with 6:1 row ratio of cluster bean and pearl millet or sesame. Sharma (2008) showed that intercropping of pearl millet and cluster bean with a row ratio of 2:2 recorded the maximum values of plant height and number of tillers per plant than other intercropping row ratios and sole stands of pearl millet and cluster bean at Bikaner, Rajasthan. Rao *et al*. (2009) reported that sole sorghum recorded the highest grain yield among all the treatments, however it was statistically at par with that recorded under sorghum + green gram in 2:1 row ratio fertilized with 50 kg N/ha and with 75 kg N/ha. The lowest yield of sorghum was obtained under sorghum + green gram in 1:1 row ratio at Pali (Rajasthan).

A field experiment conducted during the summer season at Sabour showed that pearl millet + cowpea at 2:2 row ratio recorded significantly higher total grain yield and dry fodder compared to other treatments (Sharma *et al*., 2009). Sharma *et al.* (2010) noticed that intercropping of pigeon pea with green gram and pearl millet influenced the plant height, number of primary and secondary branches and number of pods significantly at Karnataka during *Kharif* season. Ashish Kumar (2011) observed that different yield attributes of pearl millet, viz. length of ear, grain weight/ ear and 1,000- grain weight were not influenced by intercropping system at Bikaner.

Patel and Sadhu (2013) conducted a field experiment during summer, 2010 at Anand and reported that sole pearl millet, though, produced higher grain and straw yields yet, intercropping of pearl millet + green gram at 1:2 row ratio recorded higher pearl millet equivalent yield, net return and benefit: cost ratio and it was found superior to sole pearl millet and intercropping of pearl millet with green gram, moth bean or cluster bean in different row ratios.

**2.1.3 Nutrient content, uptake and quality**

Sharma and Gupta (2002) observed that N and P nutrition of pearl millet was greatly improved by intercropping with legumes. They reported that the highest N and P uptake by grain and Stover was recorded in pearl millet + cluster bean system which was significantly greater than that of pearl millet + cowpea system. Goswami *et al.* (2002) also reported that total uptake of N, P and K was influenced significantly by intercropping system being maximum with pearl millet + green gram intercropping at IARI New Delhi. However, Ram and Singh (2003) at Faizabad (Uttar Pradesh) also recorded significantly higher crude protein and nitrogen uptake of sorghum sole compared to its intercropping with cluster bean.

Singh and Agrawal (2004) observed that the N and P uptake was maximum in sole pearl millet due to its higher grain yield. Ram *et al.* (2004) observed that the maximum removal of N, P and K by weeds was recorded under sole pearl millet, whereas the minimum under pearl millet intercropped with cowpea and green gram. Sole pearl millet showed the maximum removal of N, P and K by weeds to an extent of 15.3, 1.4 and 13.9 kg $ha^{-1}$ at 30 DAS and 26.2, 2.4 and 24.8 kg $ha^{-1}$ respectively, at 60 DAS.

Tetarwal and Rana (2006) observed that the cropping system had no marked influence on N and P uptake by grain as well as straw of pearl millet, whereas, the total uptake of N and P was significantly higher with sole crop compared to pearl millet + moth bean intercropping system. However, Sharma *et al*. (2008) reported that influence of intercropping of maize with cowpea, rice bean and cluster bean was clearly evident in the total crude- protein of the system. Intercropping of maize + cowpea in the ratio of 2:2 gave higher crude protein content than sole stands of maize and cowpea at Sabour (Bihar). In another study, nitrogen uptake was maximum under sorghum + green gram with 2:1 row ratio at 50 kg N/ha. (Rao *et al*., 2009).

### 2.1.4 Economics of intercropping

Tetarwal and Rana (2006) observed that the Pearl millet + moth bean intercropping system fetched higher net return (Rs 8,375/ha) as well as benefit: cost (B:C) ratio (0.87) over sole pearl millet. Sharma (2008) reported that intercropping system of pearl millet and cluster bean with a row ratio of 2:2 recorded the maximum values of land equivalent ratio, net return and benefit: cost ratio than other intercropping row ratios, however, maximum aggressivity index and relative crowding coefficient were obtained with mixed seed sowing of pearl millet and cluster bean at Bikaner, Rajasthan. Intercropping of maize with black gram at 1:1 row ratio was found to be the most economically viable system with highest land equivalent ratio and maize grain yield at Pantnagar (Pathak and Singh, 2008).

Sharma *et al*. (2009) reported that pearl millet + cowpea (2:2) intercropping system recorded significantly higher land equivalent ratio, relative crowding coefficient, maximum aggressivity index and competitive ratio were obtained with pearl millet + cluster bean at 1:2 row ratio. However, Intercropping of pearl millet with cluster bean at 1:7 row ratio was found to be the most economically viable system with highest land equivalent ratio and pearl millet grain yield during *Kharif* season at Bikaner (Ashish, K. 2011). In another study, pearl millet + moth bean, pearl millet + cluster bean both the intercropping systems gave higher net return over sole pearl millet. Pearl millet intercropped with cluster bean gave highest mean net return of Rs. 23133 $ha^{-1}$ followed by pearl millet + moth bean (Rs. 21143 $ha^{-1}$) at Bikaner (Kiroriwal and yadav, 2013).

## 2.2 Weed control Studies

### 2.2.1 Weed growth

Reager *et al.* (2003) while conducting an experiment on weed control 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 in cluster bean at Jobner (Jaipur). Kalpana and Velayatham (2004) while working at Tamilnadu Agriculture University reported that post emergence imazethapyr 100 g $ha^{-1}$ resulted in significant reduction in grasses and sedges in soybean. Mishra and Chandrabhanu (2006) observed that pre emergence application of pendimethalin @ 1.0 kg $ha^{-1}$ gave significantly lower weed population, weed dry weight as compared to any other herbicide treatment in summer black gram at NRCW (Jabalpur). In groundnut, post-emergence imazethapyr @ 0.1 kg $ha^{-1}$ 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 @ 0.1 kg $ha^{-1}$. They further concluded that post emergent Imazethapyr @ 0.1 kg $ha^{-1}$ significantly decreased weed biomass recorded 30 days after treatment compared to post emergent imazethapyr @ 0.05 kg $ha^{-1}$ and weedy check in a field experiment at MPUAT Udaipur (Maliwal and Mundra, 2009).

Ali *et al*. (2011) concluded that application of imazethapyr @ 100 g ha $^{-1}$ as post emergence was found most effective in green gram for reducing population and dry weight of weeds in sandy loam soil of S.K. Nagar (Gujarat). However, 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 in cluster bean (Yadav *et al.*, 2011).

Ram *et al.* (2012) reported that hand weeding registered lowest weed density (2.37 per $m^2$) and weed biomass (3.45 g m$^2$) at 30 DAS 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, in mung bean at Kota. Kiroriwal *et al.* (2012) reported that all the weed control measures decreased the density and dry weight of individual as well as total weeds significantly over weedy check. Pendimethalin at @ 0.75 kg/ha significantly reduced the density and dry weight of individual as well as total weeds significantly over oxyfluorfen at @ 0.1-0.2 kg/ha as pre-emergence. Hand weeding once at 25 DAS also reduced the density and dry weight of individual and total weeds as compared to oxyfluorfen @ 0.1-0.2 kg/ha in pearl millet crop at Bikaner.

Sangeetha *et al.* (2013) reported that early post-emergence 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 in soybean. The lowest weed density and biomass were recorded with hand weeding on 30 days after sowing (DAS) followed by imazethapyr at 200 and 100 g ha$^{-1}$. in soybean at Tamil Nadu. Upadhyay *et al*. (2013) also concluded that odyssey (imazethapyr + imazamox) significantly reduced the dry weight of weeds compared with weedy check in soybean crop at Jabalpur. Deshmukh *et al.* (2014) reported that all the weed control treatments significantly minimized the weed number and weed dry matter as compared with unweeded control. Treatment hand weeding on 20 and 40 DAS recorded significantly lowest weed count, weed dry weight and weed control efficiency in soybean at Akola.

**2.2.2 Growth, yield attributes and yield**

Rao and Rao (2003) in a field experiment at Bapatla (Andhra Pradesh) observed that one hand weeding at 25 DAS produced higher grain yield of black gram as compared to chemical treatments *viz.* clodinafop-propargyl (0.045 kg $ha^{-1}$), imazethapyr (0.062 kg $ha^{-1}$) and thiobencarb (2.0 kg $ha^{-1}$). Ram *et al.* (2005) observed that the weed control measures significantly increased the yield attributes and yields over unweeded control.

Savu *et al.* (2006) also found that imazethapyr @ 80 g $ha^{-1}$ (Post emergence) produced significantly higher yield attributes and yield over weedy check in groundnut at Chhattisgarh plains. In soybean, an increase of 40.30 per cent in grain yield was reported due to post emergence application of imazethapyr @ 100 g $ha^{-1}$ compared to weedy check at Jabalpur (Dixit and Varshney, 2007). Tiwari *et al.* (2007) found that application of imazethapyr @ 0.075 kg $ha^{-1}$ at 21 DAS recorded 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 of soybean due to this treatment was 61.8 and 58.4, respectively at Jabalpur.

Malliswari *et al.* (2008) 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 $ha^{-1}$ in black gram at Tirupati, Andhra Pradesh. Dan *et al.* (2009)

reported that herbicides nicosulfuron, imazethapyr, haloxyfop-methyl and clethodim caused phytotoxicity in millet cultivars ADR-300 and ADR-500 at the stage of expanded leaves. Dan *et al.* (2010) reported that pearl millet hybrid ADR-7010 showed high sensitivity to the residual activity of sulfentrazone, imazaquin and diclosulam when grown immediately after herbicide application.

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 XL 10% SL at 150 g $ha^{-1}$ as post emergence registered maximum number of branches $plant^{-1}$, pods $plant^{-1}$, seeds $pod^{-1}$ and seed yield of soybean as compared to weedy check and imazethapyr 10% @ 50 g $ha^{-1}$. Punia et *al.* (2011) also observed that application of imazethapyr @ 80-100 g/ha at 21 to 28 DAS resulted in maximum seed yield (1424 kg $ha^{-1}$) of cluster bean. Yadav *et al.* (2011) reported that seed and haulm yield under weed free check, two hand weeding (20 and 40 DAS) and imazethapyr 100 g $ha^{-1}$ 20 DAS + hand weeding 40 DAS which were at par with each other significantly superior to over all weed control measures of cluster bean at MPUAT, Udaipur.

Qian *et al*. (2011) conducted a field experiment and results revealed that imazethapyr had significant difference in rice seedling morphology. It inhibited elongation of primary roots, shoots and reduced the number of adventitious roots and density of root hairs. Gupta *et al.* (2013) conducted an experiment on urd bean 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 post emergence application of imazethapyr 25 g $ha^{-1}$ at 20 DAS. Deshmukh *et al*. (2014) reported that odyssey (imazethapyr+ imazamox) was effective in reducing weed number and weed dry matter as well as showed highest B:C ratio in soybean at Akola, Maharashtra.

Kalhapure *et al.* (2014) 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 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 and pod yield/hectare at Rahuri.

**2.2.3 Nutrient content, uptake and quality**

Kohli *et al.* (2006) noted that pendimethalin at 1.0 kg $ha^{-1}$ + one hand weeding at 35 DAS resulted in significantly higher N and P uptake by green gram. While two hand weeding at 20 and 30 DAS recorded the maximum grain protein content at Hisar. Whereas, two hand weeding 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 cluster bean while in weedy check plots N,P,K uptake by crop was 40.6, 9.8, 41.1 kg $ha^{-1}$, respectively at Hisar (Yadav *et al.,* 2011).

Kiroriwal *et al.* (2012) reported that the maximum uptake of N and P by crop was observed under weed free closely followed by hand weeding twice at Bikaner. Chhodavadia *et al.* (2013) reported that unweeded check treatments resulted 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 green gram at Junagarh (Gujrat). Nutrient uptake by weeds was highest in weedy check. The uptake of nitrogen by maize was significantly higher due to atrazine 0.75 kg/ha pre emergence 2, 4-D 0.5 kg/ha post emergence which was at par with hand weeding, this treatment recorded significantly highest uptake of phosphorus and potassium too at akola Maharashtra (Sonawane *et al.,* 2014). Kavita *et al* (2014) reported that nutrient (N, P and K) uptake by black gram was found superior in weed free treatment 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.

### 2.2.4 Economics of weed control methods

Sukhadia *et al.* (2000) reported that weed-free (three hand weeding and interculturing) recorded highest weed control efficiency (100%), followed by integration of pendimethalin at 0.900 kg $ha^{-1}$ as pre-emergence with one hand weeding and interculturing at 40-45 DAS in pigeon pea crop at Junagarh (Gujrat). Bhandari *et al.* (2004) reported that pre emergence application of pendimethalin 2.0 kg $ha^{-1}$ gave significantly higher 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 gross return was obtained from weed free treatment at Amritsar (Punjab).

Rathi *et al.* (2004) reported 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 Rs.ha$^{-1}$) due to weed control at Kanpur(Uttar Pradesh). Malliswari *et al.* (2008) 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$^{-1}$ in blackgram at Tirupati (Andhra Pradesh).

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 (Rs. 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 @ 0.75kg ha$^{-1}$ in summer season. Weedy check, though, involved the lowest cost of cultivation yet, it provided the lowest net returns. Kalhapure *et al.* (2014) reported that highest gross monetary returns (Rs.1,09,845 ha$^{-1}$) was recorded in treatment weed free check, maximum net monetary returns (Rs.61,460 ha$^{-1}$) and B:C ratio (2.42) were recorded in the treatment application of pendimethalin @ 1.5kg 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 at Rahuri (Maharashtra).

# 3. MATERIALS AND METHODS

A field experiment entitled "Effect of Weed Control Measures in Pearl millet – Legumes Intercropping System in Arid Western Rajasthan" was conducted at the Instructional Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner during *kharif* 2014. The details of experimental techniques, materials used and methods/techniques adopted for treatment evaluation during the course of investigation are described in this chapter.

## 3.1 Experimental site and location

The experiment was conducted at the Instructional farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner during *kharif* 2014. Bikaner is situated at $28.01^0$N latitude and $73.22^0$E longitude at an altitude of 234.70 meters above mean sea level. According to "Agro-ecological region map" brought out by the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Bikaner falls under Agro-ecological region No. 2(MgE1) under Arid ecosystem (Hot Arid Eco-region with desert and Saline soil), which is characterized by deep, sandy and coarse loamy, desert soils with low water holding capacity, hot and arid climate. As per NARP, Bikaner falls in Agro-climatic zone 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

Bikaner has arid climate and average annual rainfall is 265 mm. More than 80 per cent rainfall is received in the *kharif* season (July-September) by the south-west monsoon. During summer, the maximum temperature may go as high as $48^0$C while in the winter, it may fall as low as $0^0$C. This region is prone to high wind velocity and soil erosion due to dusty winds in summer. The periodical mean weekly weather parameters for the period of the experimentation recorded from the meteorological observatory of Agricultural Research Station, SKRAU, Bikaner, are presented in table 3.1 and depicted in fig. 3.1 shows that lowest and highest values of maximum temperature of $31.3^o$C and $42.2^o$C were recorded in the $45^{th}$ and $28^{th}$ standard meteorological week, respectively. Likewise, the extreme values of minimum temperature (11.5 & $29.6^0$C) were recorded in the $45^{th}$ and $24^{th}$ standard meteorological weeks, respectively. Crop received 427.9 mm of rainfall in 12 rainy days in the growing season. Evaporation ranged from 3.0 to 16.5 mm per day during the crop growing period. The average relative humidity during experiment fluctuated in the ranges of 42.4 to 66.3%. The average bright sunshine hours during the experimental season were 8.2 hours per day.

## 3.3 Soil of experimental field

In order to know the physical and chemical properties of soil, samples were taken randomly from 0-15 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 mechanical composition, physio-chemical properties, organic carbon and available N, P and K of the soil. The results of the analysis along with methods used are presented in table 3.2.

Result of the physical and chemical analysis revealed that the soil of the experimental field was loamy sand in texture and slightly alkaline in reaction. The status of soil was poor in organic carbon and low in available nitrogen, medium in phosphorus and high in available potassium.

**Table: 3.1 Mean weekly meteorological data during crop season (*Kharif, 2014)***

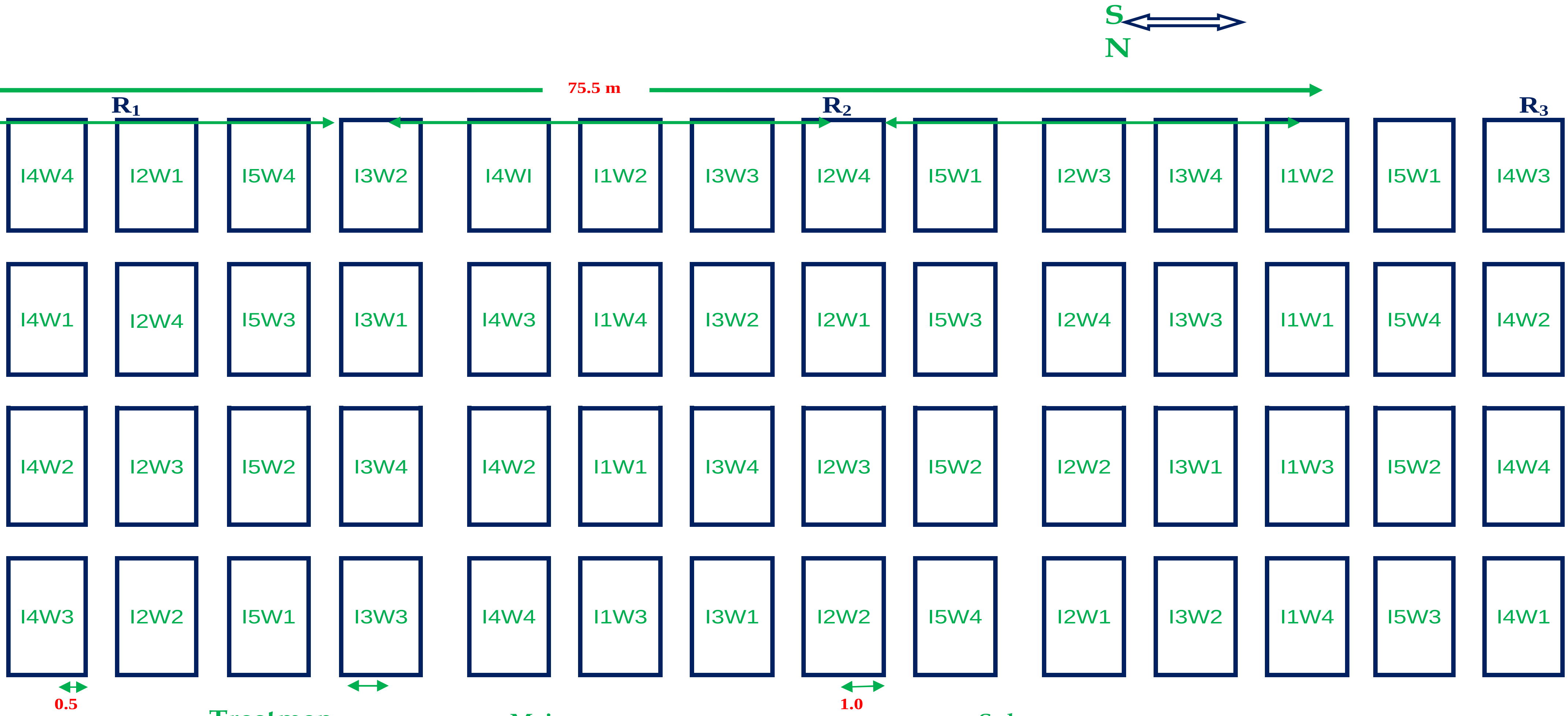
| Standard Week | Duration | | Temperature (°C) | | R.H. ( %) | | Total Rainfall (mm.) | No. of Rainy days* | Wind Velocity (km./hr.) | Evaporation (mm/day) | Bright Sunshine Hours |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Max. | Min. | Max. | Min. | | | | | |
| 24 | 11.06.14 | 17.06.14 | 42.5 | 29.6 | 51.7 | 26.8 | 0.0 | 0.0 | 15.8 | 16.5 | 10.0 |
| 25 | 18.06.14 | 24.06.14 | 42.1 | 29.0 | 59.5 | 23.7 | 0.0 | 0.0 | 14.8 | 15.0 | 7.1 |
| 26 | 25.06.14 | 01.07.14 | 39.3 | 24.1 | 63.2 | 29.4 | 0.0 | 0.0 | 14.7 | 12.7 | 6.4 |
| 27 | 02.07.14 | 08.07.14 | 38.5 | 23.0 | 63.4 | 31.5 | 10.5 | 1.0 | 10.9 | 11.7 | 6.6 |
| 28 | 09.07.14 | 15.07.14 | 42.9 | 23.2 | 58.8 | 27.0 | 0.0 | 0.0 | 12.8 | 14.0 | 11.4 |
| 29 | 16.07.14 | 22.07.14 | 40.1 | 27.3 | 77.7 | 30.8 | 0.0 | 0.0 | 11.2 | 9.0 | 5.5 |
| 30 | 23.07.14 | 29.07.14 | 37.9 | 24.2 | 68.0 | 52.8 | 22.5 | 3.0 | 9.7 | 6.0 | 5.6 |
| 31 | 30.07.14 | 05.08.14 | 34.3 | 18.1 | 75.0 | 71.2 | 175 | 2.0 | 7.2 | 6.1 | 6.7 |
| 32 | 06.08.14 | 12.08.14 | 37.4 | 26.3 | 75.2 | 53.1 | 0.2 | 0.0 | 6.4 | 8.2 | 8.3 |
| 33 | 13.08.14 | 19.08.14 | 36.1 | 19.6 | 73.7 | 41.7 | 0.0 | 0.0 | 12.2 | 9.4 | 9 |
| 34 | 20.08.14 | 26.08.14 | 38.7 | 20.8 | 55.5 | 40.1 | 0.0 | 0.0 | 9.8 | 9.4 | 10.2 |
| 35 | 27.08.14 | 02.09.14 | 33.1 | 19.0 | 80.5 | 77.4 | 138 | 3.0 | 6.3 | 5.3 | 6.2 |
| 36 | 03.09.14 | 09.09.14 | 34.0 | 20.0 | 89.1 | 81.0 | 81.7 | 3.0 | 7.1 | 4.0 | 5.9 |
| 37 | 10.09.14 | 16.09.14 | 37.7 | 22.1 | 81.4 | 68.6 | 0.0 | 0.0 | 7.2 | 8.4 | 8.7 |
| 38 | 17.09.14 | 23.09.14 | 37.5 | 23.0 | 77.9 | 54.0 | 0.0 | 0.0 | 9.5 | 8.0 | 10.2 |
| 39 | 24.09.14 | 30.09.14 | 36.0 | 23.8 | 66.9 | 45.1 | 0.0 | 0.0 | 10.3 | 8.0 | 10.2 |
| 40 | 01.10.14 | 07.10.14 | 35.6 | 23.2 | 65.9 | 35.3 | 0.0 | 0.0 | 7.3 | 7.4 | 10.1 |
| 41 | 08.10.14 | 14.10.14 | 36.9 | 25.1 | 37.2 | 29.2 | 0.0 | 0.0 | 5.0 | 5.1 | 9.9 |
| 42 | 15.10.14 | 21.10.14 | 35.6 | 19.1 | 59.0 | 28.4 | 0.0 | 0.0 | 3.2 | 4.0 | 8.7 |
| 43 | 22.10.14 | 28.10.14 | 35.6 | 19.1 | 59.0 | 28.4 | 0.0 | 0.0 | 3.2 | 4.0 | 8.7 |
| 44 | 29.10.14 | 04.11.14 | 32.2 | 19.9 | 66.4 | 44.1 | 0.0 | 0.0 | 3.6 | 3.4 | 5.4 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 45 | 05.11.14 | 11.11.14 | 31.3 | 11.5 | 53.3 | 12.4 | 0.0 | 0.0 | 3.2 | 3.0 | 8.9 |
| **Average/Total** | | | **37.1** | **22.3** | **66.3** | **42.4** | ***427.9*** | ***12.0*** | **8.7** | **8.1** | **8.2** |

*A day having 2.5 mm or more rainfall is considered as a rainy day,

Note: Figures in italic represent total of the season

Source: Agro-meteorological observatory, A.R.S.,(Beechwal), S. K. Rajasthan Agricultural University, Bikaner




Treatments →

Design: Split plot

Replication: 3

Main plot→

| | |
|---|---|
| $I_1$ | Sole pearl millet |
| $I_2$ | Sole cluster bean |
| $I_3$ | Sole moth bean |
| $I_4$ | Pearl millet + cluster bean |
| $I_5$ | Pearl millet + moth bean |

Sub plot→

| | |
|---|---|
| $W_1$ | Weedy check |
| $W_2$ | Two hand weeding |
| $W_3$ | Pendimethalin 0.75 kg ha$^{-1}$ |
| $W_4$ | Imazethapyr 40 gm ha$^{-1}$ |

**Fig 3.2: Plan of layout**

**Table 3.2 Physico-chemical characteristics of the experimental soil**

| **Soil properties** | ***Value at 0-15 cm depth*** | ***Methods of analysis with reference*** |
|---|---|---|
| **A. Mechanical Composition** | | |
| Sand (%) | 85.60 | Hydrometer method (Bouyoucos, 1962) |
| Silt (%) | 7.42 | |
| Clay (%) | 6.98 | |
| Texture | Loamy Sand | Triangular method (Brady, 1983) |
| **B. Physical properties** | | |
| Bulk density (Mg $m^3$) | 1.65 | 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 (%) | 8.35 | Method No. 30, USDA HandBook No. 60 (Richards, 1954) |
| Porosity (%) | 39.4 | 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 nitrogen (kg ha$^{-1}$) | 86.40 | Alkaline $KMnO_4$ method (Subbiah and Asija, 1956) |
| Available phosphorus ($P_2O_5$ kg ha$^{-1}$) | 21.91 | Olsen's method (Olsen *et al*., 1954) |
| Available potassium ($K_2O$ kg ha$^{-1}$) | 234.00 | Flame photometric Method (Jackson, 1973) |
| Soil pH (1:2 soil water suspension) | 8.5 | Method No. 21 b, USDA Hand Book No. 60 (Richards, 1954) |

## 3.4 Cropping history of experimental field

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

**Table 3.3 Cropping history of the experimental field**

| Crop year | Season | |
|---|---|---|
| | ***Kharif*** | ***Rabi*** |
| 2012-2013 | Mungbean | Barley |
| 2013-2014 | Pearl millet | Gram |
| 2014 | Pearl millet, Cluster bean & Moth bean* | |

* Experimental crop

## 3.5 Experimental details

### 3.5.1 Treatments

**Table 3.4 Treatments along with the symbols**

| Treatments | Symbol |
|---|---|
| **Intercropping (Main plot)** | |
| 1. Pearl millet sole | $I_1$ |
| 2. Cluster bean sole | $I_2$ |
| 3. Moth bean sole | $I_3$ |
| 4. Pearl millet + cluster bean at 1:2 row ratio | $I_4$ |
| 5. Pearl millet + moth bean at 1:2 row ratio | $I_5$ |
| **Weed control (Sub plot)** | |
| 1. Weedy check | $W_1$ |
| 2. Two hand weeding at 20 and 35 DAS | $W_2$ |
| 3. Pendimethalin 0.75 kg $ha^{-1}$ as PE | $W_3$ |
| 4. Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | $W_4$ |

### 3.5.2 Experimental design and layout

The experiment was laid out in a split plot design and replicated thrice. The plan of layout is depicted in Fig. 3.2. The 20 treatments were randomized with the help of random number table (Fisher, 1950).

### 3.5.3 Details of experiment

Experimental details are given in table no. 3.5

**Table 3.5 Details of experiment**

| | | |
|---|---|---|
| i. | Season | *Kharif*, 2014 |

| | | |
|---|---|---|
| ii. | Total number of treatments | 5 x 4 =20 |
| iii. | Replications | 3 |
| iv. | Total number of plots | 20 x 3=60 |
| v. | Experimental design | Split plot |
| vi. | Plot size | |
| | (a) Gross plot size | 5.0 m x 4.5 m = 22.5 $m^2$ |
| | (b) Net plot size | 4.0 m x 3.3 m = 13.2 $m^2$ |
| vii. | Crops and varieties | |
| | (a) Pearlmillet | RHB-173 |
| | (b) Clusterbean | RGC-1066 |
| | (c) Mothbean | RMO-435 |
| viii. | Crop geometry | 30cm X 10cm |
| ix. | Seed rate | |
| | (a) Pearlmillet | 4 kg $ha^{-1}$ |
| | (b) Clusterbean | 20 kg $ha^{-1}$ |
| | (c) Mothbean | 12 kg $ha^{-1}$ |
| x. | Fertilizers | |
| | (a) Nitrogen | 60 kg $ha^{-1}$ |
| | (c) Phosphorus | 40 kg $ha^{-1}$ |

## 3.6 Salient features of crop variety

**RHB 173:** It is a hybrid variety of pearl millet which matures in 78-80 days. Plants are of medium height (1.5 to 2.1 m) and having long thin ear heads. Its yield potential of grain is 30- 33 q $ha^{-1}$ and 68-77 q $ha^{-1}$ straw yield.

**RGC 1066:** The variety RGC-1066 (lathi) of cluster bean was developed in the year 2007 for Rajasthan state. It is an early maturing (92-97 days), erect type with rare branches per plant and pod length is 5.50-6.35 cm. It has synchronous maturity and yield potential is 1032 to 1451 kg $ha^{-1}$. The variety is suitable for rainfed condition.

**RMO 435:** It is an early maturing variety of moth bean (62-65 days), good for grain and fodder purposes both. It exhibits synchronized maturity. Yield potential of grain and straw 6-8 q $ha^{-1}$ and 14-20 q $ha^{-1}$, respectively. The variety is suitable for arid and semi arid region.

## 3.7 Details of crop raising

The details of different operations undertaken for raising the crops are given as follows.

### 3.7.1 Field preparation

With the onset of monsoon rains, the experimental field was prepared by two cross harrowing followed by planking. The experiment was laid out as per plan.

### 3.7.2 Seed rate and sowing

The seed of the crops were sown @ 4 kg $ha^{-1}$ of pearl millet, 20 kg $ha^{-1}$ of cluster bean and 12 kg $ha^{-1}$ of moth bean in lines spaced as per treatments in sole cropping and intercropping. The sowing was done by "*kera*" method in open furrow on July 23, 2014.

### 3.7.3 Fertilizer application

Nitrogen was applied @ 60 kg $ha^{-1}$ through urea duly calculated after application phosphorus through DAP @ 40 kg $P_2O_5$ $ha^{-1}$. Full dose of phosphorus and half dose of nitrogen was applied as basal.

The remaining half dose of nitrogen was applied as top dressing at 30 DAS through urea in rows of pearl millet only.

### 3.7.4 Hoeing and weeding

Hoeing and weeding was done manually as per treatment with the help of hoe locally knows as "Kasola or Kasia" and spray herbicide as per treatment.

### 3.7.5 Irrigation

Two irrigations were applied to the crop during the dry spell. The respective dates of irrigation to the crop are presented in chronological record.

### 3.7.6 Harvesting

To assess the grain, straw and biological yield, harvesting was done 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 and weight of each bundle was recorded in kg and converted to kg $ha^{-1}$ as biological yield.

### 3.7.7 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 ears and pods of each plot separately and grains were collected in numbered bags. After winnowing, cleaned seeds were weighed to record grain yield kg/plot then converted to kg $ha^{-1}$ as grain yield. The straw yield was computed by subtracting the grain yield from biological yield and express in kg $ha^{-1}$.

## 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 | Ploughing and planking | 15.07.2014 | Tractor drawn harrow and planker |
| 2 | Layout of experimental field | 20.07.2014 | Manually |
| 3 | Fertilizer application | 21.07.2014 | Pora |
| 4 | Sowing of seeds | 23.07.2014 | Kera |
| 5 | Pendimethalin (PE) treatment | 24.07.2014 | Manually |
| 6 | Imazethapyr (PoE) treatment | 17.08.2014 | Manually |
| 7 | Top dressing of urea in Pearlmillet | 21.08.2014 | Manually |
| 8 | Hand weeding<br>1st (as per treatment)<br>2nd (as per treatment) | <br>12.08.2014<br>27.08.2014 | <br>Manually<br>Manually |
| 9 | Irrigation | 21.08.2014<br>20.09.2014 | Sprinkler system<br>Sprinkler system |
| 10 | Harvesting<br>i.Mothbean<br>ii.pearlmillet<br>iii.Clusterbean | <br>02.10.2014<br>09.10.2014<br>27.10.2014 | <br>Manually<br>Manually<br>Manually |
| 11 | Threshing & winnowing<br>i.Pearlmillet<br>ii.Mothbean<br>iii.Clusterbean | <br>06.11.2014<br>07.11.2014<br>10.11.2014 | <br>Manually<br>Manually<br>Manually |

## 3.9 Weed studies

### 3.9.1 Weed flora

List of dominant weed species observed during the course of investigation are presented in table 3.7.

**Table 3.7 Weed flora of experimental site**

| S. | Botanical name | Common/English | Growth |
|---|---|---|---|

| No. | | name | habit |
|---|---|---|---|
| 1. | *Cynodon dactylon* (L.) | Bermuda grass | Perennial |
| 2. | *Tribulus terrestris* (L.) | Puncture vine | Biennial |
| 3. | *Amaranthus spinosus* (L.) | Spiny Amaranthus | Annual |
| 4. | *Portulaca oleracea* (L.) | Common Purslane | Annual |
| 5. | *Cenchrus biflorus* (L.) | Sandbur | Annual |
| 6. | *Corchorus tridense* (L.) | Wild jute | Annual |
| 7. | *Digera arvensis* Forsk. | Digera | Annual |
| 8. | *Eleusine verticillata* (L.) | Goosegrass | Annual |
| 9. | *Eragrostis tennela* | Kusagrass | Annual |
| 10. | *Euphorbia hirta* (L.) | Garden spurge | Annual |
| 11. | *Gisekia poiedious* | Suleri | Annual |

### 3.9.2 Weed density

Weed density was recorded at 30, 45 DAS and at harvest as described by Meharia (2006). A quadrate of 50 x 50 cm (0.25 $m^2$) was thrown randomly at two places in each plot and numbers of weeds present within the quadrate were counted and recorded. The count was then expressed as number per square metre of land area and analyzed after $\sqrt{x}+0.5$ transformations (Gomez and Gomez, 1984) where x is the original data.

### 3.9.3 Dry matter of weeds

The dry matter of weeds was recorded as grams per square metre at 30, 45 DAS and at harvest as per Meharia (2006). All the weeds falling within the quadrate were cut close to the ground and were collected in paper bags. After that, these weed samples were weighed after drying them in oven at $65^0$C for 8 hours.

### 3.9.4 Weed Control Efficiency (WCE)

The weed control efficiency was calculated as suggested by Tiwari *et al* (1989).

$$\text{WCE} = \frac{X-}{X} \times 100$$

Where,

X = Dry matter of total weeds per unit area under weedy check plot.

Y = Dry matter of total weeds per unit area under treated plot

### 3.9.5 Weed Smothering Efficiency (WSE)

The weed smothering efficiency was calculated as suggested by Tiwari *et al* (1989).

$$\text{WSE} = \frac{X-}{X} \times 100$$

Where,

X = Dry matter of total weeds per unit area under main crop.

Y = Dry matter of total weeds per unit area under intercrops.

## 3.10 Treatment evaluation of pearl millet

To evaluate the effect of various treatments, observation on plant growth parameters, yield attributes, yield, quality and other aspects were recorded. The methodology adopted for recording each of the aforesaid observations is given as follows.

### 3.10.1 Growth and yield attributes of Pearlmillet

#### 3.10.1.1 Plant stand

Number of plants per plot was counted at 30 DAS and at crop harvest and converted in number of plants per hectare.

#### 3.10.1.2 Plant Height

Five plants were selected randomly from each plot and tagged. Height of individual plant was measured at 30 DAS and harvest from base of the plant to top of the main shoot by metre scale and average was computed.

#### 3.10.1.3 Dry matter accumulation

To find out the effect of different treatments on dry matter accumulation of crop, five plants randomly uprooted from sampling rows of each plot at 30 DAS 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 used as dry matter (g $plant^{-1}$).

#### 3.10.1.4 Total number of tillers per plant

The tillers of five randomly selected and tagged plants of pearlmillet were counted at harvest. Average number of tillers per plant was also workout and recorded as mean number of tillers per plant.

### 3.10.1.5 Number of effective tillers per plant

The effective tillers of five randomly selected and tagged plants were counted at harvest and average number of effective tillers per plant was worked out and recorded as mean number of effective tillers per plant.

### 3.10.1.6 Ear head length

Five ears were taken randomly from selected tagged plants from each plot and their length was measured from the neck node to the tip and average was computed in cm.

### 3.10.1.7 Test weight

A small seed sample was taken from the produce of each of the plot harvested and 1000-seed were counted and weighed in grams.

### 3.10.1.8 Grain yield

The grain yield (kg $plot^{-1}$) of each plot was recorded after cleaning the threshed produce and was converted as kg $ha^{-1}$.

### 3.10.1.9 Straw yield

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

### 3.10.1.10 Biological yield

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

#### 3.10.1.11 Harvest index

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

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

## 3.11 Treatment evaluation of legumes

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

### 3.11.1 Growth and yield attributes

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

#### 3.11.1.1 Plant Stand

Number of plants was counted after thinning at 30 DAS and at harvest and converted in hectare.

#### 3.11.1.2 Plant height

Five plants were selected randomly from each plot and tagged. Height of individual plant was measured in cm at 30 DAS and at harvest from base of the plant to top of the main shoot by metre scale and average was computed.

#### 3.11.1.3 Dry matter accumulation

To find out the effect of different treatments on dry matter accumulation of crop, five plants randomly uprooted from sampling rows of each plot at 30 DAS 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 used as dry matter (g $plant^{-1}$).

#### 3.11.1.4 Number of nodule per plant

The nodules of five randomly selected plants were counted at 50 DAS and average number of nodules per plant was worked out and recorded as number of nodules per plant.

#### 3.11.1.5 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.

#### 3.11.1.6 Number of seeds per pod

Five pods were randomly selected from each five tagged plants and numbers of seeds per pod were counted and mean value for number of seeds per pod was calculated.

#### 3.11.1.7 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.

#### 3.11.1.8 Grain Yield

The grain yield (kg $plot^{-1}$) of each plot was recorded after cleaning the threshed produce and was converted as kg $ha^{-1}$.

### 3.11.1.9 Straw yield

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

### 3.11.1.10 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. Later, biological yield per plot was converted in terms of kg $ha^{-1}$

### 3.11.1.11 Harvest index

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

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

## 3.12 Chemical studies

### 3.12.1 Plant nutrient analysis

For estimation of nitrogen, phosphorus and potassium samples of grain and straw were taken at the time of threshing. Each dried straw sample was ground fine powder in willey mill for estimating the nutrient content. For estimating the nutrient content in grain, each sample was ground by an electric grinder. Nutrient content in grain 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 | Calorimetric method using spectrophotometer - 106 | Snell and Snell (1939) |
| 2. | Phosphorus content | Vanado-molybdo-phosphoric yellow colour method | Jackson (1973) |
| 3. | Potassium content | Flame photometry method | Jackson (1973) |

### 3.12.2 Nutrient uptake

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

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

## 3.13 Indices of yield advantage

### 3.13.1 Pearl millet equivalent yield

Seed yield of cluster bean and moth bean was calculated in terms of pearl millet for all intercropping treatments. On the basis of their market price and then analyzed statistically as equivalent grain yield of pearl millet.

$$\text{Pearl millet grain equivalent yield (kg ha}^{-1}\text{)} = \frac{\text{Yield of intercrop (kg ha}^{-1}\text{)} \times \text{Price of intercrop (Rs. kg}^{-1}\text{)}}{\text{Price of pearlmillet (Rs. kg}^{-1}\text{)}} + \text{Pearlmillet grain yield (kg ha}^{-1}\text{)}$$

### 3.13.2 Land equivalent ratio

It denotes the relative land area under sole crop required to produce the same yield as obtained under a mixed or an intercropping system at the same management level. It is calculated as sum total of the ratios of yield of each component crop in an intercropping system to its corresponding yield when grown as a sole crop thus:

$$\text{LER} = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Yab = is the yield of crop ‘a’ in association with crop ‘b’

Yba = is the yield of crop ‘b’ in association with crop ‘a’

Yaa = is the pure stand yield of crop ‘a’

Ybb = is the pure stand yield of crop ‘b’

### 3.13.3 Aggressivity

It gives a simple measure of how much the relative yield increase in crop ‘a’ is greater than that for crop ‘b’ in an intercropping system

$$Aab = \frac{Yab}{Yaa\ Zab} - \frac{Yba}{Ybb\ Zba}$$

Yab = is the yield of crop ‘a’ in association with crop ‘b’

Yba = is the yield of crop ‘b’ in association with crop ‘a’

Yaa = is the pure stand yield of crop ‘a’

Ybb = is the pure stand yield of crop ‘b’

Zab= is the crop ‘a’ proportion with crop ‘b’

Zba= is the crop ‘b’ proportion with crop ‘a’

### 3.13.4 Relative crowding coefficient (RCC)

It is a measure of the relative dominance of one component crop over the other in an intercropping system. The coefficient (K) is determined separately for each component crop *e.g.* for crop ‘a’ in association with ‘b’ the coefficient is as:

$$Kab = \frac{Yab \times Zba}{(Yaa - Yab) \times Zab}$$

$$Kab = \frac{Yba \times Zab}{(Ybb - Yba) \times Zba}$$

Yab= is the yield of crop ‘a’ in association with crop ‘b’

Yba=is the yield of crop ‘b’ in association with crop ‘a’

Yaa=is the pure stand yield of crop ‘a’

Ybb = is the pure stand yield of crop ‘b’

Zab= is the crop ‘a’ proportion with crop ‘b’

Zba= is the crop ‘b’ proportion with crop ‘a’

## 3.14 Economic analysis

### 3.14.1 Net returns (Rs. ha$^{-1}$)

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

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

### 3.14.2 Benefit: Cost (B: C) ratio

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

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

## 3.15 Statistical analysis

### 3.15.1 Analysis of variance and test of significance

The data on growth, yield and other characters were statistically analyzed with the help of fisher's analysis of variance technique (Fisher, 1950). The critical difference (CD) for the treatment comparisons were worked out where ever the variance ratio (F test) was found significant at 5% level of probability. To evaluate the nature and magnitude at treatment effect, summary tables along with S.Em.± and critical difference (C.D.) were prepared and are given in the last of the chapter entitled "Experimental results" and their analysis of variance for mean sum of squares (MSS) are given or finding in the appendices at the end.

# 4. EXPERIMENTAL RESULTS

A field experiment entitled "Effect of Weed Control Measures in Pearl millet – Legumes Intercropping System in Arid Western Rajasthan" was conducted at the instructional farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner during *kharif* 2014. The experimental findings pertaining to weed density, weed dry matter, crop growth parameters, yields & yield attributes of pearl millet and legumes, nutrient content & uptake by pearl millet and legumes as influenced by intercropping system and weed control measures based upon field trial are presented in this chapter. Data pertaining to various criteria used for treatment evaluation were analyzed statistically to test their significance. Data pertaining is important characters have also been depicted graphically for elucidation of the important trends, where ever considered necessary.

## 4.1 Weed studies

### 4.1.1 Weed flora

Weed flora of experimental field consisted of *Amaranthus spinosus* L., *Cynodon dactylon* L. *Euphorbia hirta* L., *Amaranthus spinosus* L.., *Portulaca oleracea* L., *Digera arvensis* Forsk., *Gisekia poiedious, Cenchrus biflorus* L., *Tribulus terrestris* L., *Corchorus tridense* L., *Eleusine verticillata* L. and *Eragrostris tennela*.

### 4.1.2 Density of weeds

**Intercropping**

Pearl millet – legumes intercropping system had significant influence on weed density (Table 4.1 and fig. 4.1). Sole cluster bean, sole moth bean, pearl millet intercropping with cluster bean and pearl millet intercropping with moth bean being at par with each other, reduced the density of weeds compared to sole pearl millet at 30 DAS, 45 DAS and at harvest. Maximum density of weeds was recorded in sole pearl millet at 30 DAS, 45 DAS and at harvest.

Sole cluster bean, sole moth bean, pearl millet intercrop with cluster bean and pearl millet intercrop with moth bean significantly reduced the weed density by 13.09, 17.65, 13.48 and 18.08 per cent at 30 DAS, 13.85, 17.78, 21.57 and 26.83 per cent at 45 DAS and 15.25, 18.31, 18.72 and 27.47 per cent over sole pearl millet, respectively.

**Weed control**

It is evident from data presented in table 4.1 and fig. 4.1 that the weed density reduced significantly under all the weed control treatments as compared to weedy check at 30 DAS, 45 DAS and at harvest. Two hand weeding, pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ reduced the weed density by 83.02, 72.57 and 64.81per cent at 30 DAS, 86.46, 67.30 and 76.67 per cent at 45 DAS and 83.00, 66.71 and 70.94 per cent at harvest, respectively over weedy check.

Further, hand weeding twice reduced weed density significantly over chemical herbicide at 30 DAS, 45 DAS and at harvest. The weed density reduction with hand weeding twice by 38.09, 58.58 and 48.94 percent over pendimethalin at 0.75 kg $ha^{-1}$ 51.75, 41.95 and 41.50 percent over imazethapyr at 40 g $ha^{-1}$at 30 DAS, 45 DAS and at harvest, respectively.

**Interaction effect on density of weeds**

Table 4.1(a) and fig. 4.1(a) indicated that intercropping systems significantly reduced the density of weeds at harvest under weedy check plots as compared to sole crops of pearl millet and legumes. Further, sole crops of moth bean being statistically at par with legume intercropping system also reduced weed density significantly, over sole

**Table 4.1 Effect of weed control measures and pearl millet legumes intercropping system on density and dry matter of weeds**

| Treatment | Weed Density (no/m$^2$) | | | Weed dry matter (g/m$^2$) | | |
|---|---|---|---|---|---|---|
| | 30 DAS | 45 DAS | At harvest | 30 DAS | 45 DAS | At harvest |
| **Intercropping** | | | | | | |
| Pearl millet sole | 6.74# (38.92)* | 6.23 (32.78) | 6.29 (33.51) | 8.61 | 97.32 | 71.72 |
| Cluster bean sole | 6.32 (33.83) | 5.81 (28.25) | 5.83 (28.40) | 6.56 | 84.13 | 62.85 |
| Moth bean sole | 6.16 (32.05) | 5.69 (26.95) | 5.73 (27.37) | 6.41 | 80.61 | 62.52 |
| PM+CB (1:2) | 6.30 (33.67) | 5.57 (25.71) | 5.72 (27.24) | 6.17 | 70.96 | 54.13 |
| PM+MB (1:2) | 6.15 (31.88) | 5.40 (23.99) | 5.43 (24.30) | 5.76 | 66.22 | 52.20 |
| S.Em.± | 1.08 | 1.31 | 1.42 | 0.32 | 3.63 | 2.55 |
| CD (P=0.05) | 3.52 | 4.28 | 4.62 | 1.05 | 11.84 | 8.32 |
| **Weed control** | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Weedy check | 9.21 (75.88) | 8.56 (64.96) | 8.43 (62.81) | 16.82 | 230.45 | 186.03 |
| Two hand weeding at 20 and 35 DAS | 4.09 (12.88) | 3.47 (8.80) | 3.77 (10.68) | 1.77 | 15.55 | 11.10 |
| Pendimethalin 0.75 kg $ha^{-1}$ as PE | 5.06 (20.81) | 5.11 (21.24) | 5.07 (20.91) | 3.09 | 37.29 | 25.34 |
| Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | 5.67 (26.70) | 4.39 (15.15) | 4.77 (18.26) | 5.13 | 36.10 | 20.26 |
| S.Em.± | 0.94 | 0.83 | 1.17 | 0.26 | 2.64 | 2.14 |
| CD (P=0.05) | 2.71 | 2.40 | 3.37 | 0.75 | 7.62 | 6.17 |

DAS**:** Days after sowing; NS**:** Non-significant; *****: Figures in parenthesis are original values, #: Weed density transformed to $\sqrt{n+0}$.

pearl millet when imazethapyr 40 g $ha^{-1}$ was at par with pendimethalin at 0.75 kg $ha^{-1}$. However, Hand weeding twice at 20 DAS and 35 DAS resulted in lowest density of weeds irrespective to cropping systems.

### 4.1.3 Dry matter of weeds

**Intercropping**

It is evident from data presented in table 4.1 and fig. 4.2 that significantly higher total dry matter of weeds was recorded under pearl millet sole at 30 DAS, 45 DAS and at harvest over all intercropping systems as well sole of both cluster bean and moth bean.

Sole cluster bean, sole moth bean, pearl millet intercrop with cluster bean and pearl millet intercrop with moth bean significantly reduced the total weed dry matter accumulation by 23.81, 25.56, 28.36 and 33.11 per cent at 30 DAS, 13.56, 17.16, 27.08 and 31.95 per cent at 45 DAS and 12.37, 12.83, 24.52 and 27.21 per cent over sole pearl millet, respectively.

Further, cluster bean as well as moth bean grown in intercropped with pearl millet reduced significantly total dry matter of weeds over sole of either cluster bean or moth bean at 45 DAS and at harvest. Pearl millet intercrop with cluster bean reduced total weed dry matter accumulation by 15.65 and 13.86 per cent over sole cluster bean and pearl millet intercrop with moth bean reduced total weed dry matter accumulation by 17.86 and 16.50 per cent over sole moth bean, respectively, at 45 DAS and at harvest.

**Weed control**

A perusal data (Table 4.1 and fig. 4.2) indicated that all weed control treatments considerably decreased the total weed dry matter over weedy check at 30 DAS, 45 DAS and at harvest.

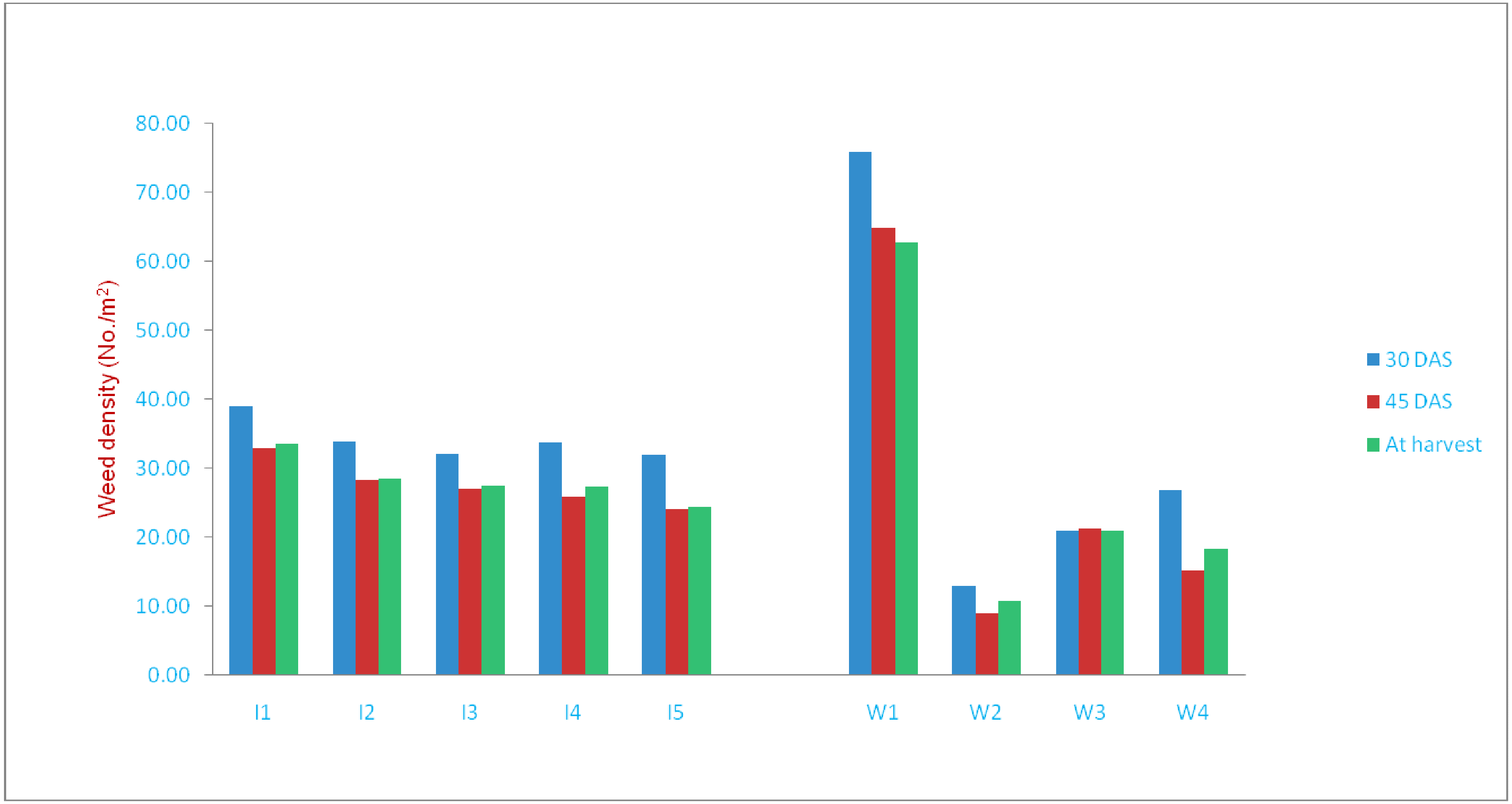



**Fig. 4.1 Effect of weed control measures and pearl millet legumes intercropping system on density of weeds**

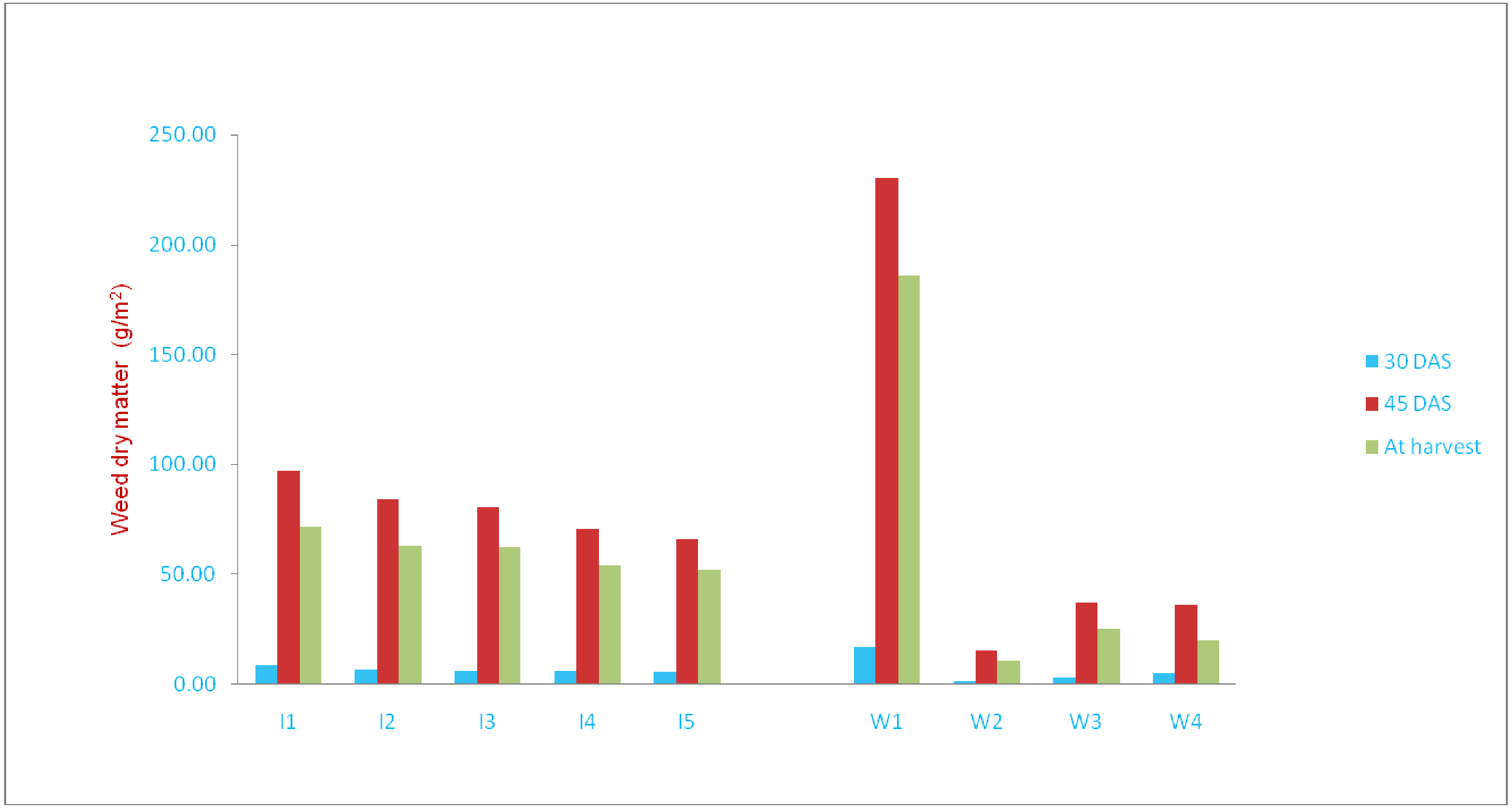

Weed dry matter (g/m2)
250.00
200.00
150.00
100.00
50.00
0.00
I1
I2
I3
I4
I5
W1
W2
W3
W4
30 DAS
45 DAS
At harvest

**Fig. 4.2 Effect of weed control measures and pearl millet legumes intercropping system on dry matter of weeds**

**Table 4.1(a): Interaction effect of weed control measures and pearl millet legumes intercropping system on density of weeds (no/$m^2$) at harvest**

| Treatments | Pearl millet sole | Cluster bean sole | Moth bean sole | PM+CB (1:2) | PM+MB (1:2) |
|---|---|---|---|---|---|
| Weedy check | 74.59 | 67.77 | 63.72 | 56.22 | 51.77 |
| Two hand weeding at 20 and 35 DAS | 12.70 | 10.40 | 9.37 | 10.90 | 10.03 |
| Pendimethalin 0.75 kg $ha^{-1}$ as PE | 22.98 | 20.37 | 20.15 | 20.84 | 20.23 |
| Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | 23.78 | 15.06 | 16.26 | 21.00 | 15.18 |
| S.Em.± | 2.60 | | | | |
| CD (P=0.05) | 7.52 | | | | |

**Table 4.1(b): Interaction effect of weed control measures and pearl millet legumes intercropping system on dry matter of weeds (g/$m^2$) at harvest**

| Treatments | Pearl millet sole | Cluster bean sole | Moth bean sole | PM+CB (1:2) | PM+MB (1:2) |
|---|---|---|---|---|---|
| Weedy check | 211.80 | 214.87 | 185.00 | 165.77 | 152.73 |
| Two hand weeding at 20 and 35 DAS | 12.33 | 7.97 | 15.58 | 7.35 | 12.27 |

| | | | | | |
|---|---|---|---|---|---|
| Pendimethalin 0.75 kg $ha^{-1}$ as PE | 30.30 | 14.43 | 30.67 | 26.63 | 24.67 |
| Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | 32.45 | 14.12 | 18.82 | 16.78 | 19.15 |
| S.Em.± | 4.78 | | | | |
| CD (P=0.05) | 13.80 | | | | |

Two hand weeding, pendimethalin at 0.75 kg ha$^{-1}$ and imazethapyr at 40 g ha$^{-1}$ reduced the weed density by 89.50, 81.65 and 69.52 per cent at 30 DAS, 93.25, 83.82 and 84.34 per cent at 45 DAS and 94.03, 86.38 and 89.11 per cent at harvest, respectively over weedy check.

Further, hand weeding twice reduced total weed dry matter significantly, over chemical herbicide at 30 DAS, 45 DAS and at harvest. Total weed dry matter reduction with hand weeding twice by 42.76, 58.30 and 56.20 percent over pendimethalin at 0.75 kg ha$^{-1}$ 65.54, 56.92 and 45.22 percent over imazethapyr at 40 g ha$^{-1}$at 30 DAS, 45 DAS and at harvest, respectively.

**Interaction effect on dry matter of weeds**

Data table 4.1b and fig. 4.2 (a) revealed that intercropping systems significantly reduced the dry matter of weeds among weedy check plots as compared to sole crops of pearl millet and legumes. Further, sole crops of cluster bean being statistically at par with sole moth bean as well as legume intercropping system also reduced dry matter of weeds significantly, over sole pearl millet when imazethapyr 40 g ha$^{-1}$ was applied. However, Hand weeding twice at 20 DAS and 35 DAS was produced lowest dry matter of weeds irrespective to cropping systems.

## 4.1.4 Weed control efficiency

**Weed control**

It is obvious from data presented in table 4.2 and fig. 4.3 that maximum weed control efficiency was recorded under two hand weeding and minimum in weedy check treatment. Among herbicidal weed control measures, pre-emergence application of pendimethalin at 0.75 kg ha$^{-1}$

have higher (81.65%) weed control efficiency as compared to imazethapyr at 40 g ha$^{-1}$ (69.52%) at 30 DAS. However, post-emergence application of imazethapyr at 40 g ha$^{-1}$ gave higher weed control efficiency (84.34 and 89.11 per cent) as compared to

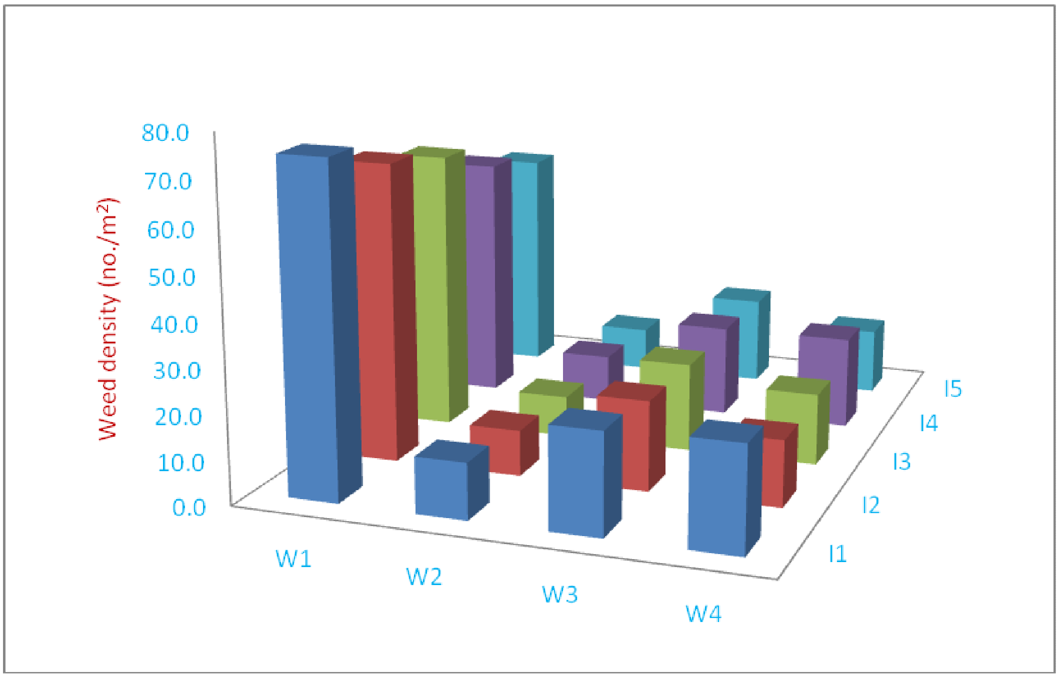



**Fig. 4.1(a) Interaction effect of weed control measures and pearl millet legumes intercropping system on density of weeds at harvest**

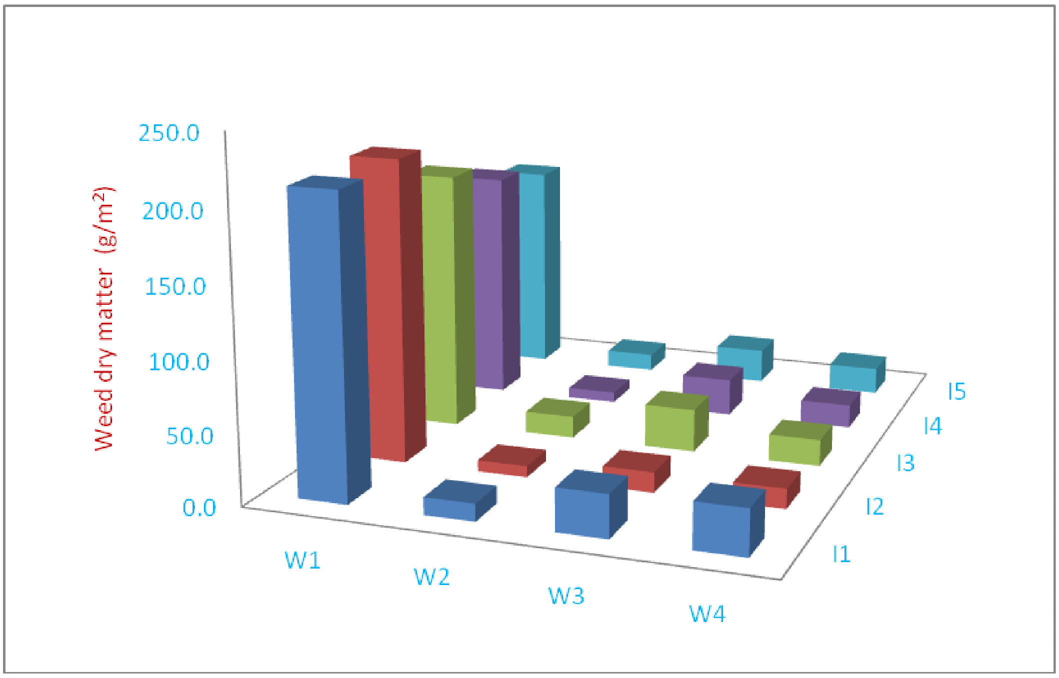



**Fig.4.2(a) Interaction effect of weed control measures and pearl millet legumes intercropping system on dry matter of weeds at harvest**

**Table 4.2 Effect of weed control measures and pearl millet legumes intercropping system on weed control efficiency and weed smothering efficiency**

| Treatments | Weed control efficiency | | | Weed smothering efficiency | | |
|---|---|---|---|---|---|---|
| | 30 DAS | 45 DAS | At harvest | 30 DAS | 45 DAS | At harvest |
| **Intercropping** | | | | | | |
| Pearl millet sole | - | - | - | - | - | - |
| Cluster bean sole | - | - | - | - | - | - |
| Moth bean sole | - | - | - | - | - | - |
| PM+CB (1:2) | - | - | - | 28.34 | 27.08 | 24.52 |
| PM+MB (1:2) | - | - | - | 33.10 | 31.95 | 27.21 |
| S.Em.± | - | - | - | - | - | - |
| CD (P=0.05) | - | - | - | - | - | - |
| **Weed control** | | | | | | |
| Weedy check | 0.00 | 0.00 | 0.00 | - | - | - |
| Two hand weeding at 20 and 35 DAS | 89.50 | 93.25 | 94.03 | - | - | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| Pendimethalin 0.75 kg $ha^{-1}$ as PE | 81.65 | 83.82 | 86.38 | - | - | - |
| Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | 69.52 | 84.34 | 89.11 | - | - | - |
| S.Em.± | - | - | - | - | - | - |
| CD (P=0.05) | - | - | - | - | - | - |

pendimethalin at 0.75 kg $ha^{-1}$ (83.82 and 86.38 per cent) at 45 DAS and at harvest, respectively.

### 4.1.5 Weed smothering efficiency

**Intercropping**

Data presented in table 4.2 and fig. 4.4 showed that maximum weed smothering efficiency was recorded under pearl millet intercropped with moth bean 33.10, 31.95 and 27.21 per cent followed by pearl millet + cluster bean intercropping system 28.34, 27.08 and 24.52 percent, respectively, at 30 DAS, 45 DAS and at harvest.

## 4.2 Crop studies

### 4.2.1 Growth and yield attributes of pearl millet

#### 4.2.1.1 Plant stand

**Intercropping**

An appraisal of data (Table 4.3) explicits that plant stand at 30 DAS and at harvest was significantly higher in pearl millet sole as compared to pearl millet intercrop with cluster bean as well as moth bean. However, plant stand observed in both intercrops pearl millet + moth bean and pearl millet + cluster bean remained statistically at par with each other. Pearl millet intercroped with cluster bean and moth bean reduced plant stand by 66.80 and 67.10 per cent at 30 DAS and 66.35 and 66.60 per cent at harvest, respectively, over sole pearl millet.

**Weed control**

It is evident from data presented in table 4.3 that herbicidal weed control measures significantly reduced plant stand at 30 DAS as compared to weedy check and two hand weedings. However, two hand weedings recorded significantly, higher plant stand of pearl millet at harvest as compared to herbicidal weed control measures and weedy

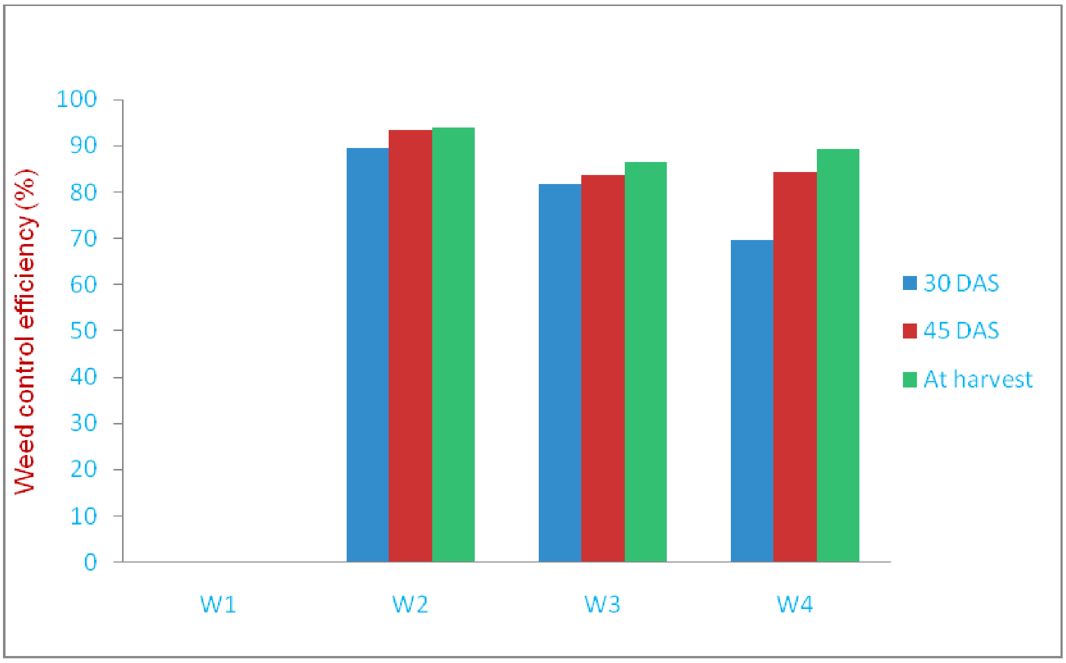



**Fig. 4.3 Effect of weed control measures on weed control efficiency**

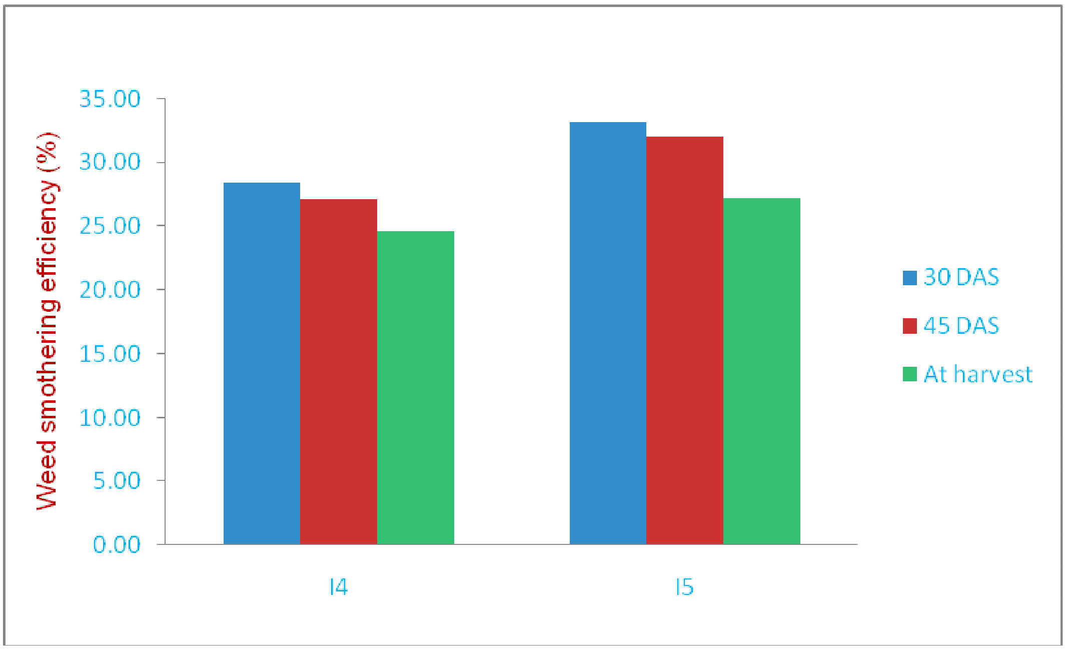



**Fig. 4.4 Effect of pearl millet legumes intercropping system on weed smothering efficiency**

**Table 4.3 Effect of weed control measures and pearl millet legumes intercropping system on plant stand, plant height and dry matter accumulation of pearl millet**

| Treatments | Plant stand ('000 $ha^{-1}$) | | Plant height (cm.) | | Dry matter accumulation (g $plant^{-1}$) | |
|---|---|---|---|---|---|---|
| | 30 DAS | At Harvest | 30 DAS | At Harvest | 30 DAS | At Harvest |
| **Intercropping** | | | | | | |
| Pearl millet sole | 211 | 204 | 42.30 | 163.10 | 10.04 | 25.94 |
| Cluster bean sole | - | - | - | - | - | - |
| Moth bean sole | - | - | - | - | - | - |
| PM+CB (1:2) | 70 | 69 | 40.57 | 161.73 | 9.86 | 30.84 |
| PM+MB (1:2) | 69 | 68 | 40.07 | 161.48 | 9.73 | 31.23 |
| S.Em.± | 2.5 | 2.7 | 0.94 | 2.96 | 0.53 | 1.22 |
| CD (P=0.05) | 10 | 11 | NS | NS | NS | NS |
| **Weed control** | | | | | | |
| Weedy check | 134 | 125 | 44.28 | 157.99 | 10.91 | 26.80 |
| Two hand weeding at 20 and 35 DAS | 137 | 135 | 45.20 | 173.58 | 12.28 | 35.03 |
| Pendimethalin 0.75 kg $ha^{-1}$ as PE | 123 | 121 | 42.50 | 168.01 | 9.76 | 31.97 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | 73 | 71 | 31.93 | 148.83 | 6.56 | 23.56 |
| S.Em.± | 2.1 | 1.9 | 1.03 | 2.61 | 0.59 | 1.07 |
| CD (P=0.05) | 6 | 6 | 3.06 | 7.76 | 1.74 | 3.19 |

check. Unweeded control, pendimethalin at 0.75 kg ha$^{-1}$ and imazethapyr at 40 g ha$^{-1}$ reduced plant stand of pearl millet by 7.37, 10.40 and 47.32 per cent at harvest, respectively over two hand weeding.

### 4.2.1.2 Plant height

**Intercropping**

A perusal of data (Table 4.3) showed that intercropping system did not affect the plant height of pearl millet significantly at all the growth stages.

**Weed control**

Data presented in table 4.3 indicated that taller plant was recorded under hand weeding twice as compared to both herbicidal weed control measures at 30 DAS and at harvest. Moreover, all weed control measures (except imazethapyr at 40 g ha$^{-1}$) significantly increased plant height of pearl millet over weedy check at harvest.

Hand weeding twice and pendimethalin at 0.75 kg ha$^{-1}$ increased plant height of pearl millet by 9.87 and 6.34 per cent over weedy check at harvest.

### 4.2.1.3 Dry matter accumulation

**Intercropping**

Data regarding dry matter accumulation of pearl millet recorded at different growth stages are presented in table 4.3 revealed that dry matter production per plant of pearl millet at 30 DAS was not influenced by intercropping system. However, at harvest dry matter production by pearl millet in intercropping system increased considerably. Pearl millet + cluster bean and pearl millet + moth bean intercropping increase 19.26 and 20.80 percent dry matter, respectively, over crop grown in sole.

**Weed control**

An examination of data (Table 4.3) revealed that all weed control measures (except imazethapyr at 40 g $ha^{-1}$) considerably increased the crop dry matter production per plant of pearl millet at 30 DAS and at harvest over unweeded control. Further, hand weeding twice produced significantly higher dry matter accumulation per plant of pearl millet at 30 DAS and at harvest as compared to both pre and post emergence application of herbicides. However, both herbicides pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ showed non significant result to each other.

Hand weeding twice at 20 and 35 DAS recorded significantly higher dry matter production of pearl millet to the tune of 25.85, 87.29 and 12.52 per cent at 30 DAS and, 16.91, 48.73 and 30.72 per cent at harvest over, pendimethalin at 0.75 kg $ha^{-1}$, imazethapyr at 40 g $ha^{-1}$ and weedy check, respectively.

## 4.2.1.4 Number of total tillers per plant

**Intercropping**

Data presented in table 4.4 revealed that total number of tillers per plant of pearl millet were significantly higher under intercropping system either with cluster bean or moth bean as compared to sole pearl millet. Intercropping with cluster bean and moth bean increased total number of tillers by 26.12 and 35.07 per cent respectively, over sole pearl millet.

**Weed control**

A perusal of data table 4.4 showed that all weed control measures (except imazethapyr at 40 g $ha^{-1}$) considerably increased total number of tillers per plant of pearl millet at harvest over weedy check. Hand weeding twice produced significantly higher total number of tillers per plant of pearl millet at harvest as compared to both pre and post emergence application of herbicides. However, both herbicides, pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ was statistically at par to each other.

Hand weeding twice at 20 and 35 DAS recorded significantly increased number of tillers per plant of pearl millet to the tune of 13.48, 56.99 and 47.80 per cent over pendimethalin at 0.75 kg $ha^{-1}$, imazethapyr at 40 g $ha^{-1}$ and weedy check, respectively.

### 4.2.1.5 Number of effective tillers per plant

**Intercropping**

It is obvious from data (Table 4.4) that effective tillers per plant of pearl millet was significantly, higher in intercropping system either with cluster bean or moth bean as compared to pearl millet sole.

Pearl millet intercropping system with cluster bean and moth bean, respectively, increased by 28.86 and 28.76 per cent effective tillers per plant of pearl millet over pearl millet sole.

**Weed control**

A perusal of data (Table 4.4) showed that all weed control measures (except imazethapyr at 40 g $ha^{-1}$)

considerably increased effective tillers per plant of pearl millet over weedy check. Hand weeding twice produced significantly higher effective tillers per plant of pearl millet as compared to both pre and post emergence application of herbicides. However, both herbicides, pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ statistically at par to each other in regard to effective tillers of pearl millet.

Hand weeding twice at 20 and 35 DAS recorded significantly increased effective tillers per plant of pearl millet to the tune of 16.89, 100 and 72.97 per cent over pendimethalin at 0.75 kg $ha^{-1}$, imazethapyr at 40 g $ha^{-1}$ and weedy check, respectively.

**Table 4.4 Effect of weed control measures and pearl millet legumes intercropping system on total number of tillers per plant, effective tillers per plant, length of ear head and test weight of pearl millet.**

| Treatment | Total tillers per plant | Effective tillers per plant | Length of ear head (cm.) | Test weight (g) |
|---|---|---|---|---|
| **Intercropping** | | | | |
| Pearl millet sole | 2.23 | 1.75 | 21.73 | 6.89 |
| Cluster bean sole | - | - | - | - |
| Moth bean sole | - | - | - | - |
| PM+CB (1:2) | 2.82 | 2.26 | 22.19 | 6.98 |
| PM+MB (1:2) | 3.02 | 2.25 | 22.74 | 7.10 |
| S.Em.± | 0.14 | 0.11 | 0.60 | 0.30 |
| CD (P=0.05) | 0.53 | 0.43 | NS | NS |
| **Weed control** | | | | |
| Weedy check | 2.28 | 1.64 | 20.73 | 6.62 |
| Two hand weeding at 20 and 35 DAS | 3.37 | 2.84 | 23.87 | 7.37 |
| Pendimethalin 0.75 kg $ha^{-1}$ as PE | 2.97 | 2.43 | 23.07 | 6.96 |
| Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | 2.14 | 1.42 | 21.21 | 7.01 |

| | | | | |
|---|---|---|---|---|
| S.Em.± | 0.13 | 0.09 | 0.44 | 0.26 |
| CD (P=0.05) | 0.39 | 0.26 | 1.32 | NS |

### 4.2.1.6 Ear head length

**Intercropping**

It is obvious from data presented in table 4.4 that ear head length of pearl millet did not affect significantly by sole pearl millet as well as intercropping system with cluster bean and moth bean.

**Weed control**

A further examination of data (Table 4.4) revealed that all weed control measures (except imazethapyr at 40 g $ha^{-1}$) produced considerably longer ear length of pearl millet over weedy check. However, Hand weeding twice and pendimethalin at 0.75 kg $ha^{-1}$ gave at par ear head length of pearl millet as compared to post emergence application of imazethapyr at 40 g $ha^{-1}$.

Hand weeding twice at 20 and 35 DAS and pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ recorded significantly increased length of ear in pearl millet to the tune of 15.15, and 11.29 per cent over weedy check, respectively.

### 4.2.1.7 Test weight

**Intercropping**

Data presented in table 4.4 indicated that test weight of pearl millet was not affected significantly due to various intercropping systems.

**Weed control**

A reference to data presented (Table 4.4) showed that test weight of pearl millet was not influenced significantly by intercropping system.

### 4.2.1.8 Grain yield

**Intercropping**

An assessment of data (Table 4.5) indicated that grain yield of pearl millet increased considerably in pearl millet sole as compared to both intercropping system with cluster bean and moth bean. However, grain yield of pearl millet produced in both intercropping system, pearl millet – cluster bean and pearl millet – moth bean was statistically at par to each other.

Sole crop increased by 58.12 and 58.39 per cent seed yield of pearl millet compared to pearl millet – cluster bean and pearl millet – moth bean cropping system, respectively.

**Weed control**

It is clear from data presented (Table 4.5) that all weed control measures (except imazethapyr at 40 g $ha^{-1}$) produced significantly higher grain yield of pearl millet over weedy check. Further, hand weeding twice statistically at par with pendimethalin at 0.75 kg $ha^{-1}$ produced significantly higher grain yield of pearl millet as compared to post emergence application of imazethapyr at 40 g $ha^{-1}$.

Hand weeding twice at 20 and 35 DAS and pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ recorded significantly higher grain yield of pearl millet to the tune of 30.76, and 13.71 per cent over weedy check, respectively

### 4.2.1.9 Straw yield

**Intercropping**

A perusal of data presented in table 4.5 revealed that straw yield of pearl millet was significantly higher in pearl millet sole as compare to pearl millet intercropping system with cluster bean and moth bean. However, straw yield of pearl millet produced in both intercropping system, pearl millet – cluster bean and pearl millet – moth bean was statistically at par to each other.

Sole crop increased by 158.67 and 152.80 per cent straw yield of pearl millet compared to pearl millet – cluster bean and pearl millet – moth bean cropping system, respectively.

**Weed control**

Data (Table 4.5) further revealed that hand weeding twice at 20 and 35 DAS produced significantly higher straw yield of pearl millet over weedy check and herbicidal weed control measures. Further, pre emergence application pendimethalin at 0.75 kg $ha^{-1}$ produced significantly higher straw yield of pearl millet as compared to post emergence application of imazethapyr at 40 g $ha^{-1}$.

Hand weeding twice increased the straw yield by 13.74, 20.21 and 36.25 percent over pendimethalin at 0.75 kg $ha^{-1}$, weedy check and imazethapyr at 40 g $ha^{-1}$, respectively.

### 4.2.1.10 Biological yield

**Intercropping**

An appraisal of data presented in table 4.5 explicits that biological yield of pearl millet sole (2625.58 kg $ha^{-1}$)

was recorded significantly higher than all other treatments. However, biological yield of pearl millet obtained from pearl millet– cluster bean intercropping system and pearl millet– moth bean intercropping system was statistically at par to each other.

Pearl millet sole recorded 151.55 and 148.35 per cent higher biological yield of pearl millet by over pearl millet – moth bean and pearl millet – cluster bean intercropping system, respectively.

**Weed control**

A reference to data presented in table 4.5 revealed that hand weeding twice at 20 and 35 DAS produced significantly higher

**Table 4.5 Effect of weed control measures and pearl millet legumes intercropping system on grain, straw and biological yield and harvest index of pearl millet**

| Treatments | Yield (kg $ha^{-1}$) | | | Harvest index (%) |
|---|---|---|---|---|
| | Grain | Straw | Biological | |
| **Intercropping** | | | | |
| Pearl millet sole | 908 | 1718 | 2626 | 35.15 |
| Cluster bean sole | - | - | - | - |
| Moth bean sole | - | - | - | - |
| PM+CB (1:2) | 380 | 664 | 1044 | 36.15 |
| PM+MB (1:2) | 378 | 680 | 1058 | 35.29 |
| S.Em.± | 20.5 | 57.4 | 50.0 | 0.81 |
| CD (P=0.05) | 80 | 225 | 196 | NS |
| **Weed control** | | | | |
| Weedy check | 500 | 987 | 1487 | 34.53 |
| Two hand weeding at 20 and 35 DAS | 654 | 1237 | 1891 | 35.74 |
| Pendimethalin 0.75 kg $ha^{-1}$ as PE | 569 | 1067 | 1636 | 35.98 |
| Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | 497 | 790 | 1287 | 35.85 |

| | | | | |
|---|---|---|---|---|
| S.Em.± | 23.3 | 35.4 | 63.9 | 0.67 |
| CD (P=0.05) | 69 | 105 | 190 | NS |

biological yield of pearl millet over weedy check and herbicidal weed control measures. Further, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ produced significantly higher biological yield of pearl millet as compared to post emergence application of imazethapyr at 40 g $ha^{-1}$.

Hand weeding twice increased the biological yield of pearl millet by 27.16, 15.60 and 47.03 per cent over weedy check, pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$, respectively.

### 4.2.1.11 Harvest index

**Intercropping**

A perusal of data (Table 4.5) revealed that harvest index of pearl millet was not influenced by intercropping system with cluster bean as well as moth bean.

**Weed control**

It is explicit from data (Table 4.5) that harvest index was not affected significantly due to different weed control measure.

## 4.2.2 Nutrient content and uptake by pearl millet

Data regarding content of nutrient viz., N, P & K and their uptake by pearl millet grain and straw are summarized in table 4.6 & 4.7

### 4.2.2.1 Nitrogen content in pearl millet grain

**Intercropping**

Data (Table 4.6) indicated that nitrogen content in pearl millet grain was increased significantly in crop grown with intercropping systems compared to sole crop. Highest nitrogen content of seed was recorded in pearl millet-cluster bean intercropping system which was statistically at par with pearl millet-moth bean intercropping system.

Pearl millet intercropped with cluster bean and moth bean increased nitrogen content of seed of pearl millet to the tune 6.40 and 5.42 per cent, respectively over sole crop of pearl millet.

**Weed control**

A reference to data presented in table 4.6 revealed that all the weed control treatments significantly increased nitrogen content in grain of pearl millet over weedy check. Highest nitrogen content in grain of pearl millet recorded under hand weeding twice being statistically at par with pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$.

The increase in nitrogen content in grain of pearl millet due to hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ was 15.89, 15.03 and 12.06 per cent, respectively over weedy check.

### 4.2.2.2 Nitrogen content in pearl millet straw

**Intercropping**

A perusal of data (Table 4.6) revealed that nitrogen content in straw of pearl millet was increased significantly in crop grown with intercropping systems compared to sole crop. Pearl millet intercropped with cluster bean and moth bean increased nitrogen content of straw of pearl millet to the tune 6.70 and 7.87 per cent, respectively over sole crop of pearl millet.

**Weed control**

A reference to data presented in table 4.6 revealed that all the weed control treatments significantly increased nitrogen content in straw of pearl millet over weedy check. However, nitrogen content in straw of pearl millet recorded under hand weeding twice being statistically at par with pendimethalin at 0.75 kg ha$^{-1}$ and imazethapyr at 40 g ha$^{-1}$.

The increase in nitrogen content in straw of pearl millet due to hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg ha$^{-1}$ and imazethapyr at 40 g ha$^{-1}$ was 25.68, 22.75 and 22.20 per cent, respectively over weedy check

### 4.2.2.3 Phosphorus content in pearl millet grain

**Intercropping**

Data (Table 4.6) indicated that phosphorus content in grain of pearl millet was not influenced by intercropping systems as well as sole crop.

**Weed control**

A reference to data presented in table 4.6 revealed that all the weed control treatments significantly increased phosphorus content in grain of pearl millet over weedy check. However, phosphorus content in grain of pearl millet recorded under hand weeding twice being statistically at par with pendimethalin at 0.75 kg ha$^{-1}$ and imazethapyr at 40 g ha$^{-1}$.

The increase in phosphorus content in grain of pearl millet due to hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg ha$^{-1}$ and imazethapyr at 40 g $ha^{-1}$ was 7.00, 5.45 and 5.09 per cent, respectively over weedy check.

### 4.2.2.4 Phosphorus content in pearl millet straw

**Intercropping**

A perusal of data (Table 4.6) revealed that phosphorus content in straw of pearl millet was not influenced by intercropping systems as well as sole crop.

**Weed control**

A reference to data presented in table 4.6 revealed that all the weed control treatments significantly increased phosphorus content in straw of pearl millet over weedy check. However, nitrogen content in straw of pearl millet recorded under hand weeding twice being statistically at par with pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$.

The magnitude of increase in phosphorus content in straw of pearl millet due to hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ was 7.89, 5.26 and 6.50 per cent, respectively over weedy check

### 4.2.2.5 Potassium content in pearl millet grain

**Intercropping**

Data (Table 4.6) showed that potassium content in grain of pearl millet was not influenced by intercropping systems as well as sole crop.

**Weed control**

It can be further seen from the data presented in table 4.6 revealed that all the weed control treatments significantly increased potassium content in grain of pearl millet over weedy check. However, hand weeding twice, pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ being statistically at par to each other in regard to potassium content in grain of pearl millet.

The increase in potassium content in grain of pearl millet due to hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ was 5.14, 3.55 and 3.54 per cent, respectively over weedy check.

### 4.2.2.6 Potassium content in pearl millet straw

**Intercropping**

A perusal of data (Table 4.6) revealed that potassium content in straw of pearl millet was not influenced by intercropping systems as well as sole crop.

**Weed control**

It is evident from data in table 4.6 that machanical weed control measure significantly increased potassium content in straw of pearl millet over herbicidal weed control measures and weedy check. While, nitrogen content in straw of pearl millet recorded under weedy check being statistically at par with pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$.

The magnitude of increase in potassium content in straw of pearl millet due to hand weeding twice at 20 and 35 DAS was 5.27, per cent, respectively over weedy check

### 4.2.2.7 Protein content in pearl millet

**Intercropping**

Data (Table 4.6) revealed that protein content in pearl millet grain was affected significantly due to various intercropping systems. Pearl millet intercrop with cluster bean recorded highest protein content in pearl millet grain which was statistically at par with pearl millet-moth bean intercropping system.

The magnitude of increase protein content of seed of pearl millet in pearl millet intercropped with cluster bean and moth bean was 6.41 and 5.42 per cent, respectively over sole crop of pearl millet.

**Weed control**

It is obvious from data (Table 4.6) that two hand weeding, pendimethalin at 0.75 kg $ha^{-1}$, and imazethapyr 40 g $ha^{-1}$, being at par

**Table 4.6 Effect of weed control measures and pearl millet legumes intercropping system on nitrogen, phosphorus, potassium and protein content in pearl millet**

| Treatments | Nitrogen content (%) | | Phosphorus content (%) | | Potassium content (%) | | Protein content (%) |
|---|---|---|---|---|---|---|---|
| | Grain | Straw | Grain | Straw | Grain | Straw | |
| **Intercropping** | | | | | | | |
| Pearl millet sole | 1.624 | 0.455 | 0.266 | 0.117 | 0.573 | 1.846 | 10.15 |
| Cluster bean sole | - | - | - | - | - | - | - |
| Moth bean sole | - | - | - | - | - | - | - |
| PM+CB (1:2) | 1.728 | 0.486 | 0.269 | 0.120 | 0.586 | 1.851 | 10.80 |
| PM+MB (1:2) | 1.712 | 0.491 | 0.271 | 0.122 | 0.586 | 1.852 | 10.70 |
| S.Em.± | 0.021 | 0.006 | 0.003 | 0.001 | 0.008 | 0.025 | 0.13 |
| CD (P=0.05) | 0.083 | 0.024 | NS | NS | NS | NS | 0.52 |
| **Weed control** | | | | | | | |
| Weedy check | 1.517 | 0.406 | 0.257 | 0.114 | 0.564 | 1.804 | 9.48 |
| Two hand weeding at 20 and 35 DAS | 1.758 | 0.510 | 0.275 | 0.123 | 0.593 | 1.899 | 10.99 |
| Pendimethalin 0.75 kg $ha^{-1}$ as PE | 1.745 | 0.498 | 0.271 | 0.120 | 0.584 | 1.850 | 10.91 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Imazethapyr 40 g ha$^{-1}$ at 25 DAS as PoE | 1.729 | 0.496 | 0.271 | 0.122 | 0.585 | 1.847 | 10.81 |
| S.Em.± | 0.019 | 0.005 | 0.003 | 0.001 | 0.007 | 0.021 | 0.12 |
| CD (P=0.05) | 0.057 | 0.016 | 0.009 | 0.004 | 0.020 | 0.063 | 0.36 |

with each other, significantly increased protein content in grain as compared to weedy check. The increase in protein content in pearl millet grain with two hand weeding treatment, imazethapyr 40 g $ha^{-1}$ and pendimethalin 0.75 kg $ha^{-1}$ was 15.87, 15.03 and 12.06 percent, respectively over weedy check.

### 4.2.2.8 Nitrogen uptake by pearl millet

**Intercropping**

Data (Table 4.7) indicated that total nitrogen uptake by pearl millet was increased significantly in sole crop compared to pearl millet grown with intercropping systems. However, total nitrogen uptake by pearl millet was recorded in pearl millet-cluster bean intercropping system and pearl millet-moth bean intercropping system was statistically at par to each other.

Sole crop of pearl millet increased total nitrogen uptake of pearl millet to the tune 131.09 and 130.66 per cent over pearl millet intercropped with cluster bean and moth bean, respectively.

**Weed control**

A further examination of data (Table 4.7) revealed that all weed control measures (except imazethapyr at 40 g $ha^{-1}$), significantly, increased total nitrogen uptake by pearl millet over weedy check. Further, hand weeding twice significantly superior as compared to pendimethalin at 0.75 kg $ha^{-1}$in regard to total nitrogen uptake by pearl millet. Post emergence application of imazethapyr at 40 g $ha^{-1}$showed lowest uptake of nitrogen by pearl millet.

Hand weeding twice at 20 and 35 DAS and pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$

recorded significantly increased total nitrogen uptake by pearl millet to the tune of 57.48, and 33.80 per cent over weedy check, respectively.

**Table 4.7 Effect of weed control measures and pearl millet legumes intercropping system on nitrogen, phosphorus and potassium uptake by pearl millet**

| Treatments | Nitrogen uptake ($kg\ ha^{-1}$) | | | Phosphorus uptake ($kg\ ha^{-1}$) | | | Potassium uptake ($kg\ ha^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Grain | Straw | Total | Grain | Straw | Total | Grain | Straw | Total |
| **Intercropping** | | | | | | | | | |
| Pearl millet sole | 14.80 | 7.88 | 22.68 | 2.42 | 2.00 | 4.42 | 5.20 | 31.85 | 37.05 |
| Cluster bean sole | - | - | - | - | - | - | - | - | - |
| Moth bean sole | - | - | - | - | - | - | - | - | - |
| PM+CB (1:2) | 6.57 | 3.24 | 9.81 | 1.02 | 0.80 | 1.82 | 2.23 | 12.30 | 14.53 |
| PM+MB (1:2) | 6.48 | 3.35 | 9.83 | 1.02 | 0.83 | 1.86 | 2.22 | 12.61 | 14.83 |
| S.Em.± | 0.51 | 0.37 | 0.86 | 0.08 | 0.09 | 0.16 | 0.16 | 1.49 | 1.64 |
| CD (P=0.05) | 1.99 | 1.47 | 3.38 | 0.30 | 0.36 | 0.65 | 0.64 | 5.84 | 6.42 |
| **Weed control** | | | | | | | | | |
| Weedy check | 7.39 | 3.90 | 11.28 | 1.27 | 1.11 | 2.38 | 2.80 | 17.86 | 20.65 |
| Two hand weeding at 20 and 35 DAS | 11.47 | 6.30 | 17.77 | 1.81 | 1.51 | 3.32 | 3.87 | 23.55 | 27.41 |
| Pendimethalin 0.75 kg $ha^{-1}$ as PE | 9.86 | 5.24 | 15.10 | 1.53 | 1.25 | 2.78 | 3.31 | 19.74 | 23.04 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | 8.42 | 3.85 | 12.27 | 1.33 | 0.99 | 2.32 | 2.89 | 14.55 | 17.43 |
| S.Em.± | 0.40 | 0.17 | 0.51 | 0.06 | 0.04 | 0.09 | 0.14 | 0.70 | 0.76 |
| CD (P=0.05) | 1.19 | 0.50 | 1.52 | 0.19 | 0.13 | 0.27 | 0.41 | 2.07 | 2.26 |

#### 4.2.2.9 Phosphorus uptake by pearl millet

**Intercropping**

An appraisal of data (Table 4.7) reflects that total phosphorus uptake by pearl millet was increased significantly in sole crop compared to pearl millet grown with intercropping systems. However, total phosphorus uptake by pearl millet was recorded in pearl millet-cluster bean intercropping system and pearl millet-moth bean intercropping system was statistically at par to each other.

Sole crop of pearl millet increased total phosphorus uptake of pearl millet to the tune 142.56 and 137.98 per cent over pearl millet intercropped with cluster bean and moth bean, respectively.

**Weed control**

An assessment of data (Table 4.7) indicates that all weed control measures (except imazethapyr at 40 g $ha^{-1}$), significantly, increased total phosphorus uptake by pearl millet over weedy check. Further, hand weeding twice significantly superior as compared to pendimethalin at 0.75 kg $ha^{-1}$in regard to total phosphorus uptake by pearl millet. Post emergence application of imazethapyr at 40 g $ha^{-1}$ showed lowest uptake of phosphorus by pearl millet.

Hand weeding twice at 20 and 35 DAS and pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ recorded significantly increased total phosphorus uptake by pearl millet to the tune of 39.81 and 16.88 per cent over weedy check, respectively.

#### 4.2.2.10 Potassium uptake by pearl millet

**Intercropping**

An appraisal of data (Table 4.7) reflects that total potassium uptake by pearl millet was increased significantly in sole crop compared to pearl millet grown with intercropping systems. However, total potassium uptake by pearl millet was recorded in pearl millet-cluster bean intercropping system and pearl millet-moth bean intercropping system was statistically at par to each other.

Sole crop of pearl millet increased total potassium uptake of pearl millet to the tune 154.95 and 149.84 per cent over pearl millet intercropped with cluster bean and moth bean, respectively.

**Weed control**

An assessment of data (Table 4.7) indicates that all weed control measures (except imazethapyr at 40 g $ha^{-1}$), significantly, increased total potassium uptake by pearl millet over weedy check. Further, hand weeding twice significantly superior as compared to pendimethalin at 0.75 kg $ha^{-1}$in regard to total potassium uptake by pearl millet. Post emergence application of imazethapyr at 40 g $ha^{-1}$ showed lowest uptake of potassium by pearl millet.

Hand weeding twice at 20 and 35 DAS and pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ recorded significantly increased total potassium uptake by pearl millet to the tune of 32.73 and 11.57 per cent over weedy check, respectively.

## 4.2.3 Growth and yield attributes of cluster bean

### 4.2.3.1 Plant stand

**Intercropping**

A perusal of data (Table 4.8) indicated that plant stand of cluster bean at 30 DAS and at harvest as sole crop was significantly higher compared to cluster bean grown with pearl millet intercropping system. Sole crop of cluster bean recorded higher plant stand by 49.16 and 50.00 per cent at 30 DAS and at harvest, respectively, compared to cluster bean grown with pearl millet intercropping system.

**Weed control**

An appraisal of data presented in table 4.8 explicits that all weed control measures recorded significantly, higher plant stand of cluster bean at harvest over weedy check. However, weed control measures found statistically at par to each other at harvest. Plant stand of cluster bean produce non significant result at 30 DAS.

Hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ recorded significantly higher plant stand of cluster bean at harvest to the tune of 7.38, 5.96 and 5.23 per cent over weedy check, respectively

### 4.2.3.2 Plant height

**Intercropping**

The assessment of data (Table 4.8) revealed that plant height at different growth stages of cluster bean was not influenced significantly due to intercropping system with pearl millet as well as sole crop.

**Weed control**

A critical examination of data (Table 4.8) indicates that all the weed control measures significantly affected the plant height at 30 DAS as well as at harvest compared to weedy check. Further, plant height of cluster bean among weed control measures found statistically at par to each other at 30 DAS and at harvest.

Hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ recorded significantly higher plant stand of cluster bean to the tune of 22.09, 15.36 and 13.54 per cent at 30 DAS and 29.91, 25.53 and 19.02 per cent at harvest, respectively, over weedy check.

**Table 4.8 Effect of weed control measures and pearl millet legumes intercropping system on plant stand, plant height and dry matter accumulation of cluster bean**

| Treatments | Plant stand ('000 ha$^{-1}$) | | Plant height (cm.) | | Dry matter accumulation (g plant$^{-1}$) | |
|---|---|---|---|---|---|---|
| | 30 DAS | At Harvest | 30 DAS | At Harvest | 30 DAS | At Harvest |
| **Intercropping** | | | | | | |
| Pearl millet sole | - | - | - | - | - | - |
| Cluster bean sole | 292 | 283 | 21.82 | 84.42 | 1.13 | 12.71 |
| Moth bean sole | - | - | - | - | - | - |
| PM+CB (1:2) | 196 | 187 | 21.04 | 83.35 | 1.20 | 12.83 |
| PM+MB (1:2) | - | - | - | - | - | - |
| S.Em.± | 2.0 | 4.2 | 0.64 | 2.53 | 0.07 | 0.57 |
| CD (P=0.05) | 12 | 26 | NS | NS | NS | NS |
| Weedy check | 243 | 225 | 18.88 | 69.88 | 1.11 | 8.90 |
| **Weed control** | | | | | | |
| Two hand weeding at 20 and 35 DAS | 246 | 242 | 23.05 | 90.78 | 1.18 | 15.15 |
| Pendimethalin 0.75 kg ha$^{-1}$ as PE | 245 | 239 | 21.78 | 87.72 | 1.24 | 13.68 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | 244 | 238 | 22.00 | 87.15 | 1.13 | 13.35 |
| S.Em.± | 1.5 | 3.9 | 0.83 | 2.52 | 0.07 | 0.47 |
| CD (P=0.05) | NS | 12.0 | 2.57 | 7.76 | NS | 1.44 |

### 4.2.3.3 Dry matter accumulation

**Intercropping**

A Perusal of data (Table 4.8) indicated that dry matter accumulation per plant of cluster bean at 30 DAS and at harvest was not influenced considerably due to intercropping system with pearl millet as well as sole crop.

**Weed control**

It is obvious from data (Table 4.8) that all weed control treatments did not cause significant effect on plant dry matter (g per plant) at 30 DAS. Data further indicates that all the weed control measures significantly affected per plant dry matter accumulation at harvest compared to weedy check. However, per plant dry matter accumulation of cluster bean due to mechanical (Hand weeding twice) weed control measure found statistically superior over both chemical weed control measures being statistically at par to each other at harvest. Hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ recorded significantly higher plant dry matter accumulation of cluster bean to the tune of 70.22, 53.71 and 29.37 per cent at harvest, respectively, over weedy check.

Hand weeding twice at 20 and 35 DAS increased plant dry matter accumulation of cluster bean to the tune of 10.75 and 13.48 per cent at harvest as compared pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$, respectively.

### 4.2.3.4 Nodules per plant

**Intercropping**

A Perusal of data (Table 4.9) indicated that number of root nodules per plant at 50 DAS of cluster bean was not influenced considerably due to intercropping system with pearl millet as well as sole crop.

**Weed control**

It is obvious from data (Table 4.9) that harvest index was not affected significantly due to different weed control measure.

### 4.2.3.5 Pods per plant

**Intercropping**

It is evident from the data (Table 4.9) that number of pods per plant of cluster bean was not influenced statistically by intercropping system. however, the highest pods per plant (35.18) were observed in sole cluster bean.

**Weed control**

An appraisal of data (Table 4.9) reflects that all weed control measures recorded significantly, higher number of pods per plant of cluster bean over weedy check. However, weed control measures brought statistically at par to each other in respect to number of pods per plant of clusterbean.

The magnitude of increase in number of pods per plant of cluster bean due to various weed control measures as hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ was 28.22, 25.38 and 16.87 per cent, respectively over weedy check.

### 4.2.3.6 Seeds per pod

**Intercropping**

The critical examination of data (Table 4.9) revealed that seeds per pod of cluster bean were not influenced significantly due to intercropping system with pearl millet as well as sole crop.

**Weed control**

Data (Table 4.9) revealed that all the weed control treatments significantly increased number of seeds per pod over weedy check. Highest seeds per pod recorded under hand weeding twice being statistically at par with pendimethalin at 0.75 kg ha$^{-1}$ and imazethapyr at 40 g ha$^{-1}$.

The increase in number of seeds per pod of cluster bean due to hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg ha$^{-1}$ and imazethapyr at 40 g ha$^{-1}$ was 38.89, 34.52 and 28.97 per cent, respectively over weedy check.

### 4.2.3.7 Test weight

**Intercropping**

A perusal of data (Table 4.9) indicated that test weight of cluster bean was not affected significantly due to intercropping system with pearl millet as well as sole crop.

**Weed control**

An assessment of data (Table 4.9) elucidates that all the weed control treatments caused non-significantly effect on test weight of cluster bean over weedy check. Whenever, maximum (31.45 g) test weight was recorded with two hand weeding treatment.

### 4.2.3.8 Grain yield

**Intercropping**

An assessment of data (Table 4.10) indicates that grain yield increased considerably in cluster bean sole as compared to cluster bean in intercropping system with pearl millet.

Sole crop increased by 46.29 per cent seed yield of cluster bean compared to pearl millet – cluster bean cropping system.

**Table 4.9 Effect of weed control measures and pearl millet legumes intercropping system on nodules, pods, seeds and test weight of cluster bean**

| Treatments | Nodules per plant | Pods per plant | Seeds per pod | Test weight (g) |
|---|---|---|---|---|
| **Intercropping** | | | | |
| Pearl millet sole | - | - | - | - |
| Cluster bean sole | 15.83 | 34.37 | 4.91 | 30.92 |
| Moth bean sole | - | - | - | - |
| PM+CB (1:2) | 14.50 | 35.18 | 5.64 | 30.60 |
| PM+MB (1:2) | - | - | - | - |
| S.Em.± | 0.84 | 0.83 | 0.23 | 0.61 |
| CD (P=0.05) | NS | NS | NS | NS |
| **Weed control** | | | | |
| Weedy check | 14.33 | 29.27 | 4.20 | 29.60 |
| Two hand weeding at 20 and 35 DAS | 16.41 | 37.53 | 5.83 | 30.78 |
| Pendimethalin 0.75 kg $ha^{-1}$ as PE | 15.05 | 36.70 | 5.65 | 31.22 |
| Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | 14.88 | 35.60 | 5.42 | 31.45 |

| | | | | |
|---|---|---|---|---|
| S.Em.± | 1.12 | 1.14 | 0.22 | 0.74 |
| CD (P=0.05) | NS | 3.52 | 0.69 | NS |

**Weed control**

It is clear from the data presented (Table 4.10) that all weed control measures produced significantly higher grain yield of cluster bean over weedy check. Moreover, hand weeding twice produced significantly higher grain yield of cluster bean as compared to both herbicidal weed control measures a.i. pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and post emergence application of imazethapyr at 40 g $ha^{-1}$ being statistically at par with each other.

Hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ recorded significantly higher grain yield of cluster bean to the tune of 88.08, 61.87 and 30.83 per cent, respectively, over weedy check.

Hand weeding twice at 20 and 35 DAS increased grain yield of cluster bean to the tune 16.20 and 19.05 per cent as compared pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$, respectively.

### 4.2.3.9 Straw yield

**Intercropping**

A perusal of data presented in table 4.10 revealed that straw yield of cluster bean was significantly higher in cluster bean sole as compare to cluster bean intercropping system with pearl millet. Sole crop increased by 49.97 per cent straw yield of cluster bean compared to pearl millet – cluster bean intercropping system, respectively.

**Weed control**

Data (Table 4.10) further revealed that hand weeding twice at 20 and 35 DAS produced significantly higher straw yield of cluster bean over weedy check and herbicidal weed control measures. However, mechanical as well as chemical weed control measures being

**Table 4.10 Effect of weed control measures and pearl millet legumes intercropping system on grain, straw and biological yield and harvest index of cluster bean**

| Treatments | Yield (kg ha$^{-1}$) | | | Harvest index (%) |
|---|---|---|---|---|
| | Grain | Straw | Biological | |
| **Intercropping** | | | | |
| Pearl millet sole | - | - | - | - |
| Cluster bean sole | 1086 | 2134 | 3220 | 33.4 |
| Moth bean sole | - | - | - | - |
| PM+CB (1:2) | 742 | 1423 | 2165 | 34.2 |
| PM+MB (1:2) | - | - | - | - |
| S.Em.± | 40.1 | 87.7 | 121.3 | 0.71 |
| CD (P=0.05) | 244 | 534 | 738 | NS |
| **Weed control** | | | | |
| Weedy check | 602 | 1267 | 1869 | 32.3 |
| Two hand weeding at 20 and 35 DAS | 1131 | 2070 | 3201 | 35.3 |
| Pendimethalin 0.75 kg ha$^{-1}$ as PE | 974 | 1886 | 2860 | 34.3 |
| Imazethapyr 40 g ha$^{-1}$ at 25 DAS as | 950 | 1892 | 2842 | 33.4 |

| | | | | |
|---|---|---|---|---|
| PoE | | | | |
| S.Em.± | 50.1 | 71.3 | 108.3 | 0.87 |
| CD (P=0.05) | 154 | 220 | 334 | 2.67 |

statistically at par to each other in reference to straw yield of cluster bean.

Hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ recorded significantly higher straw yield of cluster bean to the tune of 63.44, 48.90 and 30.18 per cent, respectively, over weedy check.

### 4.2.3.10 Biological yield

**Intercropping**

An appraisal of data presented in table 4.10 explicit that biological yield of cluster bean in sole crop was recorded significantly higher than pearl millet – cluster bean intercropping system. Cluster bean sole increased the biological yield of cluster bean by 48.71 per cent over pearl millet – cluster bean intercropping system.

**Weed control**

A reference to data presented in table 4.10 revealed that all weed control measures produced significantly higher biological yield of cluster bean over weedy check. Moreover, hand weeding twice produced significantly higher biological yield of cluster bean as compared to both herbicidal weed control measures a.i. pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and post emergence application of imazethapyr at 40 g $ha^{-1}$ being statistically at par with each other.

Hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ recorded significantly higher biological yield of cluster bean to the tune of 71.37, 53.08

and 30.41 per cent at harvest, respectively, over weedy check.

Hand weeding twice at 20 and 35 DAS increased biological yield of cluster bean to the tune 11.95 and 12.66 per cent at harvest as compared pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$, respectively.

#### 4.2.3.11 Harvest index

**Intercropping**

A perusal of data (Table 4.10) revealed that harvest index of cluster bean was not influenced by intercropping system with pearl millet as well as sole crop.

**Weed control**

It is clear from data (Table 4.10) that harvest index was significantly influenced due to mechanical weed control measure as compared to weedy check. Highest harvest index recorded under hand weeding twice being statistically at par with pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$. However, both chemical weed control measures being statistically at par with weedy check.

Hand weeding twice at 20 and 35 DAS, increase harvest index of cluster bean by 9.15 per cent over weedy check.

### 4.2.4 Nutrient content and uptake by cluster bean

Data regarding content of nutrient viz., N, P & K and their uptake by cluster bean grain and straw are summarized in table 4.11, & 4.12.

#### 4.2.4.1 Nitrogen content in cluster bean grain

**Intercropping**

A perusal of data (Table 4.11) revealed that nitrogen content in grain of cluster bean was not influenced by intercropping system with pearl millet as well as sole crop.

**Weed control**

A reference to data presented in table 4.11 revealed that all the weed control treatments significantly increased nitrogen content in grain of cluster bean over weedy check. Highest nitrogen content in grain of cluster bean recorded under hand weeding twice being statistically at par with pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$.

The increase in nitrogen content in grain of cluster bean due to hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ was 7.32, 5.56 and 4.53 per cent, respectively over weedy check.

#### 4.2.4.2 Nitrogen content in cluster bean straw

**Intercropping**

A perusal of data (Table 4.11) revealed that nitrogen content in straw of cluster bean was not influenced by intercropping systems as well as sole crop.

**Weed control**

A reference to data presented in table 4.11 revealed that hand weeding twice, significantly increased nitrogen content in straw of cluster bean over weedy check. However, nitrogen content in straw of cluster bean recorded under pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ being statistically at par with weedy check.

The increase in nitrogen content in straw of cluster bean due to hand weeding twice at 20 and 35 DAS was 7.38 per cent, respectively over weedy check.

#### 4.2.4.3 Phosphorus content in cluster bean grain

**Intercropping**

Data (Table 4.11) indicated that phosphorus content in cluster bean grain of pearl millet was not influenced by intercropping systems as well as sole crop.

**Weed control**

A reference to data presented in table 4.11 revealed that all the weed control treatments significantly increased phosphorus content in grain of cluster bean over weedy check. However, phosphorus content in grain of cluster bean recorded under hand weeding twice being statistically at par with pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$.

The increase in phosphorus content in grain of cluster bean due to hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ was 7.43, 4.70 and 4.38 per cent, respectively over weedy check.

#### 4.2.4.4 Phosphorus content in cluster bean straw

**Intercropping**

A perusal of data (Table 4.11) revealed that phosphorus content in straw of cluster bean was not influenced by intercropping systems as well as sole crop.

**Weed control**

A reference to data presented in table 4.11 revealed that hand weeding twice significantly increased phosphorus content in straw of cluster bean over weedy check, pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$. However, nitrogen content in straw of cluster bean recorded under weedy check being statistically at par with pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$.

The magnitude of increase in phosphorus content in straw of cluster bean due to hand weeding twice at 20 and 35 DAS was 6.88 per cent, respectively over weedy check

### 4.2.4.5 Potassium content in cluster bean grain

**Intercropping**

Data (Table 4.11) show that potassium content in cluster bean grain was not influenced by intercropping systems as well as sole crop.

**Weed control**

It can be further seen from the data presented in table 4.11 that all the weed control treatments significantly increased potassium content in grain of cluster bean over weedy check. However, hand weeding twice, pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ being statistically at par to each other in regard to potassium content in grain of cluster bean.

The increase in potassium content in grain of cluster bean due to hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg ha$^{-1}$ and imazethapyr at 40 g ha$^{-1}$ was 7.42, 5.22 and 4.09 per cent, respectively over weedy check.

### 4.2.4.6 Potassium content in cluster bean straw

**Intercropping**

A perusal of data (Table 4.11) revealed that potassium content in straw of cluster bean was not influenced by intercropping systems as well as sole crop.

**Weed control**

It is evident from data in table 4.11 that all the weed control treatments significantly increased potassium content in straw of cluster bean over weedy check. However, hand weeding twice, pendimethalin at 0.75 kg ha$^{-1}$ and imazethapyr at 40 g ha$^{-1}$ being statistically at par to each other in regard to potassium content in straw of cluster bean.

**Table 4.11 Effect of weed control measures and pearl millet legumes intercropping system on nitrogen, phosphorus, potassium and protein content in cluster bean**

| Treatments | Nitrogen content (%) | | Phosphorus content (%) | | Potassium content (%) | | Protein content (%) |
|---|---|---|---|---|---|---|---|
| | Grain | Straw | Grain | Straw | Grain | Straw | |
| **Intercropping** | | | | | | | |
| Pearl millet sole | - | - | - | - | - | - | - |
| Cluster bean sole | 3.593 | 0.855 | 0.427 | 0.261 | 0.386 | 0.620 | 22.46 |
| Moth bean sole | - | - | - | - | - | - | - |
| PM+CB (1:2) | 3.543 | 0.845 | 0.415 | 0.249 | 0.373 | 0.612 | 22.15 |
| PM+MB (1:2) | - | - | - | - | - | - | - |
| S.Em.± | 0.036 | 0.008 | 0.004 | 0.003 | 0.004 | 0.007 | 0.22 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS |
| **Weed control** | | | | | | | |
| Weedy check | 3.417 | 0.827 | 0.404 | 0.247 | 0.364 | 0.583 | 21.35 |
| Two hand weeding at 20 and 35 DAS | 3.667 | 0.888 | 0.434 | 0.264 | 0.391 | 0.640 | 22.92 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Pendimethalin 0.75 kg $ha^{-1}$ as PE | 3.607 | 0.844 | 0.423 | 0.255 | 0.383 | 0.621 | 22.54 |
| Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | 3.583 | 0.843 | 0.423 | 0.254 | 0.380 | 0.619 | 22.40 |
| S.Em.± | 0.049 | 0.012 | 0.006 | 0.003 | 0.005 | 0.009 | 0.31 |
| CD (P=0.05) | 0.152 | 0.036 | 0.018 | 0.010 | 0.017 | 0.026 | 0.95 |

The increase in potassium content in straw of cluster bean due to hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ was 9.78, 6.52 and 5.63 per cent, respectively over weedy check.

### 4.2.4.7 Protein content in cluster bean grain

**Intercropping**

Data (Table 4.11) revealed that protein content in cluster bean grain was not influenced by intercropping systems as well as sole crop.

**Weed control**

It is obvious from data (Table 4.11) that two hand weeding, pendimethalin at 0.75 kg $ha^{-1}$, and imazethapyr 40 g $ha^{-1}$, being at par with each other, significantly increased protein content in cluster bean as compared to weedy check.

The increase in protein content in cluster bean grain with two hand weeding treatment, imazethapyr 40 g $ha^{-1}$ and pendimethalin 0.75 kg $ha^{-1}$ was 7.32, 5.56 and 4.55 percent, respectively over weedy.

### 4.2.4.8 Nitrogen uptake by cluster bean

**Intercropping**

Data (Table 4.12) indicated that total nitrogen uptake by cluster bean was increased significantly in sole crop compared to cluster bean grown in intercropping system with pearl millet.

Sole crop of cluster bean increased total nitrogen uptake of cluster bean to the tune 50.02 per cent over cluster bean intercropped with pearl millet.

**Weed control**

A further examination of data (Table 4.12) revealed that all weed control measures, significantly, increased total nitrogen uptake by

**Table 4.12 Effect of weed control measures and pearl millet legumes intercropping system on nitrogen, phosphorus and potassium uptake by cluster bean**

| Treatments | Nitrogen uptake ($kg\ ha^{-1}$) | | | Phosphorus uptake ($kg\ ha^{-1}$) | | | Potassium uptake ($kg\ ha^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Grain | Straw | Total | Grain | Straw | Total | Grain | Straw | Total |
| **Intercropping** | | | | | | | | | |
| Pearl millet sole | - | - | - | - | - | - | - | - | - |
| Cluster bean sole | 39.33 | 18.37 | 57.69 | 4.67 | 5.59 | 10.26 | 4.24 | 13.32 | 17.56 |
| Moth bean sole | - | - | - | - | - | - | - | - | - |
| PM+CB (1:2) | 26.42 | 12.04 | 38.46 | 3.10 | 3.56 | 6.65 | 2.78 | 8.74 | 11.52 |
| PM+MB (1:2) | - | - | - | - | - | - | - | - | - |
| S.Em.± | 1.48 | 0.83 | 2.22 | 0.18 | 0.25 | 0.41 | 0.16 | 0.61 | 0.75 |
| CD (P=0.05) | 9.00 | 5.05 | 13.50 | 1.07 | 1.52 | 2.48 | 0.99 | 3.70 | 4.55 |
| **Weed control** | | | | | | | | | |
| Weedy check | 20.58 | 10.46 | 31.04 | 2.44 | 3.15 | 5.58 | 2.19 | 7.39 | 9.58 |
| Two hand weeding at 20 and 35 DAS | 41.63 | 18.48 | 60.10 | 4.93 | 5.50 | 10.43 | 4.46 | 13.30 | 17.76 |
| Pendimethalin 0.75 $kg\ ha^{-1}$ as PE | 35.17 | 15.93 | 51.09 | 4.12 | 4.80 | 8.92 | 3.74 | 11.70 | 15.44 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | 34.11 | 15.96 | 50.07 | 4.05 | 4.85 | 8.90 | 3.64 | 11.75 | 15.39 |
| S.Em.± | 1.99 | 0.63 | 2.45 | 0.24 | 0.19 | 0.38 | 0.22 | 0.46 | 0.62 |
| CD (P=0.05) | 6.13 | 1.93 | 7.53 | 0.72 | 0.58 | 1.18 | 0.66 | 1.40 | 1.90 |

cluster bean over weedy check. Further, hand weeding twice, significantly superior as compared to pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ in regard to total nitrogen uptake by cluster bean.

Hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 $gha^{-1}$ recorded significantly higher total nitrogen uptake by cluster bean to the tune of 93.65, 64.63 and 31.67 per cent over weedy check, respectively. The magnitude of increased total nitrogen uptake by cluster bean in hand weeding twice at 20 and 35 DAS was 17.63 and 20.03 per cent as compared to pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$, respectively.

### 4.2.4.9 Phosphorus uptake by cluster bean

**Intercropping**

An appraisal of data (Table 4.12) reflects that total phosphorus uptake by cluster bean was increased significantly in sole crop compared to cluster bean grown in intercropping system with pearl millet.

Sole crop of cluster bean increased total phosphorus uptake of cluster bean to the tune 54.22 per cent over cluster bean intercropped with pearl millet.

**Weed control**

An assessment of data (Table 4.12) indicated that all weed control measures, significantly, increased total phosphorus uptake by cluster bean over weedy check. Further, hand weeding twice significantly superior as compared to pendimethalin at 0.75 kg $ha^{-1}$ and post emergence application of imazethapyr at 40 g $ha^{-1}$in regard to total phosphorus uptake by cluster bean.

Hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and post emergence application of imazethapyr at 40 g $ha^{-1}$ increased total phosphorus uptake by cluster bean to the tune of 86.73, 59.65 and 31.76 per cent over weedy check, respectively.

### 4.2.4.10 Potassium uptake by cluster bean

**Intercropping**

An appraisal of data (Table 4.12) reflects that total potassium uptake by cluster bean was increased significantly in sole crop compared to cluster bean grown with intercropping system with pearl millet.

Sole crop increased total potassium uptake by cluster bean to the tune 52.42 per cent over cluster bean intercropped with pearl millet.

**Weed control**

An assessment of data (Table 4.12) indicates that all weed control measures, significantly, increased total potassium uptake by cluster bean over weedy check. Further, hand weeding twice significantly superior as compared to pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$in regard to total potassium uptake by cluster bean.

Hand weeding twice at 20 and 35 DAS and pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and post emergence application of imazethapyr at 40 g $ha^{-1}$ recorded significantly increased total potassium uptake by cluster bean to the tune of 85.29, 61.07 and 32.68 per cent over weedy check, respectively. The magnitude of increased total potassium uptake by cluster bean in hand weeding twice at 20 and 35 DAS was 15.04 and 15.40 per cent as compared pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$, respectively.

## 4.2.5 Growth and yield attributes of moth bean

### 4.2.5.1 Plant stand

**Intercropping**

A perusal of data (Table 4.13) indicated that plant stand in sole moth bean was significantly higher as compared to pearl millet-moth bean intercropping system. Intercropping system decreased 32.97 and 34.34 per cent plant stand of moth bean at 30 DAS and at harvest, respectively, as compared to sole crop.

**Weed control**

A critical examination of data (Table 4.13) indicates that plant stand of moth bean produce non significant result at 30 DAS. Further, revealed data that all weed control measures recorded significantly, higher plant stand of moth bean at harvest over weedy check. However, weed control measures found statistically at par to each other at harvest.

Hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ recorded significantly higher plant stand of moth bean at harvest to the tune of 10.17, 8.75 and 7.53 per cent over weedy check, respectively

### 4.2.5.2 Plant height

**Intercropping**

A Perusal of data (Table 4.13) indicated that plant height at 30 DAS and at harvest of moth bean was not influenced significantly due to pearl millet-moth bean intercropping system. Moreover, sole moth bean produced taller plant (24.41 cm) at harvest.

**Table 4.13 Effect of weed control measures and pearl millet legumes intercropping system on plant stand, plant height and dry matter accumulation of moth bean**

| Treatments | Plant stand ('000 $ha^{-1}$) | | Plant height (cm.) | | Dry matter accumulation (g $plant^{-1}$) | |
|---|---|---|---|---|---|---|
| | 30 DAS | At Harvest | 30 DAS | At Harvest | 30 DAS | At Harvest |
| **Intercropping** | | | | | | |
| Pearl millet sole | - | - | - | - | - | - |
| Cluster bean sole | - | - | - | - | - | - |
| Moth bean sole | 287 | 276 | 14.32 | 24.41 | 4.40 | 16.38 |
| PM+CB (1:2) | - | - | - | - | - | - |
| PM+MB (1:2) | 192 | 182 | 13.98 | 23.30 | 4.27 | 15.62 |
| S.Em.± | 6.5 | 7.1 | 0.30 | 0.93 | 0.17 | 0.58 |
| CD (P=0.05) | 39 | 43 | NS | NS | NS | NS |
| **Weed control** | | | | | | |
| Weedy check | 238 | 215 | 12.98 | 20.33 | 3.06 | 12.25 |
| Two hand weeding at 20 and 35 DAS | 241 | 237 | 15.17 | 26.05 | 5.31 | 19.30 |
| Pendimethalin 0.75 kg $ha^{-1}$ as PE | 240 | 233 | 14.32 | 24.72 | 4.64 | 16.73 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | 239 | 232 | 14.13 | 24.32 | 4.34 | 15.70 |
| S.Em.± | 5.2 | 5.5 | 0.42 | 1.22 | 0.20 | 0.81 |
| CD (P=0.05) | NS | 17 | 1.28 | 3.75 | 0.61 | 2.49 |

**Weed control**

A reference to data presented in table 4.13 revealed that all weed control measures (Except imazethapyr at 40 g $ha^{-1}$ at 30 DAS) significantly affected the plant height of moth bean at 30 DAS as well as at harvest compared to weedy check. Further, plant height of moth bean among weed control measures found statistically at par to each other at 30 DAS and at harvest.

Hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ recorded significantly higher plant stand of moth bean to the tune of 16.87, 10.32 and 7.58 per cent at 30 DAS and 28.14, 21.59 and 15.32 per cent at harvest, respectively, over weedy check.

### 4.2.5.3 Dry matter accumulation

**Intercropping**

The assessment of data (Table 4.13) revealed that dry matter accumulation per plant of moth bean at 30 DAS and at harvest was not affected significantly by intercropping treatment. However, maximum dry matter accumulation in moth bean was recorded 4.40 and 16.38 g per plant under sole crop at 30 DAS and at harvest, respectively.

**Weed control**

It is obvious from data (Table 4.13) that all the weed control measures significantly affected per plant dry matter accumulation at 30 DAS and at harvest compared to weedy check. However, per plant dry matter accumulation of moth bean due to mechanical (Hand weeding twice) weed control measure showed statistically superior over both chemical weed control measures being statistically at par to each other at harvest.

Hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ recorded significantly higher plant dry matter accumulation of moth bean to the tune of 73.53, 51.63 and 24.11 per cent at 30 DAS and 57.55, 36.57 and 17.88 per cent at harvest, respectively, over weedy check.

Hand weeding twice at 20 and 35 DAS increased plant dry matter accumulation of moth bean to the tune 14.44 and 22.35 per cent at 30 DAS and 15.36 and 22.93 per cent at harvest as compared pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$, respectively.

### 4.2.5.4 Nodules per plant

**Intercropping**

A Perusal of data (Table 4.14) indicated that number of root nodules per plant at 50 DAS of moth bean was not influenced considerably due to intercropping system with pearl millet as well as sole crop.

**Weed control**

An assessment of data (Table 4.14) revealed that all the weed control treatments brought about non-significant effect on number of nodules per plant of moth bean**.** Data further indicated that number of nodules per plant at 50 DAS was recorded highest 13.47 and lowest 11.10 per plant with two hand weeding and weedy check, respectively.

### 4.2.5.5 Pods per plant

**Intercropping**

It is evident from the data (Table 4.14) that number of pods per plant of moth bean was not influenced statistically by intercropping system. however, the highest pods per plant were observed in sole moth bean.

**Weed control**

An appraisal of data (Table 4.14) reflects that all weed control measures recorded significantly, higher number of pods per plant of moth bean over weedy check. However, weed control measures brought statistically at par to each other in respect to number of pods per plant of moth bean.

The magnitude of increase in number of pods per plant of moth bean due to various weed control measures as hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ was 12.90, 10.74 and 7.63 per cent, respectively over weedy check.

### 4.2.5.6 Seeds per pod

**Intercropping**

The critical examination of data (Table 4.14) revealed that seeds per pod of moth bean were not influenced significantly due to intercropping system with pearl millet as well as sole crop.

**Weed control**

Data (Table 4.14) revealed that all the weed control treatments significantly increased number of seeds per pod over weedy check. Highest seeds per pod recorded under hand weeding twice being statistically at par with pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$.

The increase in number of seeds per pod of moth bean due to hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ was 31.21, 18.01 and 16.60 per cent, respectively over weedy check.

**Table 4.14 Effect of weed control measures and pearl millet legumes intercropping system on nodules, pods, seeds and test weight of moth bean**

| Treatment | Nodules per plant | Pods per plant | Seeds per pod | Test weight (g) |
|---|---|---|---|---|
| **Intercropping** | | | | |
| Pearl millet sole | - | - | - | - |
| Cluster bean sole | - | - | - | - |
| Moth bean sole | 12.75 | 32.50 | 5.33 | 24.67 |
| PM+CB (1:2) | - | - | - | - |
| PM+MB (1:2) | 11.68 | 34.50 | 5.62 | 25.09 |
| S.Em.± | 0.60 | 0.80 | 0.29 | 0.63 |
| CD (P=0.05) | NS | NS | NS | NS |
| **Weed control** | | | | |
| Weedy check | 11.10 | 31.00 | 4.70 | 23.45 |
| Two hand weeding at 20 and 35 DAS | 13.47 | 35.00 | 6.17 | 24.95 |
| Pendimethalin 0.75 kg $ha^{-1}$ as PE | 12.40 | 34.33 | 5.55 | 25.30 |
| Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | 11.90 | 33.67 | 5.48 | 25.82 |

| | | | | |
|---|---|---|---|---|
| S.Em.± | 0.83 | 0.70 | 0.23 | 0.85 |
| CD (P=0.05) | NS | 2.13 | 0.71 | NS |

#### 4.2.5.7 Test weight

**Intercropping**

A perusal of data (Table 4.14) indicated that test weight of moth bean was not affected significantly due to intercropping system with pearl millet as well as sole crop.

**Weed control**

An assessment of data (Table 4.14) elucidates that all the weed control treatments caused non-significantly effect on test weight of moth bean over weedy check. Whenever, maximum test weight was recorded with two hand weeding treatment.

#### 4.2.5.8 Grain yield of moth bean

**Intercropping**

An assessment of data (Table 4.15) indicated that grain yield of moth bean increased considerably in sole crop as compared to moth bean in intercropping system with pearl millet.

Sole crop increased by 31.95 per cent seed yield of moth bean compared to pearl millet – moth bean cropping system.

**Weed control**

It is clear from data presented (Table 4.15) that all weed control measures produced significantly higher grain yield of moth bean over weedy check. Moreover, hand weeding twice produced significantly higher grain yield of moth bean as compared to both herbicidal weed control measures i.e. pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and post emergence application of imazethapyr at 40 g $ha^{-1}$ being statistically at par with each other.

The magnitude of increase in grain yield of moth bean due to various weed control measures as hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ was 74.71, 49.43 and 27.04 per cent, respectively over weedy check.

Hand weeding twice at 20 and 35 DAS increased grain yield of moth bean to the tune 16.92 and 18.65 per cent as compared pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$, respectively.

#### 4.2.5.9 Straw yield

**Intercropping**

A perusal of data presented in table 4.15 revealed that straw yield of moth bean was significantly higher in sole crop as compare to moth bean in intercropping system with pearl millet.

Sole crop increased straw yield of moth bean by 38.71 per cent compared to pearl millet – moth bean cropping system.

**Weed control**

Data (Table 4.15) further revealed that hand weeding twice at 20 and 35 DAS produced significantly higher straw yield of moth bean over weedy check and herbicidal weed control measures. Moreover, mechanical weed control measures, significantly superior to chemical weed control measures in respect straw yield of moth bean.

Hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ recorded significantly higher straw yield of moth bean to the tune of 52.47, 25.04 and 14.34 per cent, respectively, over weedy check.

Hand weeding twice at 20 and 35 DAS increased straw yield of moth bean to the tune 21.94 and 25.12 per cent as compared pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$, respectively.

### 4.2.5.10 Biological yield

**Intercropping**

An appraisal of data presented in table 4.15 explicit that biological yield of moth bean in sole crop was recorded significantly higher than pearl millet – moth bean intercropping system. Moth bean sole increased the biological yield of moth bean by 36.75 per cent over pearl millet – moth bean intercropping system.

**Weed control**

A reference to data presented in table 4.15 revealed that all weed control measures produced significantly higher biological yield of moth bean over weedy check. Moreover, hand weeding twice produced significantly higher biological yield of moth bean as compared to both herbicidal weed control measures *i.e.* pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and post emergence application of imazethapyr at 40 g $ha^{-1}$ being statistically at par with each other.

The significant increase of biological yield of moth bean due to hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg ha$^{-1}$ and imazethapyr at 40 g ha$^{-1}$ was 58.49, 31.64 and 18.13 per cent at harvest, respectively, over weedy check.

Hand weeding twice at 20 and 35 DAS increased biological yield of moth bean to the tune 20.40 and 23.12 per cent at harvest as compared pre emergence application of pendimethalin at 0.75 kg ha$^{-1}$ and imazethapyr at 40 g ha$^{-1}$, respectively.

**4.2.5.11 Harvest index**

**Intercropping**

A perusal of data (Table 4.15) revealed that harvest index of moth bean was not influenced by intercropping system with pearl millet as well as sole crop.

**Table 4.15 Effect of weed control measures and pearl millet legumes intercropping system on grain, straw and biological yield and harvest index of moth bean**

| Treatments | Yield (kg ha$^{-1}$) | | | Harvest index (%) |
|---|---|---|---|---|
| | Grain | Straw | Biological | |
| **Intercropping** | | | | |
| Pearl millet sole | - | - | - | - |
| Cluster bean sole | - | - | - | - |
| Moth bean sole | 794 | 1949 | 2743 | 28.8 |
| PM+CB (1:2) | - | - | - | - |
| PM+MB (1:2) | 540 | 1194 | 1734 | 30.9 |
| S.Em.± | 28.7 | 78.8 | 109.6 | 0.9 |
| CD (P=0.05) | 174 | 479 | 667 | NS |
| **Weed control** | | | | |
| Weedy check | 467 | 1259 | 1726 | 27.6 |
| Two hand weeding at 20 and 35 DAS | 816 | 1919 | 2735 | 30.3 |
| Pendimethalin 0.75 kg ha$^{-1}$ as PE | 697 | 1574 | 2271 | 30.9 |
| Imazethapyr 40 g ha$^{-1}$ at 25 DAS as | 687 | 1534 | 2221 | 30.7 |

| | | | | |
|---|---|---|---|---|
| PoE | | | | |
| S.Em.± | 37.6 | 83.6 | 125.8 | 0.8 |
| CD (P=0.05) | 116 | 257 | 388 | 2.6 |

**Weed control**

Data (Table 4.15) revealed that all the weed control treatments significantly increased harvest index over weedy check. Highest harvest index recorded under hand weeding twice being statistically at par with pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$.

The increase in harvest index of moth bean due to hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ was 9.64, 11.99 and 10.24 per cent, respectively over weedy check.

## 4.2.6 Nutrient content and uptake by moth bean

Data regarding content of nutrient viz., N, P & K and their uptake by moth bean grain and straw are summarized in table 4.16 & 4.17.

### 4.2.6.1 Nitrogen content in moth bean grain

**Intercropping**

A perusal of data (Table 4.16) revealed that nitrogen content in grain of moth bean was not influenced by intercropping system with pearl millet as well as sole crop.

**Weed control**

A reference to data presented in table 4.16 revealed that all the weed control treatments significantly increased nitrogen content in grain of moth bean over weedy check. Highest nitrogen content in grain of moth bean recorded under hand weeding twice being statistically at par with pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$.

The increase in nitrogen content in grain of moth bean due to hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ was 5.84, 5.17 and 4.56 per cent, respectively over weedy check.

### 4.2.6.2 Nitrogen content in moth bean straw

**Intercropping**

A perusal of data (Table 4.16) revealed that nitrogen content in straw of moth bean was not influenced by intercropping systems as well as sole crop.

**Weed control**

A reference to data presented in table 4.16 revealed that all weed control measures, significantly increased nitrogen content in straw of moth bean over weedy check. However, nitrogen content in straw of moth bean recorded under hand weeding twice at 20 and 35 DAS, pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ being statistically at par with each other.

The increase in nitrogen content in straw of moth bean due to hand weeding twice at 20 and 35 DAS, pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ was 5.78, 5.40 and 4.25 per cent, respectively over weedy check.

### 4.2.6.3 Phosphorus content in moth bean grain

**Intercropping**

Data (Table 4.16) indicated that phosphorus content in moth bean grain of pearl millet was not influenced by intercropping systems as well as sole crop.

**Weed control**

A reference to data presented in table 4.16 revealed that all the weed control treatments significantly increased phosphorus content in grain of moth bean over weedy check. However, phosphorus content in grain of moth bean recorded under hand weeding twice being statistically at par with pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$.

The increase in phosphorus content in grain of moth bean due to hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ was 13.05, 10.97 and 11.78 per cent, respectively over weedy check.

### 4.2.6.4 Phosphorus content in moth bean straw

**Intercropping**

A perusal of data (Table 4.16) revealed that phosphorus content in straw of moth bean was not influenced by intercropping systems as well as sole crop.

**Weed control**

A reference to data presented in table 4.16 revealed all weed control measures, significantly increased phosphorus content in straw of moth bean over weedy check. However, hand weeding twice, pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ being statistically at par to each other.

The magnitude of increase in phosphorus content in straw of moth bean due to hand weeding twice at 20 and 35 DAS, pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at

40 g ha$^{-1}$ was 14.35, 9.26 and 6.88 per cent, respectively over weedy check.

### 4.2.6.5 Potassium content in moth bean grain

**Intercropping**

Data (Table 4.16) show that potassium content in moth bean grain was not influenced by intercropping systems as well as sole crop.

**Weed control**

It can be further seen from the data presented in table 4.16 revealed that all the weed control treatments significantly increased potassium content in grain of moth bean over weedy check.

**Table 4.16 Effect of weed control measures and pearl millet legumes intercropping system on nitrogen, phosphorus, potassium and protein content in moth bean**

| Treatments | Nitrogen content (%) | | Phosphorus content (%) | | Potassium content (%) | | Protein content (%) |
|---|---|---|---|---|---|---|---|
| | Grain | Straw | Grain | Straw | Grain | Straw | |
| **Intercropping** | | | | | | | |
| Pearl millet sole | - | - | - | - | - | - | - |
| Cluster bean sole | - | - | - | - | - | - | - |
| Moth bean sole | 3.606 | 0.822 | 0.426 | 0.239 | 0.375 | 0.732 | 22.60 |
| PM+CB (1:2) | - | - | - | - | - | - | |
| PM+MB (1:2) | 3.590 | 0.796 | 0.412 | 0.227 | 0.364 | 0.725 | 22.50 |
| S.Em.± | 0.041 | 0.009 | 0.004 | 0.002 | 0.004 | 0.008 | 0.26 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS |
| **Weed control** | | | | | | | |
| Weedy check | 3.461 | 0.778 | 0.383 | 0.216 | 0.355 | 0.710 | 21.88 |
| Two hand weeding at 20 and 35 DAS | 3.663 | 0.823 | 0.433 | 0.247 | 0.377 | 0.753 | 22.89 |
| Pendimethalin 0.75 kg $ha^{-1}$ as PE | 3.640 | 0.820 | 0.425 | 0.236 | 0.375 | 0.728 | 22.75 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Imazethapyr 40 g ha$^{-1}$ at 25 DAS as PoE | 3.628 | 0.813 | 0.434 | 0.233 | 0.372 | 0.724 | 22.67 |
| S.Em.± | 0.050 | 0.011 | 0.006 | 0.003 | 0.005 | 0.010 | 0.31 |
| CD (P=0.05) | 0.153 | 0.034 | 0.018 | 0.010 | 0.016 | 0.031 | 0.96 |

However, hand weeding twice, pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ being statistically at par to each other in regard to potassium content in grain of moth bean.

The increase in potassium content in grain of moth bean due to hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ was 6.20, 5.63 and 4.51 per cent, respectively over weedy check.

### 4.2.6.6 Potassium content in moth bean straw

**Intercropping**

A perusal of data (Table 4.16) revealed that potassium content in straw of moth bean was not influenced by intercropping systems as well as sole crop.

**Weed control**

It is evident from data in table 4.16 that two hand weeding significantly increased potassium content in straw of moth bean over weedy check. However, hand weeding twice, pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ being statistically at par to each other in regard to potassium content in straw of moth bean.

The increase in potassium content in straw of moth bean due to hand weeding twice at 20 and 35 DAS was 6.06 per cent, respectively over weedy check.

### 4.2.6.7 Protein content in moth bean grain

**Intercropping**

Data (Table 4.16) revealed that protein content in moth bean grain was not influenced by intercropping systems as well as sole crop.

### Weed control

It is obvious from data (Table 4.16) that two hand weeding, significantly increased protein content in moth bean as compared to weedy check. However, two hand weeding, pendimethalin at 0.75 kg $ha^{-1}$, and imazethapyr 40 g $ha^{-1}$, being at par with each.

The increase in protein content in moth bean grain with two hand weeding treatment was 4.62 percent, respectively over weedy check.

## 4.2.6.8 Nitrogen uptake by moth bean

### Intercropping

Data (Table 4.17) indicated that total nitrogen uptake by moth bean was increased significantly in sole crop compared to moth bean grown in intercropping system with pearl millet.

Sole crop of moth bean increased total nitrogen uptake of moth bean to the tune 35.44 per cent over moth bean intercropped with pearl millet.

### Weed control

A further examination of data (Table 4.17) revealed that all weed control measures, significantly, increased total nitrogen uptake by moth bean over weedy check. Further, hand weeding twice, significantly superior as compared to pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ in regard to total nitrogen uptake by moth bean.

Hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and

and imazethapyr at 40 g ha$^{-1}$ recorded significantly increased total nitrogen uptake by moth bean to the tune of 74.87, 47.89 and 25.17 per cent over weedy check, respectively.

The magnitude of increased total nitrogen uptake by moth bean in hand weeding twice at 20 and 35 DAS was 18.25 and 21.43 per cent as compared pre emergence application of pendimethalin at 0.75 kg ha$^{-1}$ and imazethapyr at 40 g ha$^{-1}$, respectively.

### 4.2.6.9 Phosphorus uptake by moth bean

**Intercropping**

An appraisal of data (Table 4.17) reflects that total phosphorus uptake by moth bean was increased significantly in sole crop compared to moth bean grown in intercropping system with pearl millet.

Sole crop of moth bean increased total phosphorus uptake of moth bean to the tune 41.31 per cent over moth bean intercropped with pearl millet.

**Weed control**

An assessment of data (Table 4.17) indicated that all weed control measures, significantly, increased total phosphorus uptake by moth bean over weedy check. Further, hand weeding twice significantly superior as compared to pendimethalin at 0.75 kg ha$^{-1}$ and post emergence application of imazethapyr at 40 g ha$^{-1}$in regard to total phosphorus uptake by moth bean.

Hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg ha$^{-1}$ and post emergence application of imazethapyr at 40 g ha$^{-1}$

increased total phosphorus uptake by moth bean to the tune of 70.28, 35.37 and 17.67 per cent over weedy check, respectively.

The magnitude of increased total phosphorus uptake by moth bean in hand weeding twice at 20 and 35 DAS was 25.78 and 30.89 per cent as compared pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$, respectively.

**Table 4.17 Effect of weed control measures and pearl millet legumes intercropping system on nitrogen, phosphorus and potassium uptake by moth bean**

| Treatments | Nitrogen uptake (kg ha$^{-1}$) | | | Phosphorus uptake (kg ha$^{-1}$) | | | Potassium uptake (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Grain | Straw | Total | Grain | Straw | Total | Grain | Straw | Total |
| **Intercropping** | | | | | | | | | |
| Pearl millet sole | - | - | - | - | - | - | - | - | - |
| Cluster bean sole | - | - | - | - | - | - | - | - | - |
| Moth bean sole | 28.69 | 16.04 | 44.73 | 3.41 | 4.66 | 8.07 | 2.97 | 14.29 | 17.26 |
| PM+CB (1:2) | - | - | - | - | - | - | - | - | - |
| PM+MB (1:2) | 19.36 | 9.51 | 28.87 | 2.23 | 2.74 | 4.97 | 1.97 | 8.67 | 10.64 |
| S.Em.± | 1.21 | 0.66 | 1.74 | 0.14 | 0.19 | 0.30 | 0.13 | 0.59 | 0.68 |
| CD (P=0.05) | 7.37 | 4.00 | 10.58 | 0.85 | 1.13 | 1.83 | 0.76 | 3.58 | 4.15 |
| **Weed control** | | | | | | | | | |
| Weedy check | 16.15 | 9.82 | 25.97 | 1.79 | 2.76 | 4.55 | 1.67 | 8.92 | 10.59 |
| Two hand weeding at 20 and 35 DAS | 29.62 | 15.80 | 45.42 | 3.51 | 4.70 | 8.21 | 3.04 | 14.39 | 17.43 |
| Pendimethalin 0.75 kg ha$^{-1}$ as PE | 25.42 | 12.99 | 38.41 | 2.97 | 3.74 | 6.71 | 2.62 | 11.47 | 14.10 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | 24.92 | 12.49 | 37.40 | 3.00 | 3.59 | 6.60 | 2.55 | 11.13 | 13.68 |
| S.Em.± | 1.13 | 0.62 | 1.64 | 0.13 | 0.18 | 0.29 | 0.12 | 0.55 | 0.64 |
| CD (P=0.05) | 3.49 | 1.91 | 5.06 | 0.41 | 0.55 | 0.90 | 0.36 | 1.70 | 1.98 |

#### 4.2.6.10 Potassium uptake by moth bean

**Intercropping**

An appraisal of data (Table 4.17) reflects that total potassium uptake by moth bean was increased significantly in sole crop compared to moth bean grown with intercropping system with pearl millet.

Sole crop increased total potassium uptake by moth bean to the tune 39.33 per cent over moth bean intercropped with pearl millet.

**Weed control**

An assessment of data (Table 4.17) indicated that all weed control measures, significantly, increased total potassium uptake by moth bean over weedy check. Further, hand weeding twice significantly superior as compared to pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$in regard to total potassium uptake by moth bean.

Hand weeding twice at 20 and 35 DAS and pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and post emergence application of imazethapyr at 40 g $ha^{-1}$ recorded significantly increased total potassium uptake by moth bean to the tune of 61.32, 28.58 and 15.34 per cent over weedy check, respectively.

The magnitude of increased total potassium uptake by moth bean in hand weeding twice at 20 and 35 DAS was 25.46 and 29.31 per cent as compared pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$, respectively.

## 4.3 Indices

### 4.3.1 Pearl millet equivalent yield (PMEY)

#### Intercropping

Data (Table 4.18 and fig. 4.5) clearly indicated that pearl millet equivalent yield of sole cluster bean being, statistically at par with sole

**Table 4.18 Effect of intercropping system on PMEY, land equivalent ratio, Aggressivity and relative crowding coefficient**

| Treatments | PMEY (Kg ha$^{-1}$) | LER | Agg. | RCC | |
|---|---|---|---|---|---|
| | | | | Pearl millet | CB/ MB |
| **Intercropping** | | | | | |
| Pearl millet sole | 908 | 1 | - | - | - |
| Cluster bean sole | 3491 | 1 | - | - | - |
| Moth bean sole | 3118 | 1 | - | - | - |
| PM+CB (1:2) | 2766 | 1.102 | +0.0765 | 1.44 | 1.08 |
| PM+MB (1:2) | 2499 | 1.097 | +0.0759 | 1.43 | 1.06 |
| S.Em.± | 131 | - | - | - | - |
| CD (P=0.05) | 429 | - | - | - | - |
| **Weed control** | | | | | |
| Weedy check | 1807 | - | - | - | - |
| Two hand weeding at 20 and 35 DAS | 3129 | - | - | - | - |

| | | | | | |
|---|---|---|---|---|---|
| Pendimethalin 0.75 kg $ha^{-1}$ as PE | 2689 | - | - | - | - |
| Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | 2600 | - | - | - | - |
| S.Em.± | 89 | - | - | - | - |
| CD (P=0.05) | 258 | - | - | - | - |

moth bean was significantly, superior as compared to sole crop of pearl millet and legume intercropping system with pearl millet.

Further, pearl millet grown with legume intercropping system significantly, increased pearl millet equivalent yield as compared to sole crop of pearl millet

The magnitude of increased pearl millet equivalent yield due to sole cluster bean, sole moth bean, cluster bean intercropping with pearl millet and moth bean intercropping with pearl millet was 284.63, 243.53, 204.75 and 175.36 per cent, respectively, over sole pearl millet.

**Weed control**

Examination of data (Table 4.18 and fig. 4.5) revealed that all weed control measures, significantly, increased pearl millet equivalent yield over weedy check. Further, hand weeding twice, significantly superior as compared to pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40g $ha^{-1}$ in regard to pearl millet equivalent yield.

Hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and and imazethapyr at 40 g $ha^{-1}$ recorded significantly increased pearl millet equivalent yield to the tune of 73.14, 48.82 and 25.36 per cent over weedy check, respectively.

The magnitude of increased pearl millet equivalent yield in hand weeding twice at 20 and 35 DAS was 16.34 and 20.31 per cent as compared pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$, respectively.

**Interaction effect on PMEY**

Data presented in table 4.18 (a) and fig. 4.5(a) showed that hand weeding twice at 20 DAS and 35 DAS, done in sole cluster bean gave significantly higher PMEY (4351 kg $h^{-1}$) over rest all treatment combinations. Further, sole crops of moth bean and cluster bean as

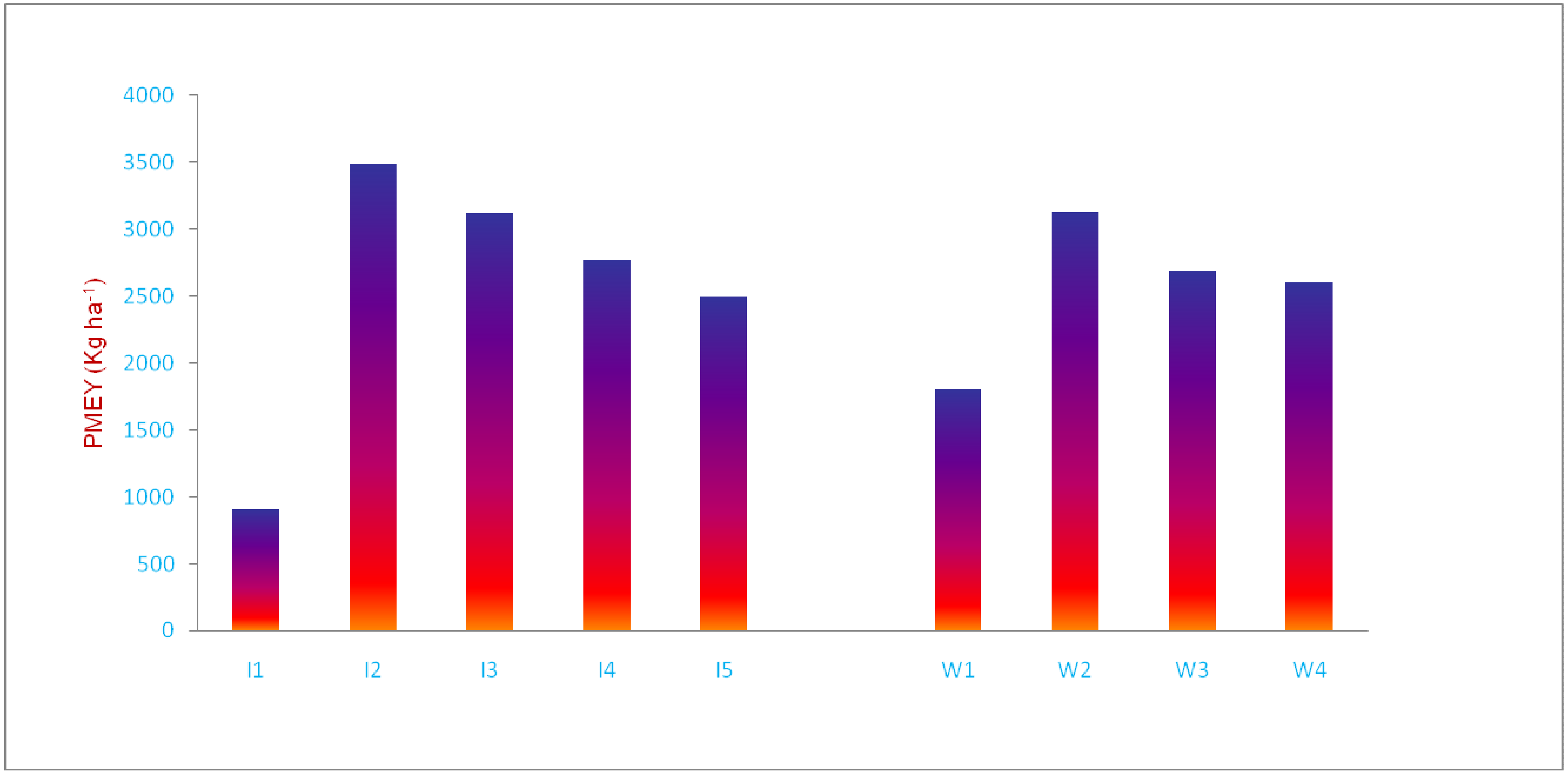



**Fig. 4.5 Effect of weed control measures and pearl millet legumes intercropping system on pearl millet equivalent yield**

well legume intercropping system produced significantly higher PMEY, over sole pearl millet of their respective weed control measures.

### 4.3.2 Land equivalent ratio

**Intercropping**

An appraisal of data (Table 4.18) reflects that land equivalent ratio was improved when pearl millet grown intercropped with legume. Maximum land equivalent ratio was obtained in cluster bean intercropped with pearl millet (1.102), followed in moth bean intercropped with pearl millet (1.097).

### 4.3.3 Aggressivity

**Intercropping**

Data (Table 4.18) reflects that aggressivity was recorded positive when pearl millet grown intercropped with legume. Maximum aggressivity was obtained in cluster bean intercropped with pearl millet (+0.0765), followed in moth bean intercropped with pearl millet (+0.0759).

### 4.3.4 Relative crowding coefficient

**Intercropping**

A perusal of data (Table 4.18) revealed that in pearl millet there was yield advantage in all intercrop combinations but highest yield advantage was recorded in pearl millet + cluster bean intercropping system. Further, revealed that among cluster bean as well as moth bean the maximum yield advantage was obtained in pearl millet + cluster bean intercropping.

## 4.4 Economics

### 4.4.1 Net return

**Intercropping**

Data (Table 4.19 and fig. 4.6) clearly indicated that net return of sole cluster bean being, statistically at par with sole moth bean was significantly, superior as compared to sole crop of pearl millet and legume intercropping system with pearl millet. Further, pearl millet grown with legume intercropping system significantly, increased net return as compared to sole crop of pearl millet

The magnitude of increased net return due to sole cluster bean, sole moth bean, cluster bean intercropping with pearl millet and moth bean intercropping with pearl millet was 544.05, 459.84, 399.95 and 335.26 per cent, respectively, over sole pearl millet.

**Weed control**

Examination of data (Table 4.19 and fig. 4.6) revealed that all weed control measures, significantly, increased net return over weedy check. Further, hand weeding twice, significantly superior as compared to pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ in regard to net return.

Hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ recorded significantly increased net return to the tune of 100.95, 72.77 and 32.11 per cent over weedy check, respectively.

The magnitude of increased net return in hand weeding twice at 20 and 35 DAS was 16.32 and 22.14 per cent as compared pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$, respectively.

**Table 4.19 Effect of weed control measures and intercropping systems on net return and B:C ratio**

| Treatments | Net return (Rs.ha$^{-1}$) | B:C ratio |
|---|---|---|
| **Intercropping** | | |
| Pearl millet sole | 6347 | 1.42 |
| Cluster bean sole | 40876 | 3.62 |
| Moth bean sole | 35531 | 3.36 |
| PM+CB (1:2) | 31730 | 3.06 |
| PM+MB (1:2) | 27624 | 2.83 |
| S.Em.± | 2060 | 0.13 |
| CD (P=0.05) | 6719 | 0.43 |
| **Weed control** | | |
| Weedy check | 17812 | 2.27 |
| Two hand weeding at 20 and 35 DAS | 35795 | 3.06 |
| Pendimethalin 0.75 kg ha$^{-1}$ as PE | 30774 | 3.06 |
| Imazethapyr 40 g ha$^{-1}$ at 25 DAS as PoE | 29306 | 3.05 |
| S.Em.± | 1366 | 0.08 |
| CD (P=0.05) | 3945 | 0.25 |

**Interaction effect on net return**

Data presented in table 4.19(a) and fig. 4.6(a)showed that hand weeding twice at 20 DAS and 35 DAS, done in sole cluster bean gave significantly higher net returns (51894 Rs $h^{-1}$) over rest all treatment combinations. Further, sole crops of moth bean and cluster bean as well legume intercropping system produced significantly higher net return, over sole pearl millet of their respective weed control measures.

## 4.4.2 B: C ratio

**Intercropping**

Data (Table 4.19 and fig. 4.7) clearly indicated that B:C ratio of sole cluster bean being, statistically at par with sole moth bean was significantly, superior as compared to sole crop of pearl millet and legume intercropping system with pearl millet.

Further, pearl millet grown with legume intercropping system significantly, increased B:C ratio as compared to sole crop of pearl millet

The magnitude of increased B:C ratio due to sole cluster bean, sole moth bean, cluster bean intercropping with pearl millet and moth bean intercropping with pearl millet was 154.93, 136.62, 115.49 and 99.30 per cent over sole pearl millet.

**Weed control**

Examination of data (Table 4.19 and fig. 4.7) revealed that all weed control measures, significantly, increased B:C ratio over weedy check. However, hand weeding twice, pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$

being statistically at par to each other in regard to B: C ratio.

Hand weeding twice at 20 and 35 DAS, pre emergence application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ recorded

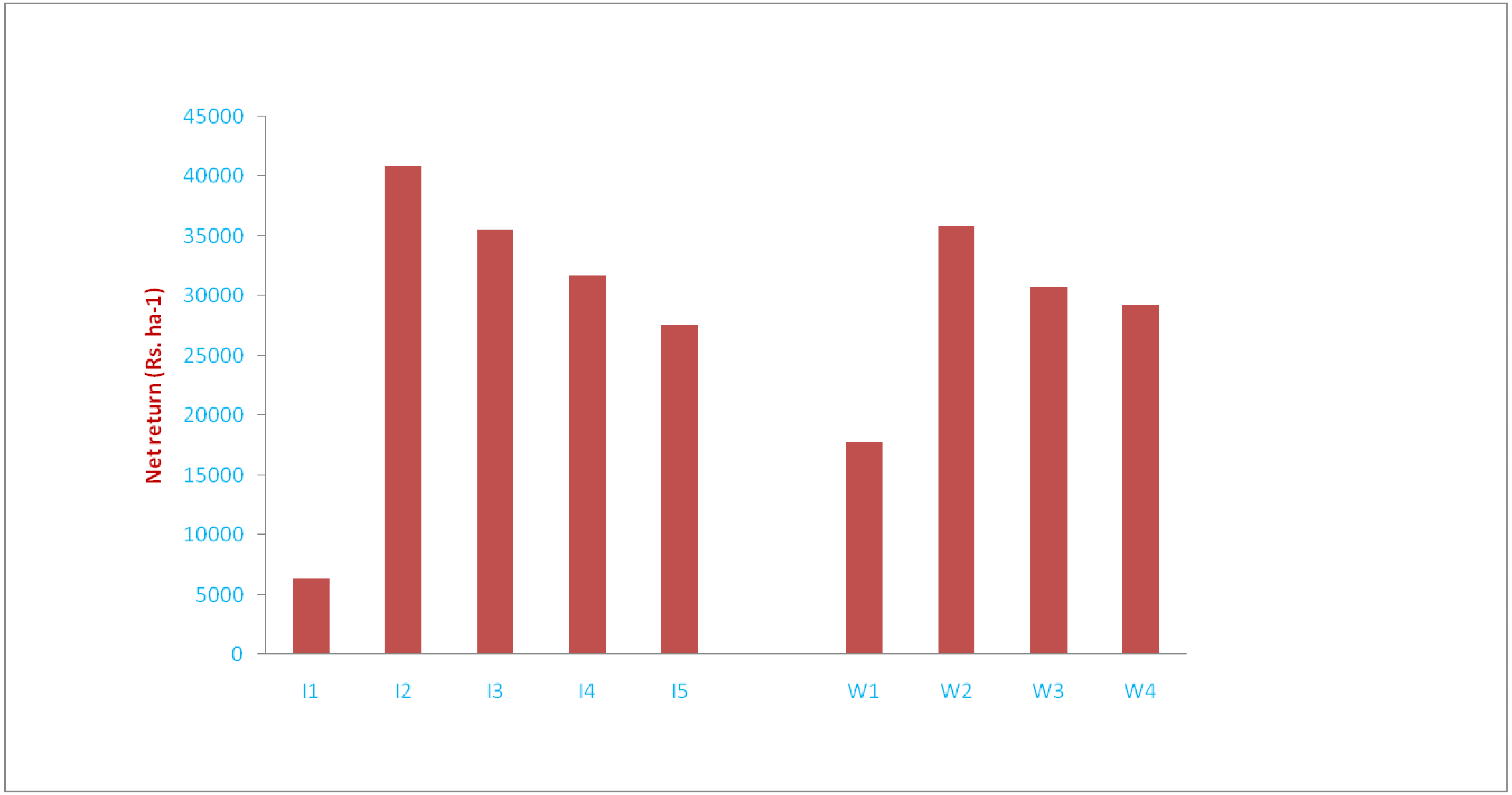



**Fig. 4.6 Effect of weed control measures and pearl millet legumes intercropping system on net return**

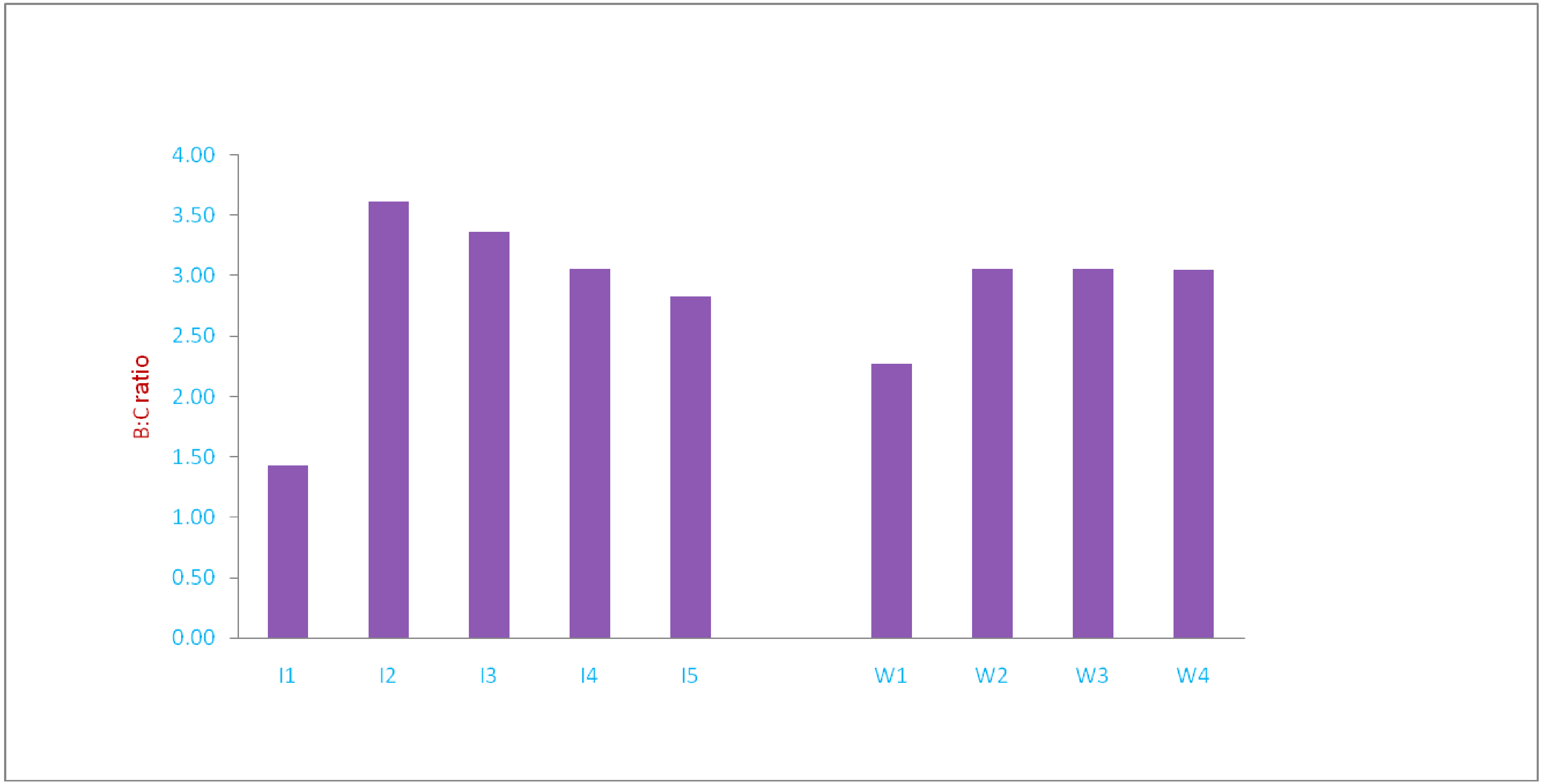



**Fig. 4.7 Effect of weed control measures and pearl millet legumes intercropping system on B:C ratio**

**Table 4.18a: Interaction effect of weed control measures and pearl millet legumes intercropping system on PMEY**

| Treatments | Pearl millet sole | Cluster bean sole | Moth bean sole | PM+CB (1:2) | PM+MB (1:2) |
|---|---|---|---|---|---|
| Weedy check | 813 | 2213 | 2033 | 1998 | 1978 |
| Two hand weeding at 20 and 35 DAS | 988 | 4351 | 3729 | 3407 | 3166 |
| Pendimethalin 0.75 kg $ha^{-1}$ as PE | 876 | 3584 | 3330 | 3091 | 2564 |
| Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | 953 | 3815 | 3379 | 2567 | 2288 |
| S.Em.± | 200 | | | | |
| CD (P=0.05) | 578 | | | | |

**Table 4.19a: Interaction effect of weed control measures and pearl millet legumes intercropping system on net return**

| Treatments | Pearl millet sole | Cluster bean sole | Moth bean sole | PM+CB (1:2) | PM+MB (1:2) |
|---|---|---|---|---|---|
| Weedy check | 6229 | 21827 | 20098 | 20548 | 20359 |
| Two hand weeding at 20 and 35 DAS | 7202 | 51894 | 43536 | 40106 | 36235 |

| | | | | | |
|---|---|---|---|---|---|
| Pendimethalin 0.75 kg ha$^{-1}$ as PE | 6757 | 42926 | 38778 | 36740 | 28667 |
| Imazethapyr 40 g ha$^{-1}$ at 25 DAS as PoE | 5199 | 46856 | 39713 | 29525 | 25237 |
| S.Em.± | 3054 | | | | |
| CD (P=0.05) | 8822 | | | | |

**Table 4.19b: Interaction effect of weed control measures and pearl millet legumes intercropping system on B:C ratio**

| **Treatments** | PM Sole | CB Sole | MB sole | PM + CB (1:2) | PM+ MB (1:2) |
|---|---|---|---|---|---|
| Weedy check | 1.45 | 2.52 | 2.46 | 2.45 | 2.47 |
| Two hand weeding at 20 and 35 DAS | 1.42 | 3.94 | 3.54 | 3.29 | 3.12 |
| Pendimethalin 0.75 kg $ha^{-1}$ as PE | 1.46 | 3.81 | 3.63 | 3.43 | 2.94 |
| Imazethapyr 40 g $ha^{-1}$ at 25 DAS as PoE | 1.37 | 4.21 | 3.82 | 3.04 | 2.79 |
| S.Em.± | 0.19 | | | | |
| CD (P=0.05) | 0.55 | | | | |

significantly increased B:C ratio to the tune of 34.80, 34.80 and 25.49 per cent over weedy check, respectively.

**Interaction effect on B:C ratio**

It is obvious from data presented in table 4.19b revealed that maximum B:C ratio (4.19b) was recorded when imazethapyr 40 g $ha^{-1}$ was applied in sole crop of cluster bean, Further, pre emergence application of pendimethalin at 0.75 in sole cluster bean closely related to imazethapyr 40 g $ha^{-1}$ applied as post emergence in moth bean sole was superior over rest treatment combinations in respect to B:C ratio. However, all weed control measures in legume intercropping system were showed significant effect on B:C ratio over weed control measures in sole pearl millet.

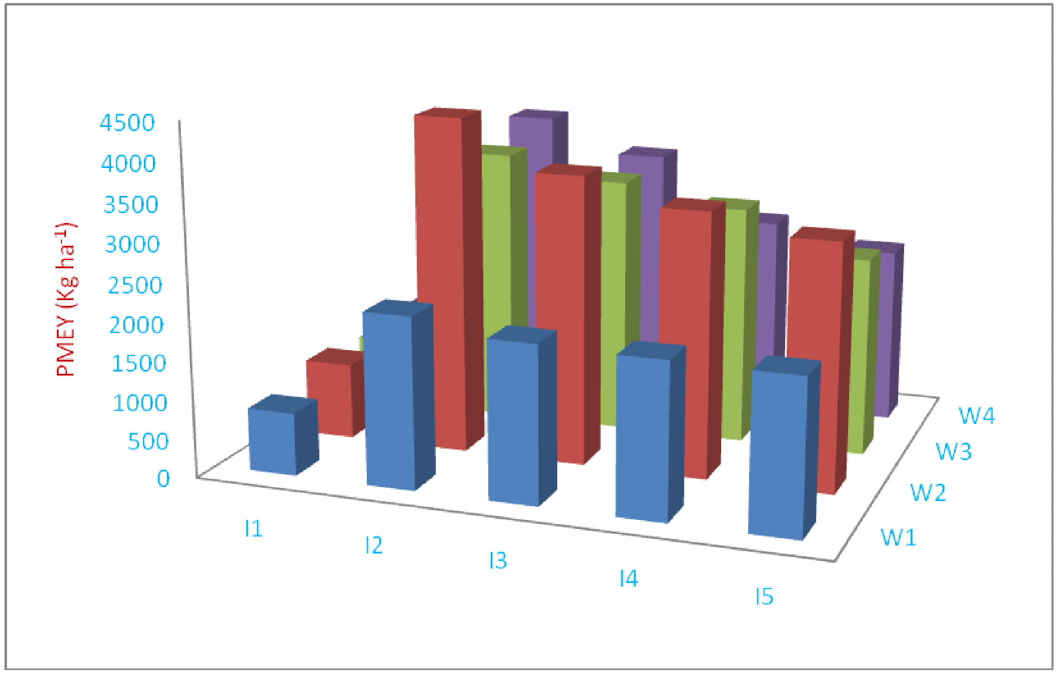



**Fig. 4.5(a) Interaction effect of weed control measures and pearl millet legumes intercropping system on PMEY**

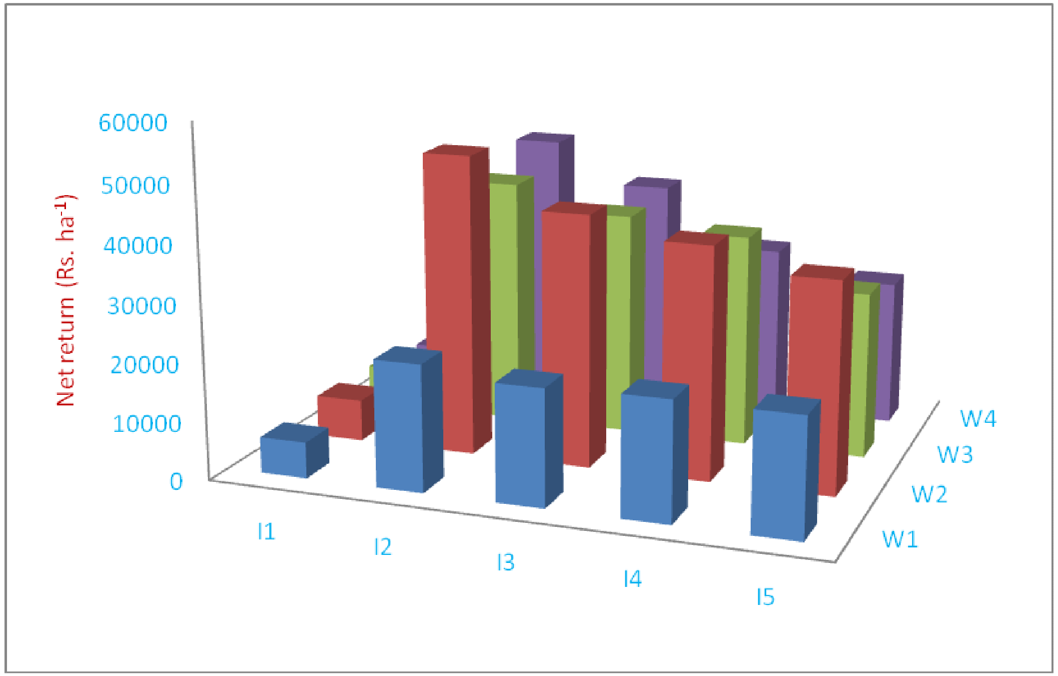



**Fig. 4.6(a) Interaction effect of weed control measures and pearl millet legumes intercropping system on net return**

# 5. DISCUSSION

In the course of presenting the results of the experiment entitled “Effect of Weed Control Measures in Pearl millet – Legumes Intercropping System in Arid Western Rajasthan” significant variation in the criteria used for evaluating the treatments were observed. In this chapter, it is endeavored to discuss the significant events or those assuming a definite pattern in respect of various parameters studied, so as to establish cause and affect relationship in the light of available evidences and literature.

## 5. 1 Effect of intercropping systems

### 5.1.1 Weed growth

Pearl millet intercropped with cluster bean and moth bean significantly reduced the density and dry matter of weeds as compared to sole pearl millet (Table 4.1). The lower density and dry matter production of different weeds under intercropping systems may be ascribed to higher crop canopy than sole pearl millet. Extensive canopy of intercrops precluded penetration of solar radiation up to the weeds and thus smothered them leading to lower weed dry matter. Kiroriwal *et al.* (2012), Ram *et al.* (2005) and Shetty (1981) also reported similar effect of intercrops on density and dry weight of all weeds as compared to sole crop of pearlmillet.

Weed smothering efficiency of pulse intercrops ranged from 24.52 to 33.10 per cent (Table 4.2) also supported the finding. Weed suppression to an extent of 20-43 per cent through inclusion of cowpea, black gram and green gram between two rows of pigeon pea has also been reported by Ali and Varshney (1988). Weed smothering efficiency of pulses ranged from 28.2 to 36.2 per cent was reported by Balasubramaniam and Subramaniam (1989). Similar results were also reported by De and Singh (1981), Dhingra *et al.* (1984), Patil and Pandey (1996) and Ram *et al.* (2004).

## 5.1.2 Growth and yield attributes of Crops

### 5.1.2.1 Pearl millet

Intercropping of pearl millet with cluster bean and moth bean had significant effect on plant population at 30 DAS and at harvest (Table 4.3). The highest number of plants $ha^{-1}$ was recorded under sole crop. Significant difference among systems of intercropping in plant stand was by the virtue of the row ratio of intercropping system. Yadav and Jat (2005) reported similar results.

Pearl millet intercrop with cluster bean as well as moth bean gave significantly enhanced dry matter accumulation per plant as compared to sole cropping at harvest (Table 4.3). Better environment particularly the light interception by pearl millet in these intercropping systems. Better growth of pearl millet in intercropping systems might be due to the ability of intercrops to enrich the soil through fixation of free nitrogen from the atmosphere. Intercrops being legume crops could fix nitrogen during growth and so benefited to companion crop. There are two aspects of this (i) the nitrogen made available from the intercrops is simultaneously used by the companion graminaceous crop at later stages (Chatterjee *et al.* 1989). (ii) Due to short duration of intercrops, they did not compete for the environmental factors, like sunlight and space which show greater compatibilities with pearl millet might be the reason for better growth of pearl millet in different intercropping systems. The significant increase in dry matter accumulation at successive crop growth stages seems to be on account of production of higher tillers per plant which might have led to greater absorption and utilization of radiant energy resulting in higher accumulation of photosynthates and finally dry matter per plant. Monteith (1972) reported that potential dry matter production of several crops is linear function of intercepted photo-synthetically active radiation (PAR). These results are in close confirmity with those of Bangali (1987) and Yadav *et al.* (2005).

Total number of tillers and effective tillers per plant were also significantly higher under intercropping system than sole pearl millet (Table 4.4). Higher number of effective tillers in intercropping treatments may be due to lower pearl millet population and wider space available for more growth and development of pearl millet (Pal *et al*. 2000). Singh and Agrawal (2004) also reported the similar findings under intercropping systems. Grain, straw and biological yields of sole pearl millet was significantly increased among pearl millet-cluster bean and pearl millet-moth bean intercropping system (Table 4.5). Significant difference by intercropping system in grain, straw and biological yield of pearl millet were due to the virtue of the row ratio of intercropping system. These findings are in close conformity of those reported by Patel and Sadhu (2013), Yadav and Yadav (2000) and Dubey et al. (1995).

### 5.1.2.2 Legumes

A significant reduction in grain, straw and biological yield of cluster bean and moth bean was observed under intercropping treatments (Table 4.10 & 4.15). The reduction in yield of cluster bean and moth bean in the intercropping system was mainly due to reduction in plant stand of cluster bean and moth bean in intercropping treatment as replacement type of intercropping system was followed in the present study. These results are supported with those of Yadav and Yadav (2000) who reported that grain yield of cluster bean was reduced by 38-67% in mixed stands of pearl millet + cluster bean in 1:2 ratios. They also reported that mixed cropping gave significantly higher pearl millet equivalent yield. Kumar *et al.* (2006), Mishra (1996) also found similar results. It is evident from the table 4.7 & 4.10 that seed yield of cluster bean and moth bean was very much linked with yield attributes *i.e*. final plant stand, pods per plant and seeds per pod in cluster bean and moth bean. Singh *et al*. (2003) reported similar findings in green gram and pearl millet intercropping system.

### 5.1.3 Nutrient content and uptake

Nitrogen content in grain as well as straw and protein content in grain of pearl millet was increased significantly under intercropping with cluster bean and moth bean compared to sole pearl millet (Table 4.6). Increase in nitrogen content due to intercrops may be attributed to leguminous nature of the crops, which caused fixation of atmospheric nitrogen and release during growth. The aspect of this availability of nitrogen from the intercrops are simultaneously used by the companion graminaceous crop so benefited to companion crop. These results are in accordance with Sharma and Gupta (2002) who showed that nitrogen content of pearl millet was significantly improved by intercropping with legumes. Sharma *et al*. (2008) also reported similar results in maize intercropped with cowpea at Sabour (Bihar).

The nitrogen, phosphorus and potassium uptake by pearl millet, cluster bean and moth bean were increased significantly in sole crops as compared to intercropping systems (Table 4.7). Since the nutrient uptake by the crop is a function of dry matter accumulation of cellular level and therefore, increased uptake of nitrogen, phosphorus and potassium were recorded under sole crops. This may be due to grain and straw yield of each sole crop was greatly increased than yield in intercropping. The findings are supported with those of Singh and Agarwal (2004) who observed that the N and P uptake was maximum in sole pearl millet due to its higher grain yield. Similar results of higher nutrient uptake in sole crops were also recorded by Ram and Singh (2003) in sorghum and Kuri (2009) in sole moth bean.

### 5.1.4 Economics and indices

Significantly higher pearl millet equivalent yield was obtained when pearl millet intercropped with cluster bean and moth bean as compared to sole pearl millet (Table 4.18). This might be due to higher yield and price of cluster bean and moth bean which resulted in enhanced pearl millet equivalent yield. Dubey et al. (1995), Tetarwal and Rana (2006), Kiroriwal *et al.* (2012) and Patel and Sadhu (2013) also observed similar results pertaining to equivalent yield.

The highest net return and B: C ratio was recorded in sole crop of cluster bean (Rs. 31730 $ha^{-1}$ and B: C ratio 3.06) and moth bean (Rs. 31730 $ha^{-1}$ and B: C ratio 3.06), followed by pearl millet + cluster bean (Rs. 31730 $ha^{-1}$ and B: C ratio 3.06) and pearl millet + moth bean intercropping system (Table 4.19). The higher net return obtained under sole legume as well as intercropping systems with legumes was due to higher yield as well as price of substitutional crops. Verma *et al.* (1992) reported that pearl millet intercropped with pigeon pea gave higher net monetary returns and B: C ratio as against sole pearl millet. Gadhia *et al.* (1993) and Gautam (1994) recorded highest pearl millet equivalent yield and B: C ratio in pearl millet intercropped with legume. These results also confirm the findings of Malik *et al*. (1993) and Ramula and Gautam (1999)

## 5.2 Effect of weed management

### 5.2.1 Weed growth

Pearlmillet, a rainy season grain crop, raised in warm and moist weather was invaded in unweeded control plots by graminaceous and broad leaf weeds simultaneously with the crop emergence. The weed control treatments tried in the present investigation *viz.* weedy check, hand weeding twice at 20 and 35 DAS, pendimethalin at 0.75 kg $ha^{-1}$, and imazethapyr at 40 g $ha^{-1}$ differed significantly in their effect on density on dry weight of weeds at 30, 45 DAS and at harvest.

All the weed control measures significantly reduced the density and dry weight of weeds (Table 4.1). The total weed density of 75.88 $no/m^2$ recorded in weedy check plots at 30 DAS, which declined to 64.96 $no/m^2$ with advancement in crop growth 45 DAS and 62.81 $no/m^2$ at harvest, possible due to severe competition, shadiness and short life of weeds resulting in exterminating some weed species. The increase in dry weight of weeds to such a high level under weedy check may be attributed to uninterrupted weed growth throughout the crop season.

Hand weeding twice at 20 and 35 DAS, reduced density and dry matter of foun at 30 DAS, 45 DAS and at harvest (Table 4.1). This might be due to effective destruction of weeds at their critical growth stages that created favorable conditions for crop growth and ultimately resulted in lowest density of later emerged weeds and their lowest biomass with higher weed control efficiency (Table 4.2). The results of study also corroborate with the findings of Kumar *et al.* (2004), Vyas and Jain (2004), Prasad *et al*. (2008), Punia *et al.* (2011), Sangeeta *et al.* (2013), Kumar *et al*. (2013) and Yadav *et al.* (2014).

Among herbicide, pendimethalin at 0.75 kg ha-1 as pre emergence and post emergence application of imazethapyr at 40 g ha$^{-1}$ reduced density and dry matter of weeds (Table 4.1). This may be attributed to the phytotoxic action of these herbicides on weeds. Pendimethalin excerts its herbicidal effect by inhibiting both root and shoot growth and development through disruption of ATP formation (Wang *et al.,* 1974) and inhibition of cell division in the meristematic tissue (Rao, 1983). Pendimethalin absorbed by germinating weeds inhibits cell division in the meristematic tissues resulting in death of most of the weeds within a few days of their emergence. It also plays a role in microtubule disruption and inhibits mitosis because it blocks synthesis of nucleic acids or any other requisites for mitosis the plants die shortly after germination or emergence from the soil (Gupta, 2008). Thus, the inhibiting effect of pendimethalin might have been responsible for reduced weed population and weed dry matter accumulation. These findings in accordance with that of Singh and Chaudhary (1992), Malik et al. (2005), Kohli et al. (2006), Yadav et al. (2011).

Imazethapyr belongs to group of imidazolinones is a selective herbicide 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 and isoleucine). The ALS inhibitors thus stop cell division and reduce carbohydrate translocation in the susceptible plants (Gupta, 2008). Imazethapyr is imidazolinones herbicide, which are absorbed both by roots and shoots, finally effective control a broad spectrum weeds (Saltoni *et al.* 2004). These results corroborate with the findings of Rao and Rao (2003), Rani et al. (2004), Sasikala et al. (2007) Singh et al. (2014).

### 5.2.2 Growth and yield attributes of Crops

#### 5.2.2.1 Pearl millet

The weed control treatments tried in the present investigation brought significant effects on crop growth in terms of periodic plant stand, plant height and dry matter accumulation, total tillers, effective tillers, ear head length and yield (Table 4.3, 4.4 & 4.5).

Hand weeding twice significantly increased the grain and straw yield of pearl millet over other weed control measures (Table 4.5).The variation in grain and straw yield due to different weed control treatments is again associated with the similar variation in weed control. Two hand weedings recorded the highest grain and pearl millet equivalent yield while the lowest recorded under weedy check. The lowest straw and grain yield recorded in weed check plots may be ascribed to the maximum density and dry matter of weeds which compete with the crop plant for growth essentials leading to maximum weed competition. On the other hand the higher grain yield obtained due to hand weeding treatment was associated with lower dry matter production of weeds under this treatment which posed less competition. Further, hand weeding treatment was done manually with the help of hand hoe, which makes the soil porous and creates favorable environment for growth in addition to effective control of weeds. The favorable effect of weed control on account of reduced weed crop competition under these treatments led to significant increase in various yield parameters *viz.* numbers of effective tillers, length of ear and test weight. Further, contribution of weed control measures towards the important yield attributes could be owing to their effect on reducing crop weed competition and increasing the weed control efficiency and hence, better utilization of inputs by crop plants. Kaushik and Gautam (1984), Verma and Kumar (1985) and Ram *et al.* (2005) also reported improvement in yield components due to elimination of severe crop weed competition.

Under herbicidal weed control treatments, although pendimethalin at 0.75 kg ha$^{-1}$ and imazethapyr at 40 g ha$^{-1}$ controlled the different type of weeds effectively but these treatments failed to produce higher yields particularly of pearl millet. The reason being significantly lower growth and yield attributing character due to some phytotoxic effect of pendimethalin at 0.75 kg ha$^{-1}$ and imazethapyr at 40 g ha$^{-1}$ on pearl millet so noticed. However, plant height was recouped at harvest. Similar results were also reported by Yadav *et al.* (2004) in pearl millet in cumin - pearl millet cropping system.

Imazethapyr at 40 g ha$^{-1}$ applied as post emergence at 25 DAS decreased all growth & yield attributes and yield compared to other weed control measures. Imazethapyr which is non selective to cereals has showed phytotoxic effect which caused injury to pearl millet and reduced yield (Table 4.5). These results are in accordance with the findings of Dan *et al*. (2009) in pearlmillet. Similar results were also reported in rice by Qian *et al*. (2011).

### 5.2.2.2 Legumes

Hand weeding twice, Pendimethalin at 0.75 kg $ha^{-1}$ and Imazethapyr at 40 g $ha^{-1}$ were found most effective in enhancing crop growth in terms of periodic plant stand, plant height and dry matter accumulation, nodules per plant, pods per plant, seeds per pod and yield of cluster bean and moth bean (Table 4.8 to 4.10 & 4.13 to 4.15).

The variation in grain and straw yield due to different weed control measures associated with the variation in weed control. Hand weeding treatment recorded the highest grain and straw yield which seems to be due to minimum dry matter production of weeds in these plots. Moreover, manual hand weeding also helps in improving soil physical condition which ultimately creates congenial condition for crop growth, besides providing effective weed control. The favourable effect of weed control on account of reduced weed crop competition under this treatment led to significant increase in various yield parameters *viz.* numbers of plant height, nodules per plant and pods per plant. Further, contribution of weed control measures on reducing crop weed competition and increasing the weed control efficiency and hence, better utilization of inputs by crop plants. Kaushik and Gautam (1984), Verma and Kumar (1985) and Ram *et al.* (2005) also reported improvement in yield components due to elimination of severe crop weed competition.

Herbicidal weed control treatments, pendimethalin at 0.75 kg $ha^{-1}$ and Imazethapyr at 40 g $ha^{-1}$ controlled the different type of weeds (monocot and dicot) effectively. These treatments significantly increased the grain and straw yield of cluster bean and moth bean by reducing density and dry matter production of weeds, generate favorable environment for better growth of crop plant. Results corroborate with the findings of Rao and Rao (2003), Rani et al. (2004) and Sasikala et al. (2007). The slight increase in weed count and weed dry weight at harvest in the treatments integrated with hand weeding at harvest was might be due to the improvement in soil and crop environment by hand weeding that is suitable for germination of new weed seeds also, which could not compete with well established crop. Results corroborate with the findings of Kumar et al. (2013) and Yadav et al. (2014).

### 5.2.3 Nutrient content and uptake

Nutrient content (N, P & K) in grain as well as straw of pearl millet, cluster bean and moth bean were increased significantly under all the weed control measures over weedy check (Table 4.6, 4.11& 4.16). Hand weeding twice effectively controlled and suppressed the weed growth and thereby provided almost weed free environment to the crop to utilize the available nutrients under reduced crop weed competition for nutrients, resulting in increased N, P and K content and crop dry matter production. Thus, increase in crop dry matter with a concomitant increase in its nitrogen, phosphorus and potassium content seems to be responsible for increased uptake of nitrogen, phosphorus and potassium, respectively, by crop under these treatments (Except pendimethalin at 0.75 kg $ha^{-1}$ and Imazethapyr at 40 g $ha^{-1}$ in pearl millet reduce uptake). Similar findings were also reported by Maley (1977), Singh *et al.* (1979), Tiwari *et al.* (1990), Sreenivas and Satyanarayan (1994) and Ram *et al.* (2004).

### 5.2.4 Economics and indices

All the weed control treatment gave significantly higher pearl millet equivalent yield, net return and B: C ratio (Table 4.19) obviously due to higher grain and straw yield obtained with these treatments. Hand weeding twice treatment provided the higher pearl millet equivalent yield (3128 kg ha$^{-1}$), net return (Rs.35794 ha$^{-1}$) and B:C ratio (3.06) due to higher yield. Similar findings were also reported by Patel *et al.* (1993) and Chandel *et al*. (1995).

# 6. SUMMARY AND CONCLUSION

A field experiment entitled "Effect of weed control measures in pearl millet legumes intercropping system in arid western Rajasthan" was conducted during *Kharif*, 2014 at instructional farm, college of agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner. The results presented and discussed in the preceding chapters are summarized as under.

## 6.1 Effect of intercropping system

### 6.1 .1 Weed studies

I. Sole cluster bean, sole moth bean, pearl millet intercropping with cluster bean and pearl millet intercropping with moth bean being at par with each other, significantly reduced the density of weeds compared to sole pearl millet at 30 DAS, 45 DAS and at harvest.

II. Significantly higher total dry matter of weeds was recorded under sole crop of pearl millet at 30 DAS, 45 DAS and at harvest over all cropping systems.

III. The highest weed smothering efficiency was recorded under pearl millet intercropped with moth bean followed by pearl millet + cluster bean intercropping system at 30 DAS, 45 DAS and at harvest.

### 6.1.2 Crop studies

#### 6.1.2.1 Pearl millet

I. The plant stand of pearl millet at 30 DAS and at harvest was significantly higher in sole pearl millet as compared to pearl millet + cluster bean and pearl millet + moth bean intercropping system

II. The plant height and dry matter accumulation per plant of pearl millet at 30 DAS and at harvest were not influenced significantly by sole crop as well as intercropping system.

III. The total number of tillers and effective tillers per plant in pearl millet + moth bean followed by pearl millet + cluster bean intercropping gave significantly higher as compared to sole crop.

IV. The length of ear head and test weight of pearl millet was not influenced significantly due to different intercropping systems.

V. The sole pearl millet recorded significantly higher grain, straw and biological yield compared to all the intercropping treatments.

VI. The nitrogen and protein content in pearl millet grain were increased significantly under intercropping with legumes compared to grown sole crop of pearl millet.

VII. The total uptake of nitrogen, phosphorus and potassium by grain as well as straw of sole pearl millet was significantly higher over to intercropping system.

### 6.1.2.2 Cluster bean

I. The plant stand at 30 DAS and at harvest of sole cluster bean was significantly higher as compared to intercropping systems.

II. The plant height and dry matter accumulation per plant at 30 DAS and at harvest of cluster bean was not influenced significantly due to various intercropping systems.

III. The number of nodules per plant, pods per plant, seeds per pod and test weight of cluster bean was not influenced considerably due to intercropping system.

IV. The grain, straw and biological yield in sole cluster bean was recorded significantly higher as compared to intercropping systems.

V. The nitrogen, phosphorus and potassium content in cluster bean grain as well as in straw were not affected significantly by intercropping system.

VI. The total uptake of nitrogen, phosphorus and potassium by grain and straw of sole cluster bean was significantly higher over to intercropping system.

**6.1.2.3 Moth bean**

I. The plant stand at 30 DAS and at harvest of sole moth bean was significantly higher as compared to intercropping systems.

I. The plant height and dry matter accumulation per plant at 30 DAS and at harvest of moth bean was not influenced significantly due to various intercropping systems.

II. The number of nodules per plant, pods per plant, seeds per pod and test weight of cluster bean was not influenced considerably due to intercropping system.

III. The grain, straw and biological yield in sole moth bean was recorded significantly higher as compared to intercropping systems.

IV. The nitrogen, phosphorus and potassium content in moth bean grain as well as in straw were not influenced considerably by intercropping system.

V. The total uptake of nitrogen, phosphorus and potassium by grain and straw of sole moth bean was significantly higher over to intercropping system.

**6.1.3 Indices and Economics**

I. The pearl millet grain equivalent yield was significantly influenced by intercropping treatments. The maximum mean pearl millet grain equivalent yield was obtained under sole cluster bean and followed by sole moth bean, pearl millet + cluster bean and pearl millet + moth bean.

II. The land equivalent ratios of intercropping systems were higher as compared to sole pearl millet. Among intercropping treatments pearl millet + cluster bean was recorded highest value of land equivalent ratio.

III. The aggressivity and relative crowding coefficient value were recorded higher in pearl millet + cluster bean.

IV. All the intercropping treatments, there was yield disadvantage in cluster bean and moth bean. Whereas in case of pearl millet there is yield advantage in all intercrop combinations.

V. The sole crop of cluster bean had maximum net return and B: C ratio. Among intercropping treatment of pearl millet + cluster bean had net returns (31730 $Rs.ha^{-1}$) was, significantly higher than sole pearl millet.

## 6.2 Effect of weed control measures

### 6.2.1 Weed studies

I. Weed density reduced significantly, under all the weed control treatments as compared to weedy check at 30 DAS, 45 DAS and at harvest. Further, hand weeding twice reduced weed density significantly, over chemical herbicides at 30 DAS, 45 DAS and at harvest.

II. All weed control treatments considerably decreased the total weed dry matter over weedy check at 30 DAS, 45 DAS and at harvest.

III. The maximum weed control efficiency was recorded under two hand weeding and minimum in weedy check treatment. Among herbicidal weed control measures, pre-emergence application of pendimethalin at 0.75 kg $ha^{-1}$ have higher weed control efficiency as compared to imazethapyr at 40 g $ha^{-1}$at 30 DAS.

IV. Post-emergence application of imazethapyr at 40 g $ha^{-1}$ gave higher weed control efficiency as compared to pendimethalin at 0.75 kg $ha^{-1}$ at 45 DAS and at harvest, respectively.

### 6.2.2 Crop studies

#### 6.2.2.1 Pearl millet

I. The plant stand of pearl millet at 30 DAS was significantly higher under hand weeding twice treatment over pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$. At harvest plant stand of pearl millet was significantly higher in hand weeding twice over all weed control treatment.

II. The taller plant of pearl millet was recorded under hand weeding twice as compared to both herbicidal weed control measures at 30 DAS and at harvest. All weed control measures (except imazethapyr at 40 g $ha^{-1}$) significantly increased plant height of pearl millet over weedy check at harvest.

III. Dry matter accumulation per plant of pearl millet at harvest increased considerably by all weed control treatments over weedy check.

IV. The total number of tillers, effective tillers per plant and length of ear head under hand weeding twice gave significantly higher as compared to remaining weed control treatment.

V. Two hand weeding recorded highest grain, straw and biological yield of pearl millet compared to other weed control measures.

VI. The nitrogen, phosphorus and potassium content in pearl millet grain and straw were increased significantly in all weed control measures compared to weedy check. Protein content in pearl millet grain also recorded highest in all weed control measures compared to weedy check.

VII. The total uptake of nitrogen, phosphorus and potassium by grain and straw were significantly higher in hand weeding treatment over all weed control treatment.

#### 6.2.2.2 Cluster bean

I. The plant stand, height and dry matter accumulation per plant of cluster bean at harvest under all weed control measures were significantly higher as compared to weedy check.

II. The number of pods per plant and seeds per pod of cluster bean were considerably increased by all weed control measures over weedy check.

III. The grain, straw and biological yield in cluster bean was recorded significantly higher in all weed control treatments as compared to weedy check.

IV. The nitrogen, phosphorus and potassium content in cluster bean grain was increased significantly under hand weeding twice compared to weedy check. Further, protein content was significantly increased in similar treatment.

V. The total uptake of nitrogen, phosphorus and potassium by grain as well as straw of cluster bean was significantly higher in hand weeding twice over weedy check.

#### 6.2.2.3 Moth bean

I. The plant stand, height and dry matter accumulation per plant of moth bean at harvest under all weed control measures were significantly higher as compared to weedy check.

II. The number of pods per plant and seeds per pod of moth bean were considerably increased by all weed control measures over weedy check.

III. The grain, straw and biological yield in moth bean was recorded significantly higher in all weed control treatments as compared to weedy check.

IV. The nitrogen, phosphorus and potassium content in moth bean grain were increased significantly in hand weeding twice treatment over weedy check. Further, protein content was significantly increased in similar treatment.

V. The total uptake of nitrogen, phosphorus and potassium by grain and straw of moth bean were considerably higher in hand weeding twice compared to weedy check.

### 6.2.3 Indices and Economics

I. Pearl millet equivalent yield was significantly increased under the weed control measures compared to weedy check.

II. The hand weeding twice treatment had maximum net return (35795 Rs.ha$^{-1}$) and B: C ratio (3.06).

III. In interaction of hand weeding twice at 20 DAS and 35 DAS, done in sole cluster bean gave significantly higher PMEY (4351 kg h$^{-1}$) and net returns (51894 Rs h$^{-1}$) over rest all treatment combinations.

## Conclusion

Based on results of one year experimentation, it may be inferred that legumes grown as sole crop recorded maximum pearl millet equivalent yield, net return and B: C ratio. Among intercropping systems, pearl millet + cluster bean produced maximum pearl millet equivalent yield (2765 kg $ha^{-1}$), net return (31730 $Rs.ha^{-1}$) and B: C ratio (3.06). Hand weeding twice at 20 DAS and 35 DAS gave significantly higher pearl millet equivalent yield (3129 kg $ha^{-1}$), net returns (35795 $Rs.ha^{-1}$) and B:C ratio (3.06) compared to other weed control measures.

The combined effect of treatments showed that two hand weeding at 20 DAS and 35 DAS in sole cluster bean gave significantly higher PMEY (4351 kg $ha^{-1}$) and net returns (51894 Rs $h^{-1}$) over rest of the other treatment combinations.

However, these results are only indicative and require further experimentation to arrive at some more consistent and final conclusion.

# LITERATURE CITED


AICPMIP, 2014. Annual report of all Indian Coordinate Pearlmillet improvement Project (ICAR), Univ. of Masure. pp-15.

Ali, M. and Varshney, J.G. 1988. Crop weed competition in pigeonpea based intercropping system under different agro- climatic zone of India. Paper presented in *Biennial Conference of Indian Society of Weed Science* held at Assam Agril. Univ. Jorhat, Assam on March, 8-9, 1988.

Ali, S., Patel, J.S., Desai, L.J. and Singh, J. 2011. Effect of herbicides on weeds and yield of rainy season greengram [*Vigna radiata* (L.) Wilczek]. *Legume Research*, **34**(4): 300-303.

Ashish, K. 2011. Performance of Pearl millet [*Pennisetum glaucum*] + Cluster bean [*Cyamopsis tetragonoloba*] intercropping system in arid Western zone of Rajasthan M.Sc. (Ag.) Thesis, Swami Keshwanand Rajasthan Agricultural University Bikaner (Rajasthan).

Balasubramanian, N. and Subramanian, S. 1989. Studies of integrated weed management in irrigated sorghum based cropping system. *Indian Journal of Agronomy*. **34** (4): 436-438.

Bangali, M.K. 1987. Studies on pearl millet (*Pennisetum americanum* L.) under intercropping system at different nitrogen levels, M.Sc. (Ag.) Thesis, Sukhadia Univ. Udaipur (Raj.).

Bhandari, V., Singh, J., Randhawa, J.S. and Randhawa, R.S. 2004. Studies on weed control in summer blackgram (*Phaseolus mungo*). *Indian Journal of Weed Science* **36**: 129-130.

Bilalis, D., Konstantas, A., Efthimiadou A., Papatheohari Y.and Kakampouki 2008. Effect of two Oat–legumes intercrop systems on weed flora under Mediterranean conditions 16th IFOAM Organic World Congress, Modena, Italy, June 16-20, 2008.

Bilalisa, D. P., Papastylianoua, A., Konstantasa, S., Patsialia, A., Karkanisa and A. Efthimiadoua, 2010. Weed-suppressive effects of maize-legume intercropping in organic farming. *International Journal of Pest Manage.* **56**: 173-181.

Bouyoucos, G.J. 1962. Hydrometer method for making practical size analysis of soils. *Agronomy Journal*. **55**: 464-465.

Brady, N.C. 1983. The nature and properties of soils. *McMillan Publishing Co., New York* pp. 750.

Chandel, A.S., Saxena, S.C. and Singh, K. 1995. Integrated weed control and its economics in soybean (*Glycine max*) grown in moillisols of Uttar Pradesh, *Indian Journal of Agron*omy. **40**: 228-234.

Chatterjee, B.N., Maiti, S. and Mandal, B.K. 1989. Intercropping – Advantage and disadvantage in cropping system – theory and practice. Oxford and IBH Publishing Co. Pvt. Ltd. Pp: 155.

Chauhan, S.P.S., Chauhan, C.P.S. and Singh, A. 2008. Assessment of cluster bean based intercropping system in south- western U.P. 3rd national symposium *On Enhancing Productivity, Nutritional Security and Export Potential through Arid Legumes.* June 28- 30**.**

Chauhan, Y.S., Bhargava, M.K. and Jain, V.K. 2002. Effect of herbicides on weeds and soybean (*Glycine max*) *Indian Journal of Weed Science* **34**: 213-216.

Chhodavadia, S.K., Mathukiya, R.K. and Dobariya, V.K. 2013. Pre- and post-emergence herbicides for integrated weed management in summer green gram. *Indian Journal of Weed Science,* **45**(2): 137-139.

Dan, H.A., Dan, L.G.M., Barroso, A.L.L., Procopio, S.O., Oliveira JR., R.S., Assis, R.L., Silva, A.G., Feldkircher, C. 2010. Effect of residual activity of pre emergent herbicides applied in soybean on pearl millet cultivated in succession. *Planta Daninha (online)*, **28**(4): 793-799.

Dan, H.A., Dan, L.G.M., Barroso, A.L.L., Tannus, V.R., Finotti, T.R. 2009. Selectivity of herbicide applied in post-emergence on millet (*Pennisetum glaucum*). *Revista Brasileira Milho Sorgo*, **(8)**3: 297-306.

De, R. and Singh, S.P. 1981. Proceedings of International workshop on intercropping. Hyderabad, India. Jan. 10-12, 1971.

Deshmukh, J.P., Shingrup, P.V., Kubde, K.J., Bhale, V.M. and Thakare, S.S. 2014. Efficacy of pre-and post-emergence herbicides against weed flora in soybean: 80. In: Biennial conference of Indian society of weed science on “Emerging challenges in weed management”, February 15-17, 2014. DWSR, Jabalpur.

Dhingra, K.K., Sekhon, H.S. and Tripathi, H.P. 1984. Effect of berbicides for weed control in mungbean. *Indian Journal of Weed Science.* **16**(2): 116-120.

Dixit, A. and Varshney, J.G. 2007. Bioefficacy of imazethapyr against weeds in soybean. *Annual Report* 2006-07. National Research Centre for Weed Science, Jabalpur.

Dubey, D.N., Kulmi, G.S. and Jba, G. 1995. Relative productivity and economics of sole, mixed and intercropping systems of sorghum *(sorghum bicolor)* and grain legumes under dryland condition. *Indian Journal of Agricultural Science.* **65**(7): 469-473.

Fisher, R.A. 1950. Statistical methods for research workers Oliver and Boyd. Edinburg, Landon (U.K.).

Gadhia, D.S., Khanpara, V.D. and Patel, J.C. 1993. Production potential and economic returns of pearl millet (*Pennisetum glaucum*) based intercropping system with different grain legumes and oil seed crop under rainfed condition. *Indian Journal of Agronomy.* **38**(2): 282-283.

Gautam, R.C. 1994. Pearl millet and pigeon pea intercropping at various fertility levels under rainfed conditions. *Indian Journal of Agronomy*. **39** : 110-111.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research* (2nd ed.). John Willey and Sons, Singapore.

Goswami, V.K., Kaushik, S.K. and Gautam, R.C. 2002. Effect of intercropping and weed control on nutrient uptake and water-use efficiency of pearl millet (*Pennisetum glaucum*) under rainfed conditions. *Indian Journal of Agronomy.* **47**(4): 504-508.

Gupta, O.P. 2008. Functional features of some currently used herbicides. 3rd Revised Edition, Modern Weed Management. *AGROBIOS (INDIA)*, Jodhpur: 223.

Gupta, V., Singh, M., Kumar A., Sharma B.C. and Kher, D. 2013. Influence of weed management practices on weed dynamics and yield of urd bean (*Vigna mungo*) under rainfed conditions of Jammu*. Indian Journal of Agronomy.* **58**(2): 220 – 225.

Gurjar, M.S., Kushwah, S.S., Jain, V.K. and Kushwah, H.S. 2001. Effect of different herbicides and cultural practices on growth, yield and economics of soybean [*Glycine max* (L.) Merrill.]. *Agricultural Science Digest* **21**:13-16.

Hamid Reza Mobasser, Mohammad Reza Vazirimehr, Khashayar Rigi 2014. Effect of intercropping on resources use, weed management and forage quality. *International Journal of Plant, Animal and Environmental Sciences* **4**(2):706-713.

Issa Piri, Farshad Abrahimpour, Abolfazl Tavassoli, Ebrahim Amiri and Fatemeh Rastegaripour 2011. Effect of fertilizer in controlling weeds under intercropping of pearl millet and red bean in Sistan region, Iran. *African Journal of Biotechnology* **10**(38):7397-7403.

Jackson, M.L. 1973. Soil chemical analysis. *Prentice Hall Inc. Engle Chitts, New Jersey*.

Kalhapure, A., Shete,B. and Dhonde,M. 2014. Response of *Kharif* groundnut to chemical and cultural weed management. Biennial conference of Indian society of weed science on "Emerging challenges in weed management", February 15-17, 2014. DWSR, Jabalpur.

Kalpana, R. and Velayutham, A. 2004. Effect of herbicides on weed control and yield of soybean. *Indian Journal of Weed Science,* **36**(1 & 2): 138-140.

Kaushik, S.K. and Gautam, R.C. 1984. Weed control studies in pearlmittet under rainfed conditions. *Indian Journal of Agronomy.* **29**(1): 31-36.

Kavita, D., Rajput, A.S., Kamble, Sonawane, R.K. and Bhale, V.M. 2014. Influence of herbicides and cultural practices on uptake of nutrients by weeds and black gram: 212. In: Biennial conference of Indian society of weed science on "Emerging challenges in weed management", February 15-17, 2014. DWSR, Jabalpur.

Kiroriwal and Yadav, R.S. 2013. Effect of Intercropping Systems on Intercrops and Weeds. *International Journal of Agriculture and Food Science Technology*. **4**(7):643-646.

Kiroriwal, A., Yadav, R.S. and Kumawat, A. 2012. Weed management in pearl millet based intercropping system. *Indian Journal of Weed Science.* **44**(3): 200–203.

Kohli, S.; Nehra, D. S. and Satbir, Singh 2006. Quality and economics of mung bean (*Vigna radiata* L.) as influenced by weed management practices. *Research on Crops*, **7**(3): 664-665.

Kumar, N.S., Natarajan, S., Veeramani, A. and Kumar, P.S. 2004. Integrated weed management in groundnut (*Arachis hypogaea* L.) under varying plant densities. *Indian Journal of Weed Science,* **36**:144-145.

Kumar, P., Hooda, R.S., Singh, H. and Nanwal, R.K. 2006. Economics of pearl millet-legume association as influenced by intercropping and strip-cropping system in sandy loam soils. *Haryana agric. Univ. J. Res.* **36**: 101-104.

Kumar, S., Rana, S.S., Chander, N. and Sharma, N. 2013. Integrated weed management in garlic. *Indian Journal of Weed Science,* **45**(2): 126-130.

Kuri, B.R. 2009. Evaluation of pearl millet and moth bean intercropping system in hyper Arid partially irrigated north western plain zone. M. Sc. (Ag.) Thesis, Swami Keshwanand Rajasthan Agricultural University, Bikaner (Rajasthan).

Maley, S.R. 1977. Crop weed Association studies in soybean and weed control methods. *Thesis Abstr*. **3**: 145-146.

Malik, R.S., Yadav, A., Malik, R.K. and Singh, S. 2005. Performance of weed control treatments in mung bean under different sowing methods. *Indian Journal of Weed Science,* **37**(3/4): 273-274.

Malik, S.P., More, S.M., Deshpande, S.S. and Patel, J.D. 1993. Intercropping for better stability in crop production in dryland watersheds. *Indian Journal of Agronomy*. **38**: 527-530.

Maliwal, P.L. and Mundra, S.L. 2009. Bio-efficacy and phytotoxicity studies of imazethapyr(XL-10 SL) for weed control in groundnut. *Project Report* 2009, Directorate of Research, MPUAT, Udaipur.

Malliswari, T., Reddy, M.P., Sagar, K.G. and Chandrika, V. 2008. Effect of irrigation and weed management practices on weed control and yield of black gram. *Indian Journal of Weed Science,* **40**(1 & 2): 85-86.

Meena, D.S., Ram, B., Jadon, C. and Tetarwal, J.P. (2011). Efficacy of imazethapyr on weed management in soybean. *Indian Journal of Weed Science* 43 (3&4): 169-171.

Mehria, M.L. 2006. Effect of crop- weed competition and weed control measures on growth, yield and quality of cumin (*Cuminum cyminum* L.). Thesis, Rajasthan Agril. Univ., Bikaner.

Mishra, J.S. and Chandra Bhanu 2006. Effect of Herbicides on Weeds, Nodulation and Growth of *Rhizobium* in Summer Blackgram (*Vigna mungo*). *Indian Journal of Weed Science,* **38**(1 & 2): 150-153.

Mishra, P. 1996. Studies on intercropping of pearl millet with cluster bean under dry land conditions. *M.Sc. thesis, CCS Haryana Agricultural University, Hisar.*

Monteith, J.L. 1972. Solar radition and productivity of tropical ecosystems. *J. App. Eco*. **9**: 747-766.

Olsen, S.R., Cole, S.C.W., Watanable, F.S. and Dean, L.A. 1954. Estimated of available phosphorus in soils by extraction with $HNO_3$. *U.S.D.A.* pp. 939.

Pal, C., Kaushik, S.K. and Gautam, R.C. 2000. Weed control studies in pearl millet (*Pennisetum glaucum*) – Pigeonpea (*Cajanus cajan*) intercropping system under rainfed condition. *Indian Journal of Agronomy.* **45** (4): 662.668.

Pandey, I.B., Bharti, V. and Mishra, S. S. 2003. Effect of maize (*Zea mays*) based Intercropping system on maize yield and associated weeds under rainfed Condition. *Indian Journal of Agronomy*, **48** (1): 30-33.

Patel K.N. and Sadhu A.C. 2013. Performance of summer pearl millet (*Pennisetum glaucum* L.) based intercropping with legume crop in different row ratios under middle Gujarat conditions. *International Journal of Agricultural sciences.* **9** (2): 510-512.

Patel, Z.C., Rai, V.C., Patel, H.C. and Patel, C.L. 1993. Integrated weed management in pigeonpea (*Cajanus cajan* L.) *In: Proc. of Indian Soc. Weed Wci. Intern. Symp., Hisar,* 18-20 Nov. Vol. III pp. 152-153.

Pathak, K. and Singh, N.P. 2008. Growth and yield of black gram (*Phaseolus mungo*) Varieties under intercropping system with maize (*Zea mays*) during rainy Season in northern *India. Journal of Farming System Research Development.* **14** (1):29-34.

Patil, B.M. and Pandey, J. 1996. Chemical weed control in pigeon pea (*Cajanus cajan*) intercropped with short-duration grain legumes. *Indian Journal of Agronomy*. **41**(4): 529-535.

Prasad, A., Singh, G. and Upadhyay, R.K. 2008. Integrated Weed Management in Maize (*Zea mays* L.) and Maize+ Black gram. *Indian Journal of Weed Science.* **40** (3 & 4): 191-192.

Punia, S.S., Samunder Singh and Dharambir Yadav 2011. Bioefficacy of imazethapyr and chlorimuron-ethyl in cluster bean and their residual effect on succeeding *rabi* crop. *Indian Journal of Weed Science.* **43**(1): 48-53. 10.

Qian,H., Hu, H., Mao, Y., Ma, J., Zhang, A., Liu, W., Fu, Z. 2011. Enantioselective phytotoxicity of the herbicide imazethapyr in rice. *Environment science and technology*, **(45)**16: 7036-7043.

Ram, B., Chaudhary, G.R., Jat, A.S. and Jat. M.L. 2005. Effect of integrated weed management and intercropping systems on growth and yield of pearlmillet (*Pennisetum glaucum*). *Indian. Journal of Agron*omy. **50**(2): 210-213.

Ram, B., Chaudhary, G.R. and Jat, A.S. 2004. Nutrient depletion by weeds, weed control efficiency and productivity of pearlmillet (*Pennisetum glaucum*) as influenced by intercropping systems and integrated weed management. *Indian Journal of Agronomy*. **74** (10): 534-538.

Ram, B., Punia, S.S., Tetarwal, J.P. and Meena, D.S. 2012. Efficacy of pre and post emergence herbicides on weed dynamics and yield of mung bean. Biennial Conference of Indian Society of Weed Science on “Weed Threat to Agriculture, Biodiversity and Environment”, April 19-20, 2012, Kerala Agricultural University, Thrissur (Kerala). P.150.

Ram, S.N. and Singh, B. 2003. Physiological growth parameters, forage yield and nitrogen uptake of sorghum (*Sorghum bicolor*) as influenced with legume intercropping, harvesting time and nitrogen level. *Indian Journal of Agronomy.* **48**(1): 38-41.

Ramula, V. and Gautam, R.C. 1999. Evaluatin of plearl millet intercropping for yield and resource utilization under rainfed conditions. *Annals of Agricultural Res*earch **20**(2): 240-242.

Rana, K.S., Shivran, R.K. and Kumar, A. 2006. Effect of moisture- Conservation practices on productivity and water use in maize (*Zea mays*) - based intercropping system under rainfed conditions. *Indian Journal of Agronomy.* **51**(1): 24-26.

Rani, B.P., Ramana, M.V. and Reddy, M.V. 2004. Evaluation of different post-emergence herbicides in soybean [*Glycine max* (L.)] in vertisols of Andhra Pradesh. *Journal of Oilseeds Research.* **21**: 293-295.

Rao, A.S. and Rao R.S.N. 2003. Bio-efficacy of clodinafop-propargyl on *Echinochloa spp.* in black gram. *Indian Journal of Weed Science.* **35**(3 & 4): 251-252.

Rao, S. S., Regar, P.L., Jangid, B.L. and Khemchand 2009. Productivity and Economics of sorghum (*Sorghum bicolour*) and green gram (*Phaseolus radiata*) intercropping system as affected by row ratio and nitrogen in arid fringes. *Indian Journal of Agricultural Science.* **79** (2): 101-105.

Rao, V.S. 1983. Principles of weed science. *Oxford and IBH Pub. Co., New Delh*i, pp. 243-503.

Rathi, J.P.S., Tewari, A.N. and Kumar, M. 2004. Integrated weed management in black gram (*Vigna mungo* L.). *Indian Journal of Weed Science.* **36**(3&4): 218-220.

Reager, M .L., Choudhary, G.R. and Dahama, A.K. 2003. Effect of weed control and phosphorus on growth and quality of clusterbean [*Cyamposis tetragonoloba* (L.) Taub.]. *Annals of Agricultural Research.* **24**: 563-566.

Richards, L.A. 1954. Diagnosis and improvement of saline and alkali soil. *USDA Hand Book NO. 60. Oxford & IBH Pub. Co., New Delhi.*

Saltoni, N., Shropshire, C., Cowan, T. and Sikkema, P. 2004. Tolerence of black beans (*Phaseolus vulgaris*) to soil application of S- Metolachlor and imazethapyr. *Weed Technology.* **18**: 111-118.

Sangeetha, C., Chinnusamy, C. and Prabhakaran, N.K. 2013. Early post-emergence herbicides for weed control in soybean. *Indian Journal of weed science.* **45**(2): 140-142.

Sasikala, B., Kumari, C.R., Obulamma, U. and Reddy, C.R. 2007. Effect of chemical weed control on yield and economics of *rabi* groundnut. *Journal of Research ANGRAU.* **35**: 70-73.

Savu, R.M., Choubey, N.K. and Tiwari, N. 2006. Chemical weed control in groundnut (*Arachis hypogaea* L.) under vertisols of Chhatisgarh plains. *Journal of Interacademicia.* **10**(2): 156-159.

Sharma R.P., Singh, A. K., Podar, B. K. and Raman, K. R. 2008. Forage production potential and economics of maize (*Zea mays*) with legumes intercropping under various row proportion*. Indian Journal of Agronomy*. **53**(2): 121-124.

Sharma, A., Padit, S., Rathod, P.S. and Basavaraj, K. 2010. Agronomic management of pigeon pea (*cajanus cajan*) based intercropping system for improving Productivity under rainfed condition*. Karnataka Journal of Agriculture Science.* **23**(4): 570-574.

Sharma, K. C. 2008. Fodder productivity and economics of multi cut pearl millet (*Pennisetum glaucum*) intercropped with cluster bean (*Cyamopsis tetragonoloba*). *Indian Journal of Agronomy.* **53**(1): 42-46.

Sharma, O.P. and Gupta, A.K. 2002. Nitrogen phosphorus nutrition of pearl millet as influenced by intercropping legumes and fertilizer levels. *Journal of Plant Nutrition.* **25**(4): 833-842.

Sharma, R.P., Raman, K.R. and Singh, A.K. 2009. Fodder productivity and economics of pearl millet (*Pennisetum typhoides*) with legumes intercropping under various row proportions. *Indian Journal of Agronomy.* **54**(3): 301-305.

Shetty, S.V.R. 1981. The status of weed control in intercropping systems in tropics. *FAO plant production and protection* 44: 119-125.

Singh Mahender, Singh Pushpendra, Nepalia, V. 2005, Integrated Weed Management Studies in Maize Based Intercropping System. *Indian Journal of Weed Science.* **37**(3&4): 205-208.

Singh, D.K. and Agrawal, R.L. 2004. Nitrogen and phosphorus nutrition of pearl millet (*Pennisetum glaucum*) grown in sole and intercropping systems under rainfed conditions. *Indian Journal of Agronomy.* **49**(3): 151-153.

Singh, G. 2011. Weed Management in Summer and *Kharif* Season Black gram [*Vigna mungo* (L.) Hepper]. *Indian Journal of Weed Science.* 43 (1 & 2): 77-80.

Singh, I.D. and Stoskhopf, V.C. 1971. Harvest index in cereals. *Agronomy Journal.* **63**: 224-226.

Singh, J., Kumar, A. and Singh, B. (2003). Production potential and economics of cluster bean under various geometry and intercropping system. *Advances in Arid Legumes Research.* 207-211.

Singh, R. and Chaudhary, G.R. 1992. Crop weed competition in mung bean. *Indian Journal of Agronomy.* **33** (4): 377-378.

Singh, R. and Yadav, S.K. 1994. Effect of method of weed control on nutrients uptake in pearlmillet, *Ann. Arid Zone.* **33**(1): 81-82.

Singh, S.P., Gautam, R.C. and Anjaneyulu, V.R. 1979. Adding a competition free period to intercrop component-A new concept. *In : Proc. Intern. Workshop on Intercropping Hyderabad, India.* 10-13 Jan. ICRISAT, 1981. pp 25-29.

Singh, S.P., Yadav, R.S., Sharma, V. and Bairwa, R.C. 2014. Efficacy of weed control measures on weeds and yield of cluster bean: 100. In: *Biennial conference of Indian society of weed science on "Emerging challenges in weed management",* February 15-17, 2014. DWSR, Jabalpur.

Snell, F.D. and Snell, G.T. 1939. Colorimetric methods of analysis. *3rd Edn. II D. Van Nostr and Co. Inc. New Yourk*.

Sonawane, R.K.,Dandge, D.S., Kamble, A.S. and Singhrup, P.V. 2014. Effect of herbicide on nutrient uptake by weeds, crop and yield of *Kharif* maize. : *Biennial conference of Indian society of weed science on* “Emerging challenges in weed management”, February 15-17, 2014. DWSR, Jabalpur.

Sreenivas, G. and Satyanarayan, V. 1994. Integrated weed management in rainy season maize (*Zea mays*). *Indian Journal of Agronomy.* **39**(1): 166-167.

Srikrishnah. S., Umarajini, S. and Seran, T.H. 2008. The effect of intercropping brinjal (Solanum melongena L.) with groundnut (*Arachis hypogaea* L.) on weed population. Proceedings of the 2nd International Symposium, July 8-12, Sabaragamuwa University, Sri Lanka, pp: 15-15.

Subhiah, B.V. and Asija, G.L. 1956. A rapid procedure for the estimation of available nitrogen in soils. *Curr. Sci.* **25**(7): 259-260.

Sukhadia, N.M., Ramani, B.B., Modhwadia, M. M. and Asodaria, K. B. 2000. Integrated weed management in pigeon pea (*Cajanus cajan* (L.) Millsp.). *GAU Research Journal.* **25**(2): 1-4.

Tenaw Workayehu 2014. Legume-based cropping for sustainable production, economic benefit and reducing climate change impacts in southern Ethiopia. *Journal of Agricultural and Crop Research.* **2**(1):11-21.

Tetarwal, J.P. and Rana, K.S. 2006. Impact of cropping system fertility level and moisture conservation practice on productivity, nutrient uptake, water use and profitability of pearl millet (*Pennisetum glaucum*) under rainfed conduction. *Indian Journal of Agronomy*. **51**(4): 263-266.

Tiwari, A.N., Singh, V., Rathi, K.S., Singh, K.K. and Kumar, D. 1989. Studies on integrated weed management in pigeon pea/ groundnut based cropping system under rainfed condition. *Indian Journal of Weed Sci*ence. **21** (1 & 2): 41-46.

Tiwari, A.N., Tiwari, K.N., Singh, K.K., Tiwari, V.S. and Sharma, J.K. 1990. Effect of weed removal on yield and nutrient uptake in pigeon pea + block grain intercropping. *Indian Journal of Agronomy*. **35**(4): 341-345.

Tiwari, D.K., Kewat, M.L., Khan, J.A. and Khamparia, N.K. 2007. Evaulation of efficacy of post-emergence herbicides in soybean (*Glycine max*). *Indian Journal of Agronomy.* **52** (1): 74-76.

Umrani, M.K., Bhoi, P.G. and Patil, N.B. 1980. Effect of weed competition on growth and yield of pearl millet. *Journal Maharashtra Agriculture University.* **5** (1): 56-57.

Upadhyay, V.B., Singh, A. and Rawat, A. 2013. Efficacy of early post-emergence herbicides against associated weeds in soybean. *Indian Journal of Weed Science.* **44** (40): 73-75.

Verma, P.S., Raj, B., Katyal, S.K. 1992. Performance of short duration hybrids in pearlmillet, pigeonpea intercropping system. *Indian Journal of Agronomy*. **37**(4): 650-654.

Verma, R.S. and Kumar, V. 1985. Effect of different tillage practices and weed control measures on growth, yield and weed flora in *bajra* [*Pennisetum americamum* (L.)] (In) *Abstr. Ann. Conf. Indian Soc. Weed Sci.* P 31.

Vyas, M.D. and Jain, A.K. 2004. Effect of pre and post emergence herbicides on weed control and productivity of soybean (*Glycine max*). *Indian Journal of Agronomy.* **48**: 309-311.

Wang, B., Grooms, S. and Frans, R.F. 1974. Response of soybean nitochondria to substituted dinitroaline herbicides. *Weed Science.* **22**: 64-66.

Workayehu, T. and Wortmann, C. S. 2011. Maize–bean intercrop weed suppression and profitability in Southern Ethiopia. *Agronomy Journal*. 1**03**(4): 1058-1063.

www.rajasthankrishi.gov.in. 2013. Department of Agricultural Statistics, Pant Bhawan, Jaipur.

Yadav, G.L. and Jat, B.L. 2005. Intercropping of moth bean varieties with pearl millet for sustainable crop production in arid ecosystem. *Indian journal* of *pulses Research.* **18**(2): 252-253.

Yadav, K.S., Rajput, R.L., Dixit, J.P. and Jaulkar, A.M. 2014. Integrated approach of weed control in okra: 117. In: *Biennial conference of Indian society of weed science on "Emerging challenges in weed management",* February 15-17, 2014. DWSR, Jabalpur.

Yadav, R.S. and Yadav, O.P. 2000. Differential competitive ability and growth habit of pearl millet and cluster bean cultivars in a mixed cropping system in the arid zone of India. *Journal of Agronomy Crop Science, Berlin*, **185**:67-71.

Yadav, S.L., Kaushik, M.K. and Mundra, S.L. 2011. Effect of weed control practices on weed dry weight, nutrient uptake and yield of cluster bean [*Cymopsis tetragonoloba(L.)Taub.*] under rainfed condition. *Indian Journal of Weed Science,* **43**(1/2): 81-84.5.

Yadav,N.D., Rathore,V.S. and Beniwal, R.K.2005. Production potential of legumes based intercropping system under hyper arid condition of Rajasthan. *Journal of Arid Legumes.* **2** (2): 230-232.

Zaviehmavadat, L., Mazaheri, D., Majnon hoseinii, N.and Rezaei, M. 2013. The effect of maize and cowpea intercropping on weed control condition. *International Journal of Agronomy and Plant Production.* **4**(11): 2885-2889.

# Effect of Weed Control Measures in Pearl millet-Legumes Intercropping System in Arid Western Rajasthan

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## ABSTRACT

A field experiment was conducted during *kharif*, 2014 at Instructional Farm, College of Agriculture, Bikaner. The experiment comprising 20 treatments combination, replicated three times and was laid out in split plot design with combination of five cropping systems (Sole pearl millet, sole cluster bean, sole moth bean, pearl millet + cluster bean and pearl millet + moth bean) and four weed control treatments (weedy check, hand weeding twice at 20 and 45 DAS, pendimethalin at 0.75 kg $ha^{-1}$ as pre emergence and imazethapyr 40 g $ha^{-1}$ as post emergence).

The results showed that intercropping systems significantly reduced the mean density and dry matter production of weeds as compared to sole pearl millet at all the stages. Pearl millet intercropped with cluster bean and moth bean (24.52 and 27.21%, respectively) had good weed smothering efficiency. Dry matter accumulation at harvest, total tillers and effective tillers per plant of pearl millet was significantly higher under intercropping with legume but non significant effect observed on plant height, ear head length and test weight. Maximum grain and straw yield of pearl millet were recorded with sole pearl millet over pearl millet with intercropping. However, growth and yield attributes of legumes viz. plant height, dry matter accumulation, nodules per plant, pods per plant, seeds per pod and test weight were not influenced by sole as well as intercropping system but maximum grain, straw and biological yield were recorded with sole crop. Significantly higher pearl millet equivalent yield was recorded under sole crop of cluster bean as well as moth bean. Pearl millet + cluster bean and pearl millet + moth bean also gave higher significant pearl millet equivalent yield compared to sole pearl millet. Mean net return and B:C ratio fetched under sole cluster bean. Further, higher mean net return of Rs. 31730 with B:C ratio of 3.06 was statistically at par with pearl millet + moth bean but significantly higher over pearl millet sole. Nitrogen and protein content in pearl millet grain considerably increase due to intercropping with legumes.

In sole grown pearl millet, cluster bean and moth bean both grain and straw were recorded significantly higher N, P & K uptake.

All the weed control treatments significantly reduced the density and dry matter production of weeds in comparison to weedy check. Hand weeding twice at 20 and 35 DAS resulted maximum reduction in density and dry matter production at 30 DAS, 45 DAS and at harvest.

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Pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ reduced the density and dry matter compared to weedy check but lower than two hand weeding treatment.

The crop plant height, dry matter, effective tillers, ear head length, grain, straw and biological yield of pearl millet increased significantly under all the weed control treatments(except imazethapyr at 40 g $ha^{-1}$) as compared to weedy check. However, maximum mean values of these parameters were recorded under hand weeding twice at 20 and 35 DAS. Application of pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ decreased the growth and yield attributes (viz. plant population, height, dry matter production, effective tillers, earl head length and test weight) of pearl millet compared to two hand weeding due to some phytotoxic effect.

The plant height, dry matter, nodules per plant, pods per plant and seeds per pod, grain, straw and biological yield of legumes increased significantly under all the weed control treatments as compared to weedy check. Further, highest mean values of these attributes were recorded under hand weeding twice at 20 and 35 DAS treatment.

Nitrogen, phosphorus, potassium and protein content as well as total uptake of these nutrients by crops increased considerably with all weed control treatment compared to weedy check.

Significantly higher pearl millet equivalent yield was recorded in two hand weeding over all other treatments. Pendimethalin at 0.75 kg $ha^{-1}$ and imazethapyr at 40 g $ha^{-1}$ treatment produce higher pearl millet equivalent yield over weedy check but lower than two hand weeding treatments. All the weed control treatments recorded significantly higher net return and B:C ratio over weedy check. Pendimethalin at 0.75 kg $ha^{-1}$ (Rs.30774 $ha^{-1}$) and imazethapyr at 40 g $ha^{-1}$ (Rs.29306 $ha^{-1}$) significantly higher compared to weedy check in respect of net return, but lower than hand weeding twice (Rs. 35795 $ha^{-1}$).

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कृषि महाविद्यालय, बीकानेर के प्रक्षैत्र फार्म पर वर्ष 2014 की खरीफ ऋतु में शुष्क पश्चिमी राजस्थान में बाजरा–फलीदार फसल अन्तःशस्य प्रणाली में खरपतवार नियन्त्रण उपयो का प्रभाव नामक प्रयोग सम्पन्न किया गया । इस शोध कार्य में कुल बीस (20) संयोज्य प्रयोगोपचारो, जिसमे अन्तःशस्य की पाँच प्रणालियों (एकल बाजरा, एकल ग्वार, एकल मोठ, बाजरा + ग्वार व बाजरा + मोठ) को मुख्य खण्ड व खरपतवार नियन्त्रण के चार उपचारों (खरपतवारीय परिक्षार्थ, दो बार हाथ से निराई, अंकुरण से पहले 0.75 किग्रा. प्रति है. पेन्डीमिथालीन व अंकुरण के बाद 40 ग्राम प्रति है. इमेजाथापर ) को उपखण्ड में विभक्त खण्ड अभिकल्पना में तीन बार पुनरावृति की गयी।

प्रयोग के परिणामों में देखा गया कि अन्तः शस्य अभिक्रिया से खरपतवारों की संख्या तथा शुष्क भार में एकल बाजरा की तुलना में सार्थक कमी हुई। बाजरा के साथ ग्वार तथा मोठ अन्तः फसल में प्रभावी खरपतवार दबाव क्रमशः 24.52 व 27.21 प्रतिशत दर्ज की गई। बाजरा के साथ फलीदार फसलों की अन्तःशस्य के तहत बाजरा के शुष्क भार संचय, कुल तथा प्रभावी कल्लों की संख्या प्रति पौधा में सार्थक वृद्धि हुई परन्तु पौधों की ऊचाई, बाली की लम्बाई तथा परिक्षण भार में सार्थक प्रभाव नही रहा। जबकि एकल बाजरा में, बाजरा के साथ फलीदार फसल की अन्तःशस्य प्रणाली की अपेक्षा दाना तथा भूसा उपज में स्पष्टतः बढोतरी दर्ज की गयी। यदपि एकल फलीदार फसलों के साथ–साथ बाजरा व फलीदार अन्तःशस्य प्रणाली में फलीदार फसलों की वृद्धि तथा उपज मापढण्ड (जिसमें पौध ऊचाई ,प्रति पौधा शुष्क भार संचयन, जड ग्रन्थियां, फालियों की संख्या, प्रति फली दानों की संख्या तथा परिक्षण भार पर कोई सार्थक प्रभाव नहीं पाया गया। परन्तु, अधिकतम दाना, भूसा व जैविक उपज फलीदार फसलों की एकल फसल में पायी गई। बाजरा समतुल्य उपज एकल ग्वार के साथ–साथ एकल मोठ में सर्वाधिक पाई गई जो अन्य सभी अन्त फसल प्रणालियो

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एवम एकल बाजरा की तुलना में अधिक रही। जबकि एकल बाजरा की तुलना में बाजरा+ग्वार तथा बाजरा+मोठ में भी सार्थक रुप से अधिक बाजरा समतुल्य उपज दर्ज की गई।

एकलम माध्य आय व लाभ लागत अनुपात एकल ग्वार में सार्थक रुप से अधिक पाया गयो, जबकि अन्तःफसली करण में एकलम माध्य आय व लाभ लागत अनुपात एकल बाजरा से अधिक रही जोकि बाजरा+मोठ में क्रमशः रुपये 31730 प्रति हेक्टेयर व 3.06 पायी गई।

बाजरा के दानो में नत्रजन व प्रोटीन की मात्रा बाजरा के साथ फलीदार फसलों के अन्तःशस्य लेने से सार्थक रुप से बढी। जबकि नत्रजन, फास्फोरस तथा पोटाश का अर्न्तग्रहण सभी एकल फसलों (बाजरा, ग्वार व मोठ) के दानों व भूसा में सार्थक रूप से अन्तः फसलीकरण से अधिक रहा।

खरपतवार परीक्षार्थ की तुलना में इसके नियन्त्रण के सभी उपचारों में खरपतवारों के माध्य घनत्व तथा शुष्क भार संचयन में कमी पायी गयी। दो बार हस्तलोचन उपचार से खरपतवारों माध्य घनत्व, शुष्क भार संचयन में सार्थक कमी दर्ज की गई। पेण्डीमेथालीन 0.75 किग्रा प्रति हैक्टेयर एवं इमेजाथापर 40 ग्राम प्रति हैक्टेयर के उपचारों में खरपतवारीय परीक्षार्थ की अपेक्षा खरपतवारों के माध्य घनत्व तथा शुष्क भार संचयन में कमी हुई परन्तु यह दो बार हस्तलोचन से कम थी। खरपतवारीय परीक्षार्थ की तुलना में खरपतवार नियन्त्रण के सभी उपचारों (इमेजाथापर 40 ग्राम प्रति हैक्टेयर को छोड़कर) के साथ बाजरा की पौध ऊंचाई, शुष्क भार, प्रभावशाली कल्लों की संख्या, बाली लम्बाई, दाना, भूसा तथा जैविक उपज में सार्थक वृद्धि हुई।

फिर भी, इन मानकों का माध्य मान दो हस्तलोचन उपचार में अधिकतम दर्ज किया गया। पेण्डीमेथालीन 0.75 किग्रा प्रति हैक्टेयर तथा इमेजाथापर 40 ग्राम प्रति हैक्टेयर के उपयोग द्वारा बाजरा की वृद्धि तथा उपज मापकों में हस्तलोचन उपचार की अपेक्षा कमी दर्ज की गयी। खरपतवारीय परीक्षार्थ की तुलना में खरपतवार नियंत्रण के सभी उपचारों के साथ फलिदार फसल की पौधों की ऊंचाई, शुष्क भार, जड़ ग्रन्थिया प्रति पौधा, फलियां प्रति पौधा, दाना प्रति फली, दाना, भूसा तथा जैविक उपज में सार्थक वृद्धि हुई। इसके अलावा इन मानकों का माध्य परिमाण दो हस्तलोचन के उपचार के साथ अधिकतम दर्ज किया गया। नत्रजन, फास्फोरस, पोटाश तथा प्रोटीन की मात्रा के साथ–साथ इनका कुल अन्तःग्रहण खरपतवार नियन्त्रण के सभी उपचारों के साथ खरपतवार परीक्षार्थ की अपेक्षा सार्थक रूप से बढ़ा। बाजरा समतुल्य उपज दो बार हस्तलोचन उपचार में अन्य सभी उपचारों से सार्थक रूप से अधिक दर्ज की गयी। पेण्डीमेथालीन 0.75 किग्रा प्रति हैक्टर तथा इमेजाथापर 40 ग्राम प्रति हैक्टर के उपचार में खरपतवारीय परीक्षार्थ की अपेक्षा बाजरा समतुल्य उपज में वृद्धि हुई परन्तु यह दो बार हस्तलोचन से कम थी।

1

## Appendix - I

**Analysis of variance for density and dry matter of weeds at different growth of crop plant**

| Source of variance | d.f. | Mean sum of square | | | | | |
|---|---|---|---|---|---|---|---|
| | | Weed Density (no/m$^2$) | | | Weed dry matter (g/m$^2$) | | |
| | | 30 DAS | 45 DAS | At harvest | 30 DAS | 45 DAS | At harvest |
| Rep | 2 | 13.48 | 3.71 | 12.18 | 3.56 | 178.91 | 29.27 |
| I | 4 | 97.79* | 132.91* | 135.08* | 14.75** | 1,766.06** | 733.99** |
| Error a | 8 | 13.99 | 20.69 | 24.03 | 1.25 | 158.17 | 78.11 |
| W | 3 | 12,133.93** | 9,721.79** | 8,284.91** | 711.42** | 152,707.12** | 105,270.29** |
| IxW | 12 | 26.91 | 86.62** | 55.73* | 4.31** | 924.95** | 615.00** |
| Error b | 30 | 13.19 | 10.37 | 20.36 | 1.01 | 104.30 | 68.46 |

* Significant at 5 per cent ** Significant at 1 per cent

## Appendix - II

**Analysis of variance for plant stand, plant height and dry matter accumulation of pearl millet**

| Source of variance | d.f. | Mean sum of square | | | | | |
|---|---|---|---|---|---|---|---|
| | | Plant stand ('000 ha$^{-1}$) | | Plant height (cm.) | | Dry matter accumulation (g plant$^{-1}$) | |
| | | 30 DAS | At Harvest | 30 DAS | At Harvest | 30 DAS | At Harvest |
| Rep | 2 | 19.20 | 18.95 | 15.95 | 11.81 | 1.14 | 25.23 |
| I | 2 | 79,510.14** | 73,380.34** | 16.48 | 9.15 | 0.30 | 104.33 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Error a | 4 | 77.54 | 87.22 | 10.51 | 104.92 | 3.35 | 17.94 |
| W | 3 | 7,746.10** | 7,395.77** | 338.51** | 1,078.76** | 53.64** | 237.67** |
| IxW | 6 | 1,278.86** | 1,290.80** | 0.13 | 1.63 | 0.04 | 3.79 |
| Error b | 18 | 38.92 | 32.97 | 9.52 | 61.46 | 3.09 | 10.39 |

* Significant at 5 per cent ** Significant at 1 per cent

## Appendix – III

**Analysis of variance for total number of tillers, effective tillers, length of ear head and test weight of pearlmillet**

| Source of variance | d.f. | Mean sum of square | | | |
|---|---|---|---|---|---|
| | | Total tillers per plant | Effective tillers per plant | Length of ear head (cm.) | Test weight (g) |
| Rep | 2 | 0.04 | 0.09 | 2.06 | 0.35 |
| I | 2 | 1.99* | 1.02* | 3.11 | 0.15 |
| Error a | 4 | 0.22 | 0.15 | 4.29 | 1.02 |
| W | 3 | 3.01** | 3.99** | 19.97** | 0.85 |
| IxW | 6 | 0.08 | 0.07 | 0.13 | 0.02 |
| Error b | 18 | 0.16 | 0.07 | 1.77 | 0.62 |

* Significant at 5 per cent ** Significant at 1 per cent

## Appendix – IV

**Analysis of variance for grain, straw and biological yield and harvest index of pearlmillet**

| Source of variance | d.f. | Mean sum of square | | | |
|---|---|---|---|---|---|
| | | Yield (kg ha$^{-1}$) | | | Harvest index (%) |
| | | Grain | Straw | Biological | |
| Rep | 2 | 2,354.23 | 5,857.09 | 19,390.34 | 0.39 |
| I | 2 | 1,119,232.60** | 4,378,212.90** | 9,924,178.62** | 3.52 |
| Error a | 4 | 5,034.55 | 39,559.86 | 29,948.38 | 7.89 |
| W | 3 | 48,859.52** | 312,194.66** | 584,512.34** | 4.05 |
| IxW | 6 | 10,916.17 | 93,679.35** | 45,667.73 | 82.40** |
| Error b | 18 | 4,872.58 | 11,312.31 | 36,782.55 | 4.07 |

* Significant at 5 per cent ** Significant at 1 per cent

# Appendix - V

**Analysis of variance for nitrogen, phosphorus, potassium and protein content of pearl millet**

| Source of variance | d.f. | Mean sum of square | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Nitrogen content (%) | | Phosphorus content (%) | | Potassium content (%) | | Protein content (%) |
| | | Grain | Straw | Grain | Straw | Grain | Straw | Grain |
| Rep | 2 | 0.0366 | 0.0025 | 0.0009 | 0.0002 | 0.0043 | 0.0434 | 1.43 |
| I | 2 | 0.0376* | 0.0045* | 0.0001 | 0.0001 | 0.0007 | 0.0001 | 1.47* |
| Error a | 4 | 0.0053 | 0.0004 | 0.0001 | 0.000001 | 0.0007 | 0.0072 | 0.21 |
| W | 3 | 0.1171** | 0.0209** | 0.0005** | 0.0002** | 0.0014* | 0.0137* | 4.57** |
| IxW | 6 | 0.0036 | 0.0007 | 0.0002 | 0.0002 | 0.0000 | 0.0003 | 0.14 |
| Error b | 18 | 0.0033 | 0.0003 | 0.0001 | 0.000001 | 0.0004 | 0.0041 | 0.13 |

* Significant at 5 per cent ** Significant at 1 per cent

## Appendix - VI

**Analysis of variance for nitrogen, phosphorus and potassium uptake of pearl millet**

| Source of variance | d.f. | Mean sum of square | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Nitrogen uptake | | | Phosphorus uptake | | | Potassium uptake | | |
| | | Grain | Straw | Total | Grain | Straw | Total | Grain | Straw | Total |
| Rep | 2 | 1.82 | 0.98 | 5.29 | 0.04 | 0.07 | 0.20 | 0.20 | 17.19 | 20.70 |
| I | 2 | 273.72** | 84.00** | 660.85** | 7.77** | 5.62** | 26.59** | 35.51** | 1,503.90** | 2,001.53** |
| Error a | 4 | 3.08 | 1.68 | 8.89 | 0.07 | 0.10 | 0.32 | 0.32 | 26.51 | 32.11 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| W | 3 | 28.37** | 12.48** | 77.25** | 0.54** | 0.46** | 1.93** | 2.15** | 126.98** | 158.92** |
| IxW | 6 | 4.34 | 3.10 | 4.79 | 0.09 | 0.07 | 0.10 | 0.40 | 35.75 | 29.77 |
| Error b | 18 | 1.45 | 0.26 | 2.34 | 0.04 | 0.02 | 0.07 | 0.17 | 4.35 | 5.21 |

* Significant at 5 per cent ** Significant at 1 per cent

**Appendix - VII**

**Analysis of variance for plant stand, plant height and dry matter accumulation of cluster bean**

| Source of variance | d.f. | Mean sum of square | | | | | |
|---|---|---|---|---|---|---|---|
| | | Plant stand ('000 $ha^{-1}$) | | Plant height (cm.) | | Dry matter accumulation (g $plant^{-1}$) | |
| | | 30 DAS | At Harvest | 30 DAS | At Harvest | 30 DAS | At Harvest |
| Rep | 2 | 51.22 | 588.45 | 3.45 | 168.37 | 0.01 | 0.31 |
| I | 1 | 55,802.60** | 53,394.55** | 3.60 | 6.83 | 0.03 | 0.09 |
| Error a | 2 | 48.98 | 214.25 | 4.89 | 76.93 | 0.06 | 3.92 |
| W | 3 | 11.96 | 321.44* | 19.12* | 537.95** | 0.02 | 43.62** |
| IxW | 3 | 14.24 | 61.77 | 7.73 | 87.78 | 0.01 | 0.60 |
| Error b | 12 | 12.90 | 91.75 | 4.19 | 38.09 | 0.03 | 1.31 |

* Significant at 5 per cent ** Significant at 1 per cent

**Appendix – VIII**

**Analysis of variance for on nodules per plant, pods per plant, seeds per pod and test weight of cluster bean**

| Source of variance | d.f. | Mean sum of square | | | |
|---|---|---|---|---|---|
| | | Nodules per plant | Pods per plant | Seeds per pod | Test weight (g) |
| Rep | 2 | 0.29 | 6.30 | 0.07 | 0.29 |
| I | 1 | 10.53 | 4.00 | 3.23 | 0.60 |
| Error a | 2 | 8.44 | 8.35 | 0.61 | 4.42 |
| W | 3 | 4.69 | 84.67** | 3.26** | 4.06 |
| IxW | 3 | 0.39 | 5.14 | 0.21 | 0.18 |
| Error b | 12 | 7.49 | 7.83 | 0.30 | 3.33 |

* Significant at 5 per cent ** Significant at 1 per cent

**Appendix – IX**

**Analysis of variance for grain, straw and biological yield and harvest index of cluster bean**

| Source of variance | d.f. | Mean sum of square | | | |
|---|---|---|---|---|---|
| | | Yield (kg ha$^{-1}$) | | | Harvest index (%) |
| | | Grain | Straw | Biological | |
| Rep | 2 | 4,225.65 | 7,287.26 | 21,006.53 | 0.25 |
| I | 1 | 7,08,516.39* | 3,034,568.29* | 6,675,688.56* | 3.36 |
| Error a | 2 | 19,267.02 | 92,297.58 | 176,525.93 | 6.02 |
| W | 3 | 2,99,531.93** | 743,015.10** | 1,978,138.09** | 9.54 |
| IxW | 3 | 29,780.58 | 55,105.27 | 149,202.21 | 6.41 |
| Error b | 12 | 15,062.46 | 30,467.52 | 70,355.30 | 4.52 |

* Significant at 5 per cent ** Significant at 1 per cent

**Appendix - X**

**Analysis of variance for nitrogen, phosphorus, potassium and protein content of cluster bean**

| Source of variance | d.f. | Mean sum of square | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Nitrogen content (%) | | Phosphorus content (%) | | Potassium content (%) | | Protein content (%) |
| | | Grain | Straw | Grain | Straw | Grain | Straw | Grain |
| Rep | 2 | 0.1133 | 0.0064 | 0.0015 | 0.0005 | 0.0011 | 0.0030 | 4.43 |
| I | 1 | 0.0150 | 0.0007 | 0.0010 | 0.0008 | 0.0011 | 0.0004 | 0.59 |
| Error a | 2 | 0.0153 | 0.0008 | 0.0002 | 0.0001 | 0.0002 | 0.0006 | 0.60 |
| W | 3 | 0.0687* | 0.0041* | 0.0009* | 0.0003* | 0.0007* | 0.0034** | 2.68* |
| IxW | 3 | 0.0038 | 0.0013 | 0.0001 | 0.0003 | 0.0002 | 0.0003 | 0.15 |
| Error b | 12 | 0.0147 | 0.0008 | 0.0002 | 0.0001 | 0.0002 | 0.0004 | 0.57 |

* Significant at 5 per cent ** Significant at 1 per cent

**Appendix - XI**

**Analysis of variance for nitrogen, phosphorus and potassium uptake of cluster bean**

| Source of variance | d.f. | Mean sum of square | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Nitrogen uptake | | | Phosphorus uptake | | | Potassium uptake | | |
| | | Grain | Straw | Total | Grain | Straw | Total | Grain | Straw | Total |
| Rep | 2 | 28.03 | 3.89 | 52.51 | 0.39 | 0.33 | 1.44 | 0.31 | 1.93 | 3.75 |
| I | 1 | 999.96* | 240.17* | 2,220.25* | 14.93* | 24.71* | 78.04* | 12.78* | 125.83* | 218.81* |
| Error a | 2 | 26.27 | 8.27 | 59.09 | 0.37 | 0.75 | 1.99 | 0.32 | 4.43 | 6.71 |
| W | 3 | 469.21** | 68.61** | 896.08** | 6.52** | 6.04** | 25.08** | 5.40** | 38.71** | 72.86** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| IxW | 3 | 42.89 | 6.61 | 79.60 | 0.63 | 0.55 | 2.34 | 0.67 | 3.09 | 6.40 |
| Error b | 12 | 23.74 | 2.36 | 35.87 | 0.33 | 0.21 | 0.88 | 0.28 | 1.24 | 2.27 |

* Significant at 5 per cent ** Significant at 1 per cent

**Appendix - XII**

**Analysis of variance for plant stand, plant height and dry matter accumulation of moth bean**

| **Source of variance** | **d.f.** | **Mean sum of square** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Plant stand ('000 $ha^{-1}$)** | | **Plant height (cm.)** | | **Dry matter accumulation (g $plant^{-1}$)** | |
| | | **30 DAS** | **At Harvest** | **30 DAS** | **At Harvest** | **30 DAS** | **At Harvest** |
| Rep | 2 | 162.64 | 306.72 | 3.99 | 2.51 | 0.44 | 11.68 |
| I | 1 | 53,666.58** | 54,229.83* | 0.67 | 7.37 | 0.10 | 3.45 |
| Error a | 2 | 503.78 | 609.18 | 1.08 | 10.38 | 0.35 | 4.06 |
| W | 3 | 12.74 | 586.84 | 4.85* | 36.35* | 5.34** | 51.16** |
| IxW | 3 | 2.63 | 3.48 | 0.25 | 0.77 | 0.13 | 0.41 |
| Error b | 12 | 165.44 | 179.59 | 1.04 | 8.88 | 0.24 | 3.92 |

* Significant at 5 per cent ** Significant at 1 per cent

**Appendix – XIII**

**Analysis of variance for on nodules per plant, pods per plant, seeds per pod and test weight of moth bean**

| **Source of** | **d.f.** | **Mean sum of square** |
|---|---|---|

| variance | | Nodules per plant | Pods per plant | Seeds per pod | Test weight (g) |
|---|---|---|---|---|---|
| Rep | 2 | 5.51 | 15.88 | 0.15 | 0.30 |
| I | 1 | 6.83 | 24.00 | 0.48 | 1.08 |
| Error a | 2 | 4.26 | 7.63 | 1.04 | 4.84 |
| W | 3 | 5.89 | 18.44** | 2.17** | 6.21 |
| IxW | 3 | 0.64 | 0.44 | 0.82 | 0.47 |
| Error b | 12 | 4.09 | 2.86 | 0.32 | 4.30 |

* Significant at 5 per cent ** Significant at 1 per cent

## Appendix – XIV

**Analysis of variance for grain, straw and biological yield and harvest index of moth bean**

| Source of variance | d.f. | Mean sum of square | | | |
|---|---|---|---|---|---|
| | | Yield (kg ha$^{-1}$) | | | Harvest index (%) |
| | | Grain | Straw | Biological | |
| Rep | 2 | 38,143.90 | 98,408.33 | 289,125.91 | 4.13 |
| I | 1 | 385,870.83* | 3,413,806.42* | 6,095,140.86* | 28.71 |
| Error a | 2 | 9,891.99 | 74,501.75 | 144,178.84 | 10.81 |
| W | 3 | 126,992.26** | 440,385.54** | 1,021,744.32** | 14.17 |
| IxW | 3 | 17,019.84 | 47,396.67 | 83,670.95 | 13.86 |
| Error b | 12 | 8,470.32 | 41,903.62 | 94,984.28 | 4.38 |

* Significant at 5 per cent ** Significant at 1 per cent

**Appendix - XV**

**Analysis of variance for nitrogen, phosphorus, potassium and protein content of moth bean**

| Source of variance | d.f. | Mean sum of square | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Nitrogen content (%) | | Phosphorus content (%) | | Potassium content (%) | | Protein content (%) |
| | | Grain | Straw | Grain | Straw | Grain | Straw | Grain |
| Rep | 2 | 0.1021 | 0 .0052 | 0.0014 | 0.0004 | 0.0011 | 0.0045 | 3.99 |
| I | 1 | 0.0015 | 0 .0040 | 0.0011 | 0.0009 | 0.0007 | 0.0003 | 0.06 |
| Error a | 2 | 0.0204 | 0.0009 | 0.0002 | 0.0001 | 0.0002 | 0.0008 | 0.80 |
| W | 3 | 0.0511 | 0.0026* | 0.0035** | 0.0010** | 0.0006* | 0.0019 | 1.23 |
| IxW | 3 | 0.0005 | 0.0003 | 0.0002 | 0.0004 | 0.0006 | 0.0001 | 0.02 |
| Error b | 12 | 0.0148 | 0.0007 | 0.0002 | 0.0001 | 0.0002 | 0.0006 | 0.58 |

* Significant at 5 per cent ** Significant at 1 per cent

**Appendix - XVI**

**Analysis of variance for nitrogen, phosphorus and potassium uptake of moth bean**

| Source of variance | d.f. | Mean sum of square | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Nitrogen uptake | | | Phosphorus uptake | | | Potassium uptake | | |
| | | Grain | Straw | Total | Grain | Straw | Total | Grain | Straw | Total |
| Rep | 2 | 22.65 | 2.51 | 38.52 | 0.31 | 0.22 | 0.99 | 0.25 | 1.98 | 3.46 |
| I | 1 | 522.15* | 255.42* | 1,507.96* | 8.29* | 22.24* | 57.69* | 5.98* | 189.42* | 262.69* |
| Error a | 2 | 17.61 | 5.18 | 36.28 | 0.23 | 0.42 | 1.08 | 0.19 | 4.14 | 5.57 |
| W | 3 | 192.01** | 36.05** | 388.98** | 3.19** | 3.80** | 13.56** | 2.01** | 30.29** | 47.07** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| IxW | 3 | 24.47 | 4.80 | 37.52 | 0.45 | 0.14 | 0.69 | 0.16 | 3.23 | 3.85 |
| Error b | 12 | 7.71 | 2.30 | 16.18 | 0.11 | 0.19 | 0.51 | 0.08 | 1.83 | 2.48 |

*Significant at 5 per cent ** Significant at 1 per cent

**Appendix – XVII**

**Analysis of variance for PMEY, net return and B: C ratio**

| **Source of variance** | **d.f.** | **Mean sum of square** | | |
|---|---|---|---|---|
| | | **PMEY** | **Net return** | **B: C ratio** |
| Rep | 2 | 138,561.22 | 29,900,578.27 | 0.12 |
| I | 4 | 11,862,312.57** | 2,113,605,236.19** | 8.79** |
| Error a | 8 | 207,495.15 | 50,940,955.64 | 0.21 |
| W | 3 | 4,542,634.87** | 866,156,513.61** | 2.30** |
| IxW | 12 | 384,978.09** | 87,363,360.88** | 0.33** |
| Error b | 30 | 120,041.94 | 27,990,125.28 | 0.11 |

* Significant at 5 per cent ** Significant at 1 per cent

**Appendix - XVIII**

**Common cost of cultivation for pearl millet legumes intercropping system**

| S.No. | Particular of operation | Cost (Rs.) | Input | Rate/unit(Rs) |
|---|---|---|---|---|
| 1. | Field preparation | | | |
| (a) | Ploughing by disc harrow (after onset of monsoon) | 1200 | Tractor drawn disc harrow | Rs 1200 $ha^{-1}$ |
| (b) | Ploughing along with fertilizer followed by planking | 900 | Tractor drawn cultivator with planker | Rs 900 $ha^{-1}$ |
| (c) | Fertilizer (phosphorus 40 kg $ha^{-1}$) | 2262 | Through DAP | Rs 26/kg |
| (d) | Layout and preparation of beds(6 labour) | 996 | Labour | Rs 166/labour |
| 2. | Sowing of seeds by kera method including labour charge (10 labour) | 1660 | Hand drawn seed drill | Rs 166/labour |
| 3. | Thinning (5 labours) | 830 | Labour | Rs 166/labour |

| | | | | |
|---|---|---|---|---|
| 4. | Plant protection | 380 | Monochrotophos | Rs 380/litre |
| 5. | Irrigation including charge(8 labours) | 1328 | Labour | Rs 166/labour |
| 6. | Harvesting (8 labours) | 1328 | Labour | Rs 166/labour |
| 7. | Threshing and winnowing (8 labours) | 1328 | Labour | Rs 166/labour |
| 8. | Miscellaneous | 500 | | |
| | **Total** | **12712** | | |

**Appendix - XIX**

**Treatment cost of cultivation of different pearl millet - legumes intercropping system**

| **S. No.** | **Particular of operation** | **Treatment Cost (Rs)** | | | | | **Rate/unit(Rs)** |
|---|---|---|---|---|---|---|---|
| | | I1 | I2 | I3 | I4 | I5 | |
| 1. | Seeds | | | | | | |
| | (a) Pearlmillet | 400 | - | - | 133 | 133 | Rs 100/kg |
| | (b) Cluster bean | - | 1500 | - | 1000 | - | Rs 75/kg |
| | (c) Moth bean | - | - | 1020 | - | 680 | Rs 85/kg |
| 2. | Seed treatment | 24 | 120 | 72 | 88 | 56 | Rs 2/g |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (Bavistin) | | | | | | |
| 3. | Fertilizer (Urea) | 679 | - | - | 226 | 226 | Rs 7/kg |
| | **Total** | **1103** | **1620** | **1092** | **1448** | **1096** | |

**Appendix - XX**

**Treatment cost of cultivation of weed control measures in pearl millet - legumes intercropping system**

| **S. No.** | **Particular of operation** | **Treatment Cost (Rs)** | | | | **Rate/unit(Rs)** |
|---|---|---|---|---|---|---|
| | | W1 | W2 | W3 | W4 | |
| 1. | Weed control | | | | | |
| (a) | Hand weeding | - | 3320 | - | - | Rs 166/labour |
| (b) | Pendimethalin | - | - | 938 | - | Rs 375/kg |
| (c) | Imazethapyr | - | - | - | 280 | Rs 700/kg |
| | **Total** | **-** | **3320** | **938** | **280** | |

Appendix - XXI

**Comparative and economics of various treatment combinations**

| Treatments | Treatment cost (Rs. $ha^{-1}$) | Common cost (Rs. $ha^{-1}$) | Total cost of cultivation (Rs. $ha^{-1}$) | Grain yield (kg $ha^{-1}$) | | Straw yield (kg $ha^{-1}$) | | Gross return (Rs. $ha^{-1}$) | Net return (Rs. $ha^{-1}$) | B:C ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Pearl Millet | CB /MB | Pearl Millet | CB /MB | | | |
| **I1W1** | 1103 | 12712 | 13815 | 813 | - | 1733 | - | 20044 | 6229 | 1.45 |
| **I1W2** | 4423 | 12712 | 17135 | 988 | - | 2101 | - | 24337 | 7202 | 1.42 |
| **I1W3** | 2041 | 12712 | 14753 | 876 | - | 1848 | - | 21510 | 6757 | 1.46 |
| **I1W4** | 1383 | 12712 | 14095 | 953 | - | 1190 | - | 19294 | 5199 | 1.37 |
| **I2W1** | 1620 | 12712 | 14332 | - | 689 | - | 1479 | 36159 | 21827 | 2.52 |
| **I2W2** | 4940 | 12712 | 17652 | - | 1354 | - | 2465 | 69546 | 51894 | 3.94 |
| **I2W3** | 2558 | 12712 | 15270 | - | 1115 | - | 2293 | 58196 | 42926 | 3.81 |
| **I2W4** | 1900 | 12712 | 14612 | - | 1187 | - | 2301 | 61468 | 46856 | 4.21 |
| **I3W1** | 1092 | 12712 | 13804 | - | 517 | - | 1556 | 33902 | 20098 | 2.46 |
| **I3W2** | 4412 | 12712 | 17124 | - | 949 | - | 2414 | 60660 | 43536 | 3.54 |
| **I3W3** | 2030 | 12712 | 14742 | - | 848 | - | 1970 | 53520 | 38778 | 3.63 |
| **I3W4** | 1372 | 12712 | 14084 | - | 860 | - | 1855 | 53797 | 39713 | 3.82 |
| **I4W1** | 1448 | 12712 | 14160 | 344 | 515 | 609 | 1055 | 34708 | 20548 | 2.45 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **I4W2** | 4768 | 12712 | 17480 | 486 | 909 | 803 | 1676 | 57586 | 40106 | 3.29 |
| **I4W3** | 2386 | 12712 | 15098 | 416 | 832 | 676 | 1480 | 51838 | 36740 | 3.43 |
| **I4W4** | 1728 | 12712 | 14440 | 273 | 714 | 569 | 1482 | 43965 | 29525 | 3.04 |
| **I5W1** | 1096 | 12712 | 13808 | 343 | 416 | 622 | 962 | 34167 | 20359 | 2.47 |
| **I5W2** | 4416 | 12712 | 17128 | 488 | 682 | 809 | 1425 | 53363 | 36235 | 3.12 |
| **I5W3** | 2034 | 12712 | 14746 | 413 | 547 | 679 | 1178 | 43413 | 28667 | 2.94 |
| **I5W4** | 1376 | 12712 | 14088 | 267 | 515 | 608 | 1213 | 39325 | 25237 | 2.79 |

Respectively rate of grain and straw of pearl millet (Rs.14 & 5 $kg^{-1}$), Cluster bean (Rs.45 & 3.5 $kg^{-1}$) and moth bean (Rs.55 & 3.5$kg^{-1}$)