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CERTIFICATE - I

Dated : / /2003

This is to certify that ***Mr. Mahender Kumar Chalka*** had successfully completed the Comprehensive/Preliminary Examination held on / /2002 as required under the regulation for **Ph.D. Degree**.

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This is to certify that this thesis entitled **"Effect of Weed Control on the Productivity of Maize Intercropped with Legumes**, submitted for the degree of **Doctor of Philosophy** in Agriculture in the subject of **Agronomy,** embodies bonafide research work carried out by ***Mr. Mahender Kumar Chalka*** 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 27/5/2003.

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This is to certify that this thesis entitled **"Effect of Weed Control on the Productivity of Maize Intercropped with Legumes"**, submitted by ***Mr. Mahender Kumar Chalka*** to the Maharana Pratap University of Agriculture and Technology, Udaipur in partial fulfilment of the requirements for the degree of **Doctor of Philosophy** in Agriculture in the subject of **Agronomy** after recommendation by the external examiner was defended by the candidate before the following members of the examination committee. The performance of the candidate in the oral examination on his thesis has been found satisfactory, we therefore, recommend that the thesis be approved.

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This is to certify that ***Mr. Mahender Kumar Chalka*** student of the Department of **Agronomy**, Rajasthan College of Agriculture, Udaipur has made all corrections/modifications in the thesis entitled **"Effect of Weed Control on the Productivity of Maize intercropped with Legumes"** which were suggested by the external examiner and the advisory committee in the oral examination held on ______/_____/2003. The final copies of the thesis duly bound and corrected were submitted on ___/__/2003, are enclosed herewith for approval.

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ACRONYMS AND ABBREVIATIONS

a i	Active ingredient
@	at the rate of
C	Degree Celsius
E	Degree East
N	Degree North
B:C	Benefit cost ratio
cm	Centimeter
cv.	Cultivar
C.D.	Critical difference
d.f.	Degree of freedom
dSm^{-1}	Deci Simon per meter
DAP	Di Ammonium Phosphate
DAS	Days after sowing
DM	Dry matter
et al.	*(et alibi)* and else where
EC	Electrical conductivity
Fig.	Figure
g	Gramme
ha	Hectare
hrs.	Hours
HI	Harvest index
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agriculture Research
i.e.	(ie est) that is
K/K_2O	Potassium
Kg	Kilogram
Max.	Maximum
MEGY	Maize equivalent grain yield
MESY	Maize equivalent stover yield
Min.	Minimum
MPUAT	Maharana Pratap University of Agriculture and Technology
m^2	Square metre
Mg	Megagram
M.S.	Mean square
N	Nitrogen
NS	Not significant
PE	Pre-emergence
P/P_2O_5	Phosphorus
pH	Negative log of H ions activity
q	Quintal
r	Correlation coefficient
r^2	Coefficient of determination
Rs.	Rupees
RCA	Rajasthan College of Agriculture
R.H.	Relative humidity
S.Em±	Standard error of mean
t	Tonnes
USDA	United State Department of Agriculture
var.	(vide licet) namely
Wc	Weedy check

1. INTRODUCTION

Intercropping has been a popular farming practice from time immemorial. The concept, however, has changed over the years. In the early years of agricultural development, farmers adopted it chiefly as a risk covering practice in tradition bound agriculture to make up a part of crop losses particularly under rainfed and dry land farming situations.

Recently with the technological improvement in agriculture and consequent need for enhancement of crop production levels, necessitated by increasing population pressure in the country, the concept of intercropping has assumed considerable significance. Scientifically the practice envisages simultaneous growing of two or more crops differing in height, canopy development, growth rate and nutrient requirement in such a way that they experience least competition, utilize environmental factors more efficaciously and result in efficient utilization of available resources. It has been emphasized by many workers that intercropping offers more profitable and stable production in both good and unfavourable years.

Advantage of legume intercropped with cereals have been highlighted as early as in 1949 by Ayier. The suggested advantages include greater stability of yield, better use of growth resources, better control of weeds, insect pests and diseases, effective runoff water and erosion control and better utilization of light and radiation. Moreover, in recent times, intercropping has opened up possibilities of enhancing returns to the farmers under multiple cropping patterns in irrigated areas also. The increased cropping intensity in term of time and space ultimately results in increased total crop production and monetary returns.

One such system is the intercropping of pulses in maize, which is one of the principle crop grown for food and fooder in India. Maize (*Zea mays* L.) is an important cereal crop of tropical and sub-tropical regions of the world. It has an important role in the world agricultural economy both as food for men and feed for animals. There is no cereal on the earth which has so immense yield potential as maize and that is why it is called as "Queen of cereals." Being a C_4 plant, maize is capable of utilizing solar radiation more efficiently than several other crops. Amongst cereals, maize in India ranked fifth in total area (6.43 m. ha) and fourth in the total production (11.47 mt.) with the average yield of 1784 kg ha^{-1} (Govt. of India, 2000-01). In Rajasthan maize was grown on 0.97 m. ha land with out turn of 1.01 mt with the productivity of 1041 kg ha^{-1} (Govt. of Rajasthan 2000-01). Agroclimatic zone IV A

(Sub Humid Southern Plain and Aravali Hill Region) has the largest area under maize in Rajasthan. The farmers of this region are usually advocated to intercrop legumes with maize.

The selection of an appropriate intercropping system having desirable plant type and growth pattern which does not coincide with the peak period of growth of maize is important to the success of intercropping system. Short duration varieties of four *kharif* legumes viz., blackgram, greengram, cowpea and soybean were chosen for intercropping in maize particularly with a view to explore the possibilities of augmenting the production of these grain legumes which constitute the main source of vegetable protein in Indian diet. Blackgram and greengram are the traditional pulses of Southern Rajasthan. Their respective area and production in Udaipur district during 2000-01 were 11431 ha and 1747 t and 162 ha and

20 t. Whereas, soybean is a fast coming crop of this region which produced 694 t grain from 1004 ha land (Govt. of Rajasthan, 2000-01). Therefore, it is of great interest to compare these crops and cowpea as intercrops with maize.

Despite best management practices being adopted, the per hectare yield tends to be low during *kharif*, mainly because of weeds. Since the conditions in rainy season are such as to support luxuriant growth of weeds, the crop severely suffers from the beginning of germination. Although intercropping itself appears to offer considerable potential as a means of increasing crop dominance over weeds, the effectiveness of weed control in various intercropping systems differ from intercrop to intercrop due to several factors influencing intercrop - weed relationship. Research on intercropping has indicated how niche differences in crop species can lead to resource capture and conversion leading to increased biological efficiency and yield advantage (Willey, 1979). Intercrop weed management combines two qualitatively different aspects of plant interaction. To increase intercrop yields, complementarity of resource use by the component crops must be emphasised. The goal is to maximise the degree of overlap in resource use by intersown crop such that more resources are exploited and more yield can be harvested per unit of ground area. In contrast, to achieve weed control, the similarity of requirements of crop and weed species, the consequent competition for limited resources and suppression of growth and yield of associated species are emphasised. Therefore, there is a need to create an environment that is detrimental to weeds and favourable to crops. Intercropping has a potential as a means of weed control because it offers the possibility of a mixture of crops capturing a greater share of available resources than the sole crop (Altieri and Liebman, 1986). Provided that interference between component crops is weaker than that between crops and weeds, intercropping can supress the weed growth more than sole crop. However, intercropping alone is not sufficient to prevent weed infestation during *kharif* season when rains provide them congenial environment for fast growth. Hence, weed control needs to be restored during initial period of crop growth. Manual weeding and hoeing in maize based intercropping systems is a difficult task, since the operations coincide with continuous rains which makes the typical heavy soils of maize growing belt difficult to manage. Therefore, herbicides offer great potential under such situations. Herbicides can also hold key for weed control in intercropping situations because mechanical weed removal is a difficult task in closely spaced plants of component crops. Moreover, pre-emergence herbicides provide early season weed control. A large number of herbicides have been evaluated for sole crops but an efficacious herbicide is yet to be identified for maize based intercropping system. Since weeds cause heavy crop losses in rainy season, an appropriate control system needs to be evolved.

Keeping these factors in view it was thought plausible to carry out investigation entitled "Effect of Weed Control on the Productivity of Maize Intercropped with Legumes"

With the following objectives :

1. To study the effect of legumes intercropped with maize on weed dynamics and crop productivity.
2. To assess efficacy of herbicides and hand weeding for maize legume intercropping systems.
3. To evaluate interactive effect of maize legume intercropping system and weed control, if any
4. To workout economic viability of intercropping systems and herbicides.

2. REVIEW OF LITERATURE

A compendium of available research work done on effect of weed control in maize intercropped with different legumes has been reviewed in this chapter. At some places in the text work on other crops and intercropping systems has also been presented due to paucity of literature on maize based intercropping systems.

2.1 CROP WEED INTERFERENCE

2.1.1 Maize

Chandrasagar (1983) found that weeding thirty days after sowing was essential for getting maximum maize yield. Varshney (1991) found that first 20-40 days after sowing were most critical for crop weed competition in maize. In a field trial at Shillong (Maghalaya), he found significant reduction in crop yield if weeds were allowed to grow beyond this critical period.

At Udaipur, a weed free maize crop yielded 34.43 q ha^{-1} as against 13.49 q ha^{-1} when no attempt was made to control them (Gaur *et al.*, 1991). At Bajaura (H.P.), 70.5 per cent reduction in maize yield was observed on account of weed interference (Thakur and Sharma, 1996). Angiras and Singh (1989) reported increased uptake of NPK nutrients by maize due to weed control. Similarly, Sreenivas and Satyanarayan (1996) have also reported significantly higher uptake of primary nutrients by maize crop under varying degree of weed control.

2.1.2 Kharif Legumes

The most critical period of crop weed competition in greengram coincides with early period of weed growth i.e. 10 to 30 DAS. For maximum seed yield green gram crop should be weeded about 20 days after sowing (Yadav *et al.*, 1983). Similarly, Singh *et al.* (1991) have also ascribed first 30 days of monsoon crop of greengram and blackgram as critical for crop-weed competition. Singh *et al.* (1992) have reported 43.0 per cent loss in rainy season blackgram on account of uncontrolled weeds at Sehore (M.P.), Mishra and Mishra (1995) reported 58.7 per cent drop down in blackgram yield when weeds were allowed to grow with the crop throughout crop season.

At Hisar 48.1 and 63.9 per cent soybean yield was reduced due to uncontrolled weeds (Chhokar *et al.*, 1996). Ponnuswamy *et al.* (1996) found that weeds did not offer significant competition to soybean crop if they were either allowed to grow for first fifteen days and removed thereafter or the crop was kept weed free for first 45 days followed by no effort to control them. A wide ranging drop down in soybean yield has been reported by several authors on account of weeds (Koch *et al.*, 1982, Dubey *et al.*, 1984 and Kurmawanshi *et al.*, 1995).

2.1.3 Intercropping System

Though intercropping can be a potential biological tool to manage weeds, the system by itself would not ensure complete weed control (Moody, 1978). In pigeon pea + cowpea intercropping system about 33.0 per cent crop yield was lost due to the presence of weeds (Thomas *et al.*, 1994). Field experiments with groundnut + pigeonpea intercropping system revealed that critical period for weed competition was between two to eight weeks after sowing. Provision of weed free environment throughout crop season did not have any significant effect over weed free condition maintained upto eight weeks after sowing (Tewari *et al.*, 1989). Similarly, in pigeonpea (T_{21}) and blackgram (T_9) intercropping system two to eight weeks after sowing was identified to be critical for weed competition at Kanpur (Tewari *et al.*, 1989). At Hyderabad, variation was recorded in critical period for crop-weed competition in sorghum based intercropping systems. Whereas, sorghum + cowpea system need only 15 days initial weed free period, sorghum + green gram and sorghum + groundnut needed at least 30 days weed free period (Kondap *et al.*, 1990). While studying crop-weed competition in maize + blackgram intercropping system at Bajaura (H.P.). It was observed that 4-5 weeks after sowing was the most critical period in this regard. On mean basis a weed free crop (maize + blackgram) produced 29.8 q ha^{-1} of maize equivalent yield as against 14.6 q ha^{-1} under unweeded one (Sharma and Nayital, 1991).

2.2 EFFECT OF WEED CONTROL ON MAIZE

2.2.1 Hand Weeding

Thakur *et al.* (1989) reported 107.2 per cent increase in grain yield of maize over weedy check (19.2 q ha^{-1}) by two hand weedings at 21 and 42 DAS. Likewise, two hand weedings in maize crop gave effective control of weeds and number of functional leaves, dry matter and yield components which resulted into increased grain yield (Thakur and Singh, 1990). Two hand weedings proved better in reducing weed dry matter and nutrient removal by weeds (Thakur *et al.*, 1990). Similarly, Oh *et al.* (1992) observed an increase in fodder yield of maize (21 q ha^{-1}) with hand weeding over weedy check (100 q ha^{-1}). Manual weeding done at 20 and 40 DAS in maize + legume intercropping at Bajaura (H.P.) tended to reduce the weed density and biomass significantly in comparison to weedy control and other weed control treatments except metolachlor 1.25 kg ha^{-1}. Correspondingly the yield of maize increased from 11.9 q ha^{-1} (control) to 28.5 q ha^{-1} with hand weeding. Simultaneously increase in maize equivalent yield (140 per cent) over control (18.0 q ha^{-1}) and net returns of Rs. 4110 ha^{-1} were recorded with hand weeding (Thakur, 1994). Effective control of *Cyperus rotundus* and other weeds in maize was achieved by two hand weedings at 20 and 40 DAS (Thakur and Sharma, 1996). Significant improvement in dry matter production at different growth stages and yield attributes viz. cobs $plant^{-1}$, number of seeds cob^{-1}, single plant yield and 1000-grain weight were reported with two hand weedings which resulted in significantly higher grain yield (155 per cent) over weedy check (20.5 q ha^{-1}). The author also recorded significant increase in seed yield of maize by 88 and 78 per cent over metribuzin and fluchloralin, respectively (Jat, 1996). At Phulbani (Orissa), significant reduction in weed dry weight and significant improvement in cob and grain yield of maize by 48.9 and 50.4 per cent, respectively over weedy check (1.39 and 1.17 t ha^{-1}) with two hand weedings (20 & 40 DAS) were reported by Behera *et al.* (1998). Likewise, two hand weedings at 15 and 30 DAS significantly reduced dry matter accumulation by weeds at 30, 60 DAS and at harvest and significant improvement in yield attributes of maize concomitantly resulted in 103 per cent higher seed yield over weedy check (31.4 q ha^{-1}) and 22.3 per cent higher over pendimethalin (Sharma, 1998). Sharma *et al.* (1998) reported that hand weedings at 15 and 35 DAS reduced the weed density and dry matter significantly at 25, 55 and 90 DAS. Correspondingly increase in grain yield (105.01 per cent) was reported over control (19.54 q ha^{-1}). Similarly, from Jagtial (A.P.), Avilkumar and Reddy (2000) reported superiority of hand weeding in increasing grain yield of maize over weedy check. Hand weeding showed effectiveness in controlling weeds and increasing the crop efficiency in growth, consequently improvement in yield attributes like length of cob, number of grains cob^{-1}, weight of grains cob^{-1} which resulted in highest yield (Sinha *et al.*, 2000). Pandey *et al.* (2000) from Almora (U.P.) reported superiority of two hand weeding (15 and 30 DAS) in reducing weed dry matter with 87 per cent weed control efficiency in maize crop. Results of two years experimentation under rainfed conditions showed that one hand weeding 20 DAS in maize + soybean intercropping system significantly reduced the population of *E. colonum*, *B. ramosa*, *A. conyzoids*, *C. benghalensis* and *C. rotundus* and total weed biomass. Simultaneous increase in seed yield (132.31 per cent and 360.72 per cent) over weedy check (557 kg ha^{-1} and 387 kg ha^{-1}), respectively were recorded. (Pandey and Vedprakash, 2002). Experiment conducted at

Killikulam (T.N.) where maize was intercropped with *kharif* legumes showed that hand weeding done at 15 and 30 DAS reduced the weed population and dry matter significantly. Simultaneously increase in maize yield (148.36 per cent) over control (1898 kg ha^{-1}) was obtained (Bhuvaneshwari *et al.*, 2002).

2.2.2 Pendimethalin

Significant improvement in grain yield of maize (133.9 per cent) was reported with the application of pendimethalin as pre-emergence over weedy check (29.29 ha^{-1}) at solan (Thakur *et al.*, 1989). Pre-emergence application of pendimethalin 1.5 kg ha^{-1} on sandy loam soil resulted in higher seed yield (68.3 q ha^{-1}) and increased N, P and K uptake over hand weeding (Thakur *et al.*, 1990). Thakur and Singh (1990) also reported improvement in seed yield of maize due to application of pendimethalin @ 1.5 kg ha^{-1} and attributed it to the increase in growth and yield components as a result of effective control of weeds. From Ranchi (Bihar), Saha and Srivastava (1992) reported 29.7 per cent weed control efficiency of pendimethalin 1.0 kg ha^{-1} pre-emergence application in maize field. In fodder maize pre-emergence application of pendimethalin 0.95 kg ha^{-1} resulted in 1.74 t ha^{-1} yield of fodder maize dry matter compared to 1.02 t ha^{-1} in weedy check. The weed dry matter in treated plots reduced to 55.9 g m^{-2} from 307.2 g m^{-2} in weedy check (Oh *et al.*, 1992). Daelomanas and Ngouajio (1992) registered 75 per cent control of broad leaf weeds and annual grasses by the use of pendimethalin @ 0.3 kg ha^{-1}. Pendimethalin treatment also recorded higher net profit than hand weeding. Similarly, pre-emergence application of pendimethalin 4.0 kg ha^{-1} was reported effective against virtually all mono and dicotyledon weeds infesting maize, giving their 84 and 81 per cent control, respectively (Rubets *et al.*, 1992). Maize grain yield was significantly increased with the application of pendimethalin 0.5 and 0.75 kg ha^{-1} at Banglore. This treatment also gave best `benefit : cost' ratios (Madhu and Nanjappa, 1993). Madhu and Nanjappa (1993) further reported superiority of pendimethalin for weed control in maize. They reported higher gross and net-returns and B:C ratios with the application of 0.75 kg ha^{-1} pendimethalin (Rs. 8587 and 2521 ha^{-1} and 6.58, respectively). Thakur (1994) reported that application of pendimethalin 1.5 kg ha^{-1} in maize legume intercropping system reduced the weed population from 509 m^{-2} in control to 283 m^{-2}, similarly reduction in weed dry matter was from 70.1 q ha^{-1} (in weedy check) to 28.3 q ha^{-1} with the weed control efficiency of 59.6 per cent. Corresponding the grain yield of maize increased by 108.4 per cent to over control (11.9 q ha^{-1}). Pre-emergence application of pendimethalin 1.0 kg ha^{-1} proved at par with two hand weeding (30 and 60 DAS) in reducing weed population and increasing maize grain yield (Prasad and Rafey, 1996). Jat (1996) from Udaipur reported reduction in total weed density due to application of pendimethalin 1 kg ha^{-1} by 64, 67 and 68 per cent at 30 and 60 DAS and at harvest, respectively, compared to weedy check. While reduction in weed dry matter at respective stages were from 35.82, 112.8 g m^{-2} and 14.8 q ha^{-1} compared to weedy check with weed control efficiency of 68 per cent. He found that yield attributes of maize crop improved significantly under pendimethalin treatment which concurrently resulted in 146 per cent higher seed yield compared to weedy check (20.46 q ha^{-1}). Similarly, Sharma (1998) found that application of pendimethalin 0.75 kg ha^{-1} as pre-emergence reduced weed dry matter by 69.5, 144.7 and 1527 g m^{-2} at 30, 60 DAS and at harvest compared to weedy check (114.4, 219.8 and 2259.7 g m^{-2}, respectively) which resulted in enhanced maize grain yield by 64.2 per cent over weedy check (31.39 q ha^{-1}). An application of pendimethalin 1.25 kg ha^{-1} significantly increased plant height, no. of cobs, cob length, cob diameter and 1000 grain weight. In this experiment the grain yield increased by 108.4, 291.4 and 223.2 per cent in three respective years over weedy check (2367, 653 and 516 kg ha^{-1}) under the influence of weed control through pendimethalin (Pandey *et al.*, 1999). When maize was intercropped with turmeric at Jagtial (A.P.), the reduction in the weed dry matter was 33.91 per cent and 54.16 per cent to over control (11.5 g m^{-2} and 19.2 g m^{-2}) at 30 DAS and at harvest due to the application of pendimethalin 1.0 kg ha^{-1} + 4 HW. While increase in grain yield of maize was 4480 kg ha^{-1} as compared to 3469 kg ha^{-1} in control was recorded (Avil kumar and Reddy, 2000). At Almora, pre-emergence of pendimethalin 1.5 kg ha^{-1} reduced the weed population (54.4 per cent) and weed dry matter (62.47 per cent) compared to weedy check (625 m^{-2} and 305.8 g m^{-2}) with weed control efficiency of 63.1 per cent. It increased height, number of cobs (1000 ha^{-1}), cob length, cob girth, grains cob^{-1} and 1000 grain weight significantly. The grain yield increased by 367.14 per cent over control (633 kg ha^{-1}) due to pendimethalin application. (Pandey *et al.*, 2001). In the heavy textured soil of Kumher (Bharatpur), pre-emergence application of pendimethalin 1.0 kg ha^{-1} resulted in significant reduction in weed density and biomass as well as N uptake by weeds in maize + blackgram intercropping system. Significant increase in the yield of component crops was also observed. The pooled statistics indicated 83.2 per cent increase in maize equivalent yield by weed control through pendimethalin over weedy check (1836 kg ha^{-1}). Additional returns Rs. 2796 and B:C ratio of 5.18 were obtained by weed control by pendimethalin (Deshveer and Singh, 2002). Significant reduction in weed density and dry matter when pendimethalin 1.5 kg ha^{-1} PE was applied in maize + soybean intercropping system. Corresponding increase in grain yield were 265.7 and 362.7 per cent over weedy check 557 kg ha^{-1} and 387 kg ha^{-1}) in two respective years of study. (Pandey and Ved Prakash, 2002)

2.2.3 Alachlor

At Kanpur (U.P.) effective control of weeds and increased seed and stover yield of maize intercropped with blackgram (*Vigna mungo*) were achieved when weeds were controlled with pre-emergence application of alachlor 1.0 kg ha^{-1} (Rathi and Tiwari, 1982). Alachlor or metolachlor (1.5 kg ha^{-1}) incorporated pre-sowing or pre-emergence controlled *Digetaria sanguinalis* and *Echinochloa spp.*, but control of broad leaf spp. was inadequate with 2 kg alachlor ha^{-1} (Gimenez and Rios, 1985). Application of Lasso 7 litres ha^{-1} (alachlor 3.5 litres/ha) with sprinkler irrigation soon after sowing was more effective than its pre-sowing application in decreasing weed population and dry weight and increasing fresh fodder yield of maize (Miver *et al.*, 1985). Yaduraju *et al.* (1986) reported that pre-emergence application of alachlor 1.0 kg ha^{-1} gave adequate control of weeds. This treatment gave grain yield of sole maize as well as intercrop equivalent to that obtained with hand weeding in maize + blackgram intercropping system. Result of experiment at Bajaura (H.P.) with maize based intercropping system indicated 38.1 and 50.6 per cent reduction in weed density and dry matter with the application of alachlor 1.5 kg ha^{-1} compared to weedy control (509 m^{-2} and 70.1 q ha^{-1}), respectively, with the weed control efficiency of 50.6 per cent. Concomitantly it increased grain yield of maize by 91.59 per cent over weedy control (11.91 q ha^{-1}). Alachlor application tended to increase maize equivalent yield from 18 q ha^{-1} (in control) to 33.8 q ha^{-1} (Thakur, 1994). Results of an experiment conducted at Udaipur revealed that application of alachlor 1.0 kg ha^{-1} as pre-emergence in maize based intercropping system significantly reduced weed density and biomass at 30, 60 DAS and at harvest as well as N drain by weeds as compared to weedy check. Significant increase were observed in number of cobs plant^{-1} and number of seeds cob^{-1}. The net result was 102.2 per cent increase in seed yield of maize compared to weedy check (Sharma, 1998). Application of alachlor (1.0 kg ha^{-1}) + pendimethalin (0.625 kg ha^{-1}) as pre-emergence was effective in controlling *Echinochloa colonum* and *Brachairea ramosa* and total weed population but failed to control *Ageratum conyzoides*. The treatment recorded significant reduction in total weed dry weight (73.5 and 67.3 per cent) compared to weedy check (560 g m^{-2}) during two respective years of experimentation (Pandey *et al.*, 2000). Application of alachlor 2.0 kg ha^{-1} in the maize at Almora significantly increased plant height, number of cobs, cob length, cob girth, grains cob^{-1} and 1000 grain weight of maize. Simultaneously the grain yield of maize increased by 382.3 per cent compared to 633 kg ha^{-1} weedy check (Pandey *et al.*, 2001). Results of an experiment with winter maize at Pusa (Bihar) revealed that application of alachlor 1.5 kg ha^{-1} as pre-emergence significantly increased the plant height, leaf area index, dry matter accumulation, crop growth rate, grains cob^{-1} and grain yield as compared to weedy check and it was statistically at par with higher doses (2.0 kg ha^{-1} and 2.5 kg ha^{-1}). The grain yield increased by 25.08 per cent over control (36.20 q ha^{-1}) by weed control with alachlor 1.5 kg ha^{-1} (Sinha *et al.*, 2001). An experiment conducted on maize intercropped with legumes showed significant reduction in weed population and dry weight with the pre-emergence application of alachlor 1.0 kg ha^{-1} + hand weeding at 30 DAS. Compared to weedy control (1898 kg ha^{-1}), increase in grain yield was 137.4 per cent (Bhuvneshwari, *et al.*, 2002). In maize + soybean intercropping system, application of alachlor 2 kg ha^{-1} pre-emergence provided effective control of weeds at Almora. It reduced the weed dry weight by 84.7 and 78.4 per cent during two successive years of study. Concomitant increase in main and component crop yields were recorded. Maize equivalent yield tended to increase by 167.4 and 357.6 per cent over weedy check (1586 and 932 kg ha^{-1}; respectively) during these two years (Pandey and Ved Prakash, 2002).

2.2.4 Metolachlor

Zuga *et al.* (1990) reported that effective suppression of weeds in maize could be achieved by using dual (metolachlor) 4 kg ha^{-1} as pre-emergence. Oh *et al.* (1992) observed that maize dry matter yields were 1.86 and 1.02 t ha^{-1} with metolachlor 1.2 kg ha^{-1} and unweeded, respectively. Results of an experiment conducted at Bajaura (H.P.) revealed that application of metolachlor 1.25 kg ha^{-1} pre-emergence in maize based intercropping system significantly reduced the weed density (81.3 per cent) and weed dry weight (82.3 per cent) compared weedy control (509 m^{-2} and 70.1 q ha^{-1}, respectively) with the weed control efficiency of 82.1 per cent. Correspondingly increase in grain yield of maize was 154.6 per cent while maize equivalent yield increased from 18.0 q ha^{-1} (control) to 48.5 q ha^{-1} with 1.25 kg ha^{-1} metolachlor. It was statistically superior to its lower dose (1.0 kg ha^{-1}) and all other weed control treatments including manual weeding with highest net returns of Rs. 6086 ha^{-1} (Thakur, 1994). In an experiment conducted at Udaipur, application of metolachlor 1.0 kg ha^{-1} recorded significant control of *Echinochloa crusgali, Echinochloa colonum, Portulacao oleracea*, *Phyllanthus niruri*, *Commelina benghalensis, Digera arvensis* and *Convolvulus arvensis* in maize + soybean intercropping system. This application recorded significantly lower total weed population, weed biomass, N, P and K drain by weeds compared to weedy control. Grain yield of maize enhanced by 186.6 and 128.6 per cent over weedy check (14.69 and 26.22 q ha^{-1}, respectively) during these two years (Jat, 1996). Weed control in maize through pre-emergence metolachlor 1.5 kg ha^{-1} effectively reduced the grassy weeds as compared to broad leaf and Cyperus at 55 DAS and 90 DAS. Reduction in total weed dry matter at 90 DAS were 34.59 and 56.30 per cent in the respective years as compared to weedy check (33.62 and 16.80 g m^{-2}). Concomitantly 96.8 and 110.6 per cent increase in grain yield over unweeded check (19.41 and 19.65 q ha^{-1}, respectively) were obtained during two successive years of study (Sharma and Thakur, 1998). Pre-emergence application of metolachlor 1.5 kg ha^{-1} gave 39.5 per cent increase in plant height and 131.5 per cent higher grains per cob as compared to weedy check (143.33 cm and 150.78, respectively). The grain yield of maize increased from 19.54 q ha^{-1} (control) to 39.80 q ha^{-1} with metolachlor, while, it reduced the weed density by 64.6, 37.01 and 33.8 per cent and dry matter 65.4, 36.9 and 38.3 per cent compared to weedy check (22.90, 20.91 and 19.84 m^{-2} and 12.46, 22.98 and 26.58 g m^{-2}, respectively) at 25, 55 and 90 days after sowing (Sharma *et al.*, 1998). At Udaipur application of metolachlor 1.0 kg ha^{-1} PE in maize intercropped with legumes reduced the weed population by 32.1, 32.5 and 35.5 per cent and weed dry matter 63.2, 68.7 and 67.1 per cent compared to weedy check (6.39, 6.73 and 7.23 per 0.25 m^{-2} and 114.39 g m^{-2}, 219.88 g m^{-2} and 2259.73 kg ha^{-1}, respectively) at 30, 60 DAS and at harvest. It also reduced the N uptake significantly by weeds. Correspondingly metolachlor significantly increased the number of cobs $plant^{-1}$, number of grain cob^{-1} and grain yield of maize. The increase in yield due to metolachlor was 84.7 per cent over 31.39 q ha^{-1} obtained in weedy control (Sharma, 1998). Bhuvneshwari *et al.* (2002) found that at Killikulam (T.N.) application of metolachlor 1.0 kg ha^{-1} + HW 30 DAS reduced the weed population by 88.3 and 82.4 per cent and weed dry weight by 72.8 and 72.0 per cent as compared to unweeded control (151.33, 256.67 m^{-2} and 205.3, 658.3 kg ha^{-1}, respectively) at 15 and 30 DAS. It tended to increase maize grain yield by 171.2 per cent compared to control (1898 kg ha^{-1}) in maize legume intercropping system.

2.3 EFFECT OF WEED CONTROL ON KHARIF LEGUMES

2.3.1 Hand Weeding

Two hand weeding (20 and 35 DAS) treatment was found very effective in lowering the weed biomass and increased seed yield of soybean over unweeded control (Lokras *et al.*, 1985). Highest weed control efficiency (90 per cent) and significantly higher 100 seed weight, pods per plant and seed yield of soybean with two hand weedings have also been reported by Jain *et al.*, 1988. In Madhya Pradesh, three hand weeding gave significant reduction in weed dry matter and highest grain yield of green gram (Bajpai *et al.*, 1988). When chemical and cultural treatments were evaluated for their effectiveness in blackgram cv. P 15-26 on sandy loam soils, two hand weeding gave the best control of weeds and grain yield of crop. (Soni and Singh, 1988). In a trial with blackgram (*Vigna mungo*) cv. T_9 on sandy loam soil of Hissar, hand weeding twice at 15 and 25 DAS resulted in highest seed yield (Kant *et al.*, 1989). At Ambikar-Surguja (M.P.), manual weeding in blackgram cv. T_9 gave significant reduction in weed dry matter (Singh and Singh, 1990). Two hand weedings (25 and 40 DAS) were effective in controlling a variety of weeds in soybean. Significant increase of 68 per cent yield was obtained by this treatment over control (1130 kg ha^{-1}). During investigation a marked reduction in NPK uptake by monocot and dicot weed was also noticed with two hand weedings (Varshney, 1990). Likewise, Singh *et al.* (1991) observed that weeds like *Celosia argentia, Ageratum conzoids*, *Echinochloa* spp., *Commelina benghalensis, Eclipta alba* etc. were effectively controlled by hand weeding. Weed control efficiencies to the tune of 95, 84 and 82 per cent were achieved with three, two and one hand weeding, respectively.

At Jabalpur, Jain and Tiwari (1992) found that two hand weedings at 30 and 45 DAS gave excellent control of weeds in soybean. At Jobner (Raj.) greengram yield was only 3.74 q ha^{-1} without any weed control effort, compared with 6.15 q ha^{-1} by controlling weeds with two hand weeding (Singh and Chaudhary, 1992). Two hand weedings was also reported as a successful means of controlling weeds in soybean by Ulaganathan *et al.* (1992) and Prabhakaran *et al.* (1992). Ramamoorthy (1995) reported that at Vamban (T.N.), two hand weedings significantly reduced intensity as well as dry matter of weeds which resulted in 186 per cent increase in grain yield of soybean over weedy check (655 kg ha^{-1}) Rao *et al.* (1995) have also reported greater yield of soybean (20.5 q ha^{-1}) when the crop was hand weeded twice (20 and 40 DAS) as against pre-emergence application of alachlor 2.0 kg ha^{-1} (16.39 q ha^{-1}).

At Udaipur, two hand weedings in soybean intercropped with maize at 25 and 45 days after sowing showed significant improvement in yield attributes and there by 49.6 per cent higher yield of soybean than 5.14 q ha^{-1} obtained in weedy check (Jat, 1996). Billore and

Joshi (1998) from Indore reported lowest weed biomass and highest weed control efficiency (96.5 per cent) with two hand weedings at 30 and 45 days after sowing. Significant improvement in yield attributes resulted in 17.5 per cent higher seed yield compared to weedy check (17.9 q ha^{-1}). At Udaipur, two hand weedings in soybean crop at 15 and 30 DAS showed significant reduction in weed dry matter accumulation at 30, 60 DAS and at harvest. The treatment significantly increased yield attributes, thereby resulted in 32.3 q ha^{-1} higher grain yield over weedy check (31.39 q ha^{-1}). The improvement in yield over fluchloralin, pendimethalin and metolachlor treated plots were to the tune of 13.4, 11.6 and 5.8 q ha^{-1}, respectively (Sharma, 1998). Selvan (1999) from Coimbatore (T.N.) reported that hand weeding twice in recorded highest number of root nodules per plant of soybean which was comparable to 1.0 kg alachlor ha^{-1} + one hand weeding. Hand weeding also increased root nodule dry weight compared to weedy check. From Amritsar, Randhawa *et al.* (2002) reported significant reduction in weed density and dry weight when hand weeding was done in blackgram. Concomitant increase in seed yield was 27 per cent as compared to weedy check (722 kg ha^{-1}).

2.3.2 Pendimethalin

Dubey *et al.* (1984) reported significant reduction in weed biomass with the application of pendimethalin 1.0 kg ha^{-1} in comparison to weedy check with the higher degree at weed control efficiency (83.5 per cent). The use of pendimethalin improved the yield attributes viz., pods $plant^{-1}$, seeds pod^{-1} and seed weight resulting in 122 per cent higher crop dry weight and 264 per cent higher seed yield. Pre-emergence application of pendimethalin along with one hand weeding resulted in 80 per cent weed control efficacy (Bajpai *et al.*, 1988). Application of pendimethalin had no significant influence on crop plant height, branches $plant^{-1}$ and nodules $plant^{-1}$ but resulted in 37.8 per cent reduction in weed biomass against control (926 kg ha^{-1}). This was due to significantly reduced population of *Cyperus spp., Echinochloa crusagali* and *Phyllanthus niruri* (Dubey *et al.*, 1988). In a trial with blackgram cv. T_9 on sandy loam soils of Hisar, application of pendimethalin 0.75 kg ha^{-1} as pre emergence resulted in significant improvement in seed yield (Kant *et al.*, 1989). Similarly pre-emergence application of pendimethalin 0.75 kg ha^{-1} increased seed yield from 235 kg ha^{-1} (weedy check) to 680 kg ha^{-1} (Singh and Singh, 1990). Maurya *et al.* (1990) also recorded 65.8 per cent reduction in weed biomass by the application of pendimethalin 1.0 kg ha^{-1}. Seed and straw yield of soybean were increased by 33.3 and 19.9 per cent over control. Application of pendimethalin 1.25 kg ha^{-1} in soybean crop significantly reduced the weed biomass and increased crop yield over control as well as lower doses of same herbicide. (Porwal *et al.*, 1990). Singh *et al.* (1991) also recorded 47 per cent weed control efficiency with the use of pendimethalin in soybean crop. Similarly effective control of grasses and broadleaf weed in soybean crop by pre emergence application of pendimethalin 1.0 kg ha^{-1} resulted in 53.1 and 53.3 per cent higher crop yield during spring and autumn season (Aslam *et al.*, 1991). In experiments conducted on alkaline heavy soils of New South Wales (Australia), pre emergence application of pendimethalin 0.99 kg ha^{-1} was found suitable for greengram (Eveleigh *et al.*, 1991). At Jobner (Rajasthan) greengram yield was only 3.74 q ha^{-1} without any weed control efforts, compared with 6.15 q ha^{-1} by pre-emergence application of pendimethalin 1.0 kg ha^{-1} (Singh and Chaudhary, 1992). When pendimethalin was applied 1 kg ha^{-1}, weed population and weed dry matter were reduced significantly with 72.6 per cent weed control efficiency and 41.3 per cent more crop yield over control (7.16 q ha^{-1}) in soybean (Sharma *et al.*, 1992). At Pantnagar 44.4 per cent reduction in weed density and 59.6 per cent weed control efficiency tended to increased the yield of component intercrops from 1.90 to 3.60 q ha^{-1} with pre-emergence application of pendimethalin 1.5 kg ha^{-1} in maize + legume intercropping systems (Thakur, 1994). Sammauria (1995) recorded 67.0 per cent weed control efficiency of pendimethalin applied 1.0 kg ha^{-1} P.E. in soybean. At Udaipur pre-emergence application of pendimethalin 1.0 kg ha^{-1} accounted for significant reduction in density and dry matter of weeds at all stages of crop growth in maize + soybean intercropping system. Compared to weedy check (5.14 q ha^{-1}), the mean soybean seed yield in the two year experimentation enhanced by 93.2 per cent (Jat, 1996). Pre-emergence application of pendimethalin 1.0-1.5 kg ha^{-1} has been also been recommended for successful weed control in greengram, blackgram and soybean in dryland tracts of India (Patil and Karunakaran, 1998). From Coimbatore, Ramnathan and Chandrashekharan (1998) reported that application of pendimethalin 1.5 kg ha^{-1} P.E. increased the number of pods in blackgram from 20.83 (weedy check) to 32.73 and also give higher seed yield (492 kg ha^{-1}) as compared to control (238.33 kg ha^{-1}). In soybean, application of pendimethalin 1.5 kg ha^{-1} gave 50 per cent weed control efficiency and significantly (32.1 per cent) higher seed yield over weedy check (968 kg ha^{-1}) (Reddy *et al.*, 1998). From Rajendranagar (A.P.), Reddy *et al.* (1998) reported weed control efficiency of 71 per cent and increased seed yield of blackgram (89.6 per cent) over weedy control (233 kg ha^{-1}) with the application of pendimethalin 1.5 kg ha^{-1}. Results of an experiment conducted at Udaipur revealed that application of pendimethalin 0.75 kg ha^{-1} pre-emergence significantly reduced the weed dry matter and increased the seed yield of kharif legumes by 174.1 per cent over 1.39 q ha^{-1} obtained in weedy check (Sharma, 1998).

Solaimalai and Muthusankaranarayanan (1999) found that application of pendimethalin 1.0 kg ha^{-1} + HW 40 DAS to maize + pulse intercropping system significantly enhanced the seed yield of intercrops. Compared to weedy check the yield of blackgram doubled while that of cowpea increased by 69.8 per cent by this treatment. Similarly at Coimbatore (T.N.) yield of soybean increased from 945 kg ha^{-1} (under control) to 1890 kg ha^{-1} by controlling weeds with pendimethalin 0.75 kg ha^{-1} P.E. + handweeding 40 DAS (Selvam *et al.*, 1999). At Gwalior (M.P.), Jain *et al.* (2000) found that application of pendimethalin 1.0 kg ha^{-1} significantly reduced the weed dry matter by 62.6 per cent at 90 DAS compared to weedy check (1.47 kg m^{-2}). Corresponding soybean yield increased from 6.46 q ha^{-1} (control) to 8.63 q ha^{-1} by pendimethalin application. At Sehore, pre-emergence application of pendimethalin 1.0 kg ha^{-1} gave 18.5 and 25.8 per cent control of weeds during two successive year of study (Mandloi *et al.*, 2000). Results of two year experiments at Paiyur (T.N.) indicated that compared to control (337 and 173.5 kg ha^{-1}) application of pendimethalin 1.5 kg ha^{-1} P.E. + HW 30 DAS significantly increased the mean seed yield of cowpea and greengram to 1063.5 kg ha^{-1} and 872 kg ha^{-1}, respectively (Parasuraman, 2000). Chauhan *et al.* (2002) found that application of pendimethalin 1.0 kg ha^{-1} pre-emergence was effective in controlling *Cyperus iria, Digera arvensis, Cynodon dactylon, Phyllanthus niruri, Echinochloa crusgali* and *Commelina benghalensis*. It tended to reduce total weed population and dry matter of weeds at 90 DAS significantly with concomitant enhancement in seed yield of soybean. Results of two year experiment at Kumher (Raj.) indicated that application of pendimethalin 1.0 kg ha^{-1} significantly reduced weed count, weed biomass and N removal by weeds compared to weedy check. Corresponding it increased blackgram seed yield by 58.6 per cent over 249 kg ha^{-1} obtained in weedy control (Deshveer and Singh, 2002). Randhawa *et al.* (2002) reported decreased weed density and dry matter and increase in seed yield of blackgram from 722 kg ha^{-1} (weedy check) to 1207 kg ha^{-1} with the application of pendimethalin 1.5 kg ha^{-1} at Amritsar.

2.3.3 Alachlor

At Ambikapur (M.P.) pre-emergence application of alachlor 1.5 kg ha^{-1} gave 16.8 q ha^{-1} of soybean yield as against 0.7 q ha^{-1} under weedy check (Singh *et al.*, 1991). Sharma *et al.* (1992) also reported that application of 2.0 kg ha^{-1} of alachlor proved significantly superior over weedy check. At Bajaura (H.P.), application of alachlor 1.5 kg ha^{-1} reduced the weed density and dry weight significantly and gave 50.6 per cent weed control efficiency, while intercrop yield increased by 81.6 per cent over 1.90 q ha^{-1} obtained in weedy control

(Thakur, 1994). Ramamoorthy *et al.* (1995) registered 168.0 per cent increase in soybean yield when weeds were controlled through alachlor 2.0 kg ha^{-1} as against weedy crop (6.55 q ha^{-1}). At Udaipur, Sammauria (1995) recorded 77.4 per cent weed control efficiency of alachlor 1.0 kg ha^{-1} in soybean. It produced 9.68 q ha^{-1} which was significantly higher as compared to fluchloralin, pendimethalin and metolachlor (7.08, 8.40 and 8.19 q ha^{-1}, respectively). Pre-emergence application alachlor 2.0 kg ha^{-1} gave 84.1 per cent weed control efficiency and 151.4 per cent higher soybean seed yield over weedy check (7.52 q ha^{-1}) at Jabalpur (Jain *et al.*, 1997). Application of alachlor 1.0 - 1.5 kg ha^{-1} has also been recommended for successful weed control in greengram, blackgram and soybean in dryland tracts of India (Patil and Karunakaran, 1998). Results of experiment conducted at Udaipur indicated that application of alachlor 1.0 kg ha^{-1} significantly reduced weed count, dry weight and N removal of weeds compared to weedy check. Correspondingly it increased seed yield of intercrops by 277.0 per cent over control (1.39 q ha^{-1}) and also increased N content and uptake by intercrops viz. blackgram, greengram and soybean (Sharma, 1998). Application of alachlor 1.5 kg ha^{-1} gave the good control of *Commelina benghalensis* (100%), *Legasca mollis* (90%), *Celosia argentia* (89%), *Euphorbia geniculata* (87%), *Parthenium hysterophorus* (100%), *Datura metal* (100%), *Trianthema portulacastrum* (75%) but it was less effective against *Cyperus rotundus* (14%) and *Penicum spp* (25%). The overall result was significant increase in seed yield of soybean as compared to control (Reddy *et al.*, 1998). At Rajendra Nagar (A.P.), Reddy *et al.*, 1998 reported that alachlor 1.5 kg ha^{-1} P.E. suppressed weeds with 74.0 per cent weed control efficiency and increased the seed yield of greengram by 114.6 per cent over control (233 kg ha^{-1}). Application of alachlor 1.0 kg ha^{-1} + HW at 40 DAS gave significantly higher number and dry weight of nodules per plant of soybean, correspondingly yield of soybean increased from 945 kg ha^{-1} (weedy check) to 2083 kg ha^{-1} through this treatment (Selvam *et al.*, 1999). Jain *et al.* (2000) reported that alachlor 1.0 kg ha^{-1} P.E. effectively controlled *Cyperus iria, Digera arvensis, Cynodon datylon Phyllanthus niruri, Echinochloa crusgali* and *Commelina begalensis*. It significantly reduced weed population weed dry matter with weed control efficiency of 73.0 per cent. Correspondingly pods per plant, weight of pods per plant and seed yield of soybean increased significantly. Two year experiment at Jabalpur (M.P.) showed that application of alachlor 2.5 kg ha^{-1} P.E. gave significantly lower weed density and weed biomass during two years of study. The results being statistically at par with lower and higher dose (2.0 kg ha^{-1} and 5.0 kg ha^{-1}) of the test herbicide. The seed yield of soybean increased significantly by 30.3 and 68.7 per cent over control (1210 and 728 kg ha^{-1}) during respective years by controlling weeds with alachlor 2.5 kg ha^{-1} (Kurchania *et al.*, 2000). Alachlor applied at 2.0 kg ha^{-1} as pre-emergence effectively reduced the weed population from 106.2 to 89.2 and 210.2 to 138.2 during the weed dry matter from 560 kg ha^{-1} to 420 kg ha^{-1} and 844 kg ha^{-1} to 665 kg ha^{-1}, during two successive years of study indicating weed control efficiency of 25 per cent and 21.2 per cent, respectively. It significantly increased pods plant^{-1} and seed yield of soybean (24.4 per cent) over weedy control (Mandloi *et al.*, 2000). Nayak *et al.* (2000) at Sehore (M.P.) recorded significant decrease in weed density, weed dry matter with 41.4 per cent weed control efficiency when alachlor was applied to soybean crop @ 2.5 kg ha^{-1} P.E. Significant increase were observed in pods plant^{-1}, seeds pod^{-1} with the 54.0 per cent increase seed yield of soybean on pooled basis. Veermani *et al.* (2000) from Coimbatore reported significant reduction in weed population and dry matter with simultaneous significant increase in number of pods plant^{-1}, seeds pod^{-1} and 100 seed weight and 62.8 per cent increase in mean grain yield of soybean over control 1558 kg ha^{-1} with the application of alachlor 1.25 kg ha^{-1} + HW 40 DAS. Experiment at Killikulam (T.N.) with maize legume intercropping system indicated significant reduction in weed population and dry matter at 15 DAS and 30 DAS and increase in seed yield of soybean (61.9 per cent) and cowpea (48.4 per cent) over control (218 kg ha^{-1} and 190 kg ha^{-1}, respectively) when the crop was treated with alachlor 0.75 kg ha^{-1} P.E. + HW 30 DAS (Bhuvaneshwari *et al.*, 2002). Application of alachlor 1.0 kg ha^{-1} and 1.5 kg ha^{-1} gave effective control of *Cyperus iria*, *Digera arvensis*, *Phyllanthus niruri*, *Echinochloa crusgali* and *Commelina benghalensis*. The total weed dry weight at 90 DAS with alachlor application was at par with weed free and two hand weedings. Alachlor was very efficient in increasing the soybean seed yield and gave net returns of Rs. 8378 ha^{-1} when it was applied @ 1.5 kg ha^{-1} (Chauhan *et al.*, 2002). In blackgram, alachlor at 1.5 kg ha^{-1} P.E. gave significant reduction in weed dry matter and increased grain yield by 18.9 per cent and 21.3 per cent over unweeded control (544.32 and 539.20 kg ha^{-1}) in two successive years of study (Kathiresan, 2002). At Rauhri (M.H.) weed intensity and dry matter were reduced significantly in soybean crop when alachlor 2.0 kg ha^{-1} was applied as pre-emergence with weed control efficiency of 64.7 per cent. It gave 20.7 per cent higher seed yield as compared to 2168 kg ha^{-1} in weedy check (Gaikwad and Pawar, 2002). Malarvili *et al.* (2002) also reported that alachlor (G) @ 1.25 kg ha^{-1} reduced weed density and dry matter and increased the seed yield of soybean by 63.6 by per cent over control.

2.3.4 Metolachlor

Importance of metolachlor in weed control in blackgram has also been reported by (Gogoi *et al*., 1991). Mean results of two year of field trial at Ambikapur (M.P.) reflected yield status of 111.2 kg ha^{-1} soybean with the application of metolachlor which has numerically 53.3 per cent greater than weedy crop. This increase was a net reflection of 41 per cent weed control efficiency under the influence of metolachlor 1.0 kg ha^{-1}. At Sehore (M.P.) (Singh *et al.*, 1991) observed that pre-emergence application of metolachlor 1.0 kg ha^{-1} in soybean resulted in production of 10.8 q ha^{-1} of seeds which was 51.7 per cent more than that was produced under the situation of uncontrolled weeds. Net reduction of 62.1 and 80.7 per cent in weed density and dry matter were observed, respectively by the application of this herbicide (Sharma, *et al.*, 1992). Singh *et al.* (1993) while working at Delhi recorded 65.3 per cent greater yield of soybean with the application of 0.5 kg ha^{-1} of metolachlor compared to 1240 kg ha^{-1} under weedy conditions. On the basis of field experiment at Bajaura (H.P.) on intercropping system with maize, lowest weed density and dry matter was reported when metolachlor was applied @ 1.25 kg ha^{-1}. Compared to control it reduced the weed density by 81.3 per cent and dry matter by 82.3 per cent. The yield of kharif legumes was reported 208.42 per cent higher than control (1.90 q ha^{-1}) which was significant higher than all other weed control treatments. (Thakur, 1994) Ramamoorthy *et al.* (1995) registered 140.9 per cent increase in soybean yield when weeds were controlled through metolachlor 1.0 kg ha^{-1} against weedy crop (6.55 q ha^{-1}). From Pantnagar it was reported that application of metolachlor 1.0 kg ha^{-1} resulted in significant increase in pods plant^{-1}, seeds pod^{-1}, 1000-seed weight of soybean and ultimately showed 45 per cent increase in grain yield over weedy check (Singh and Chandel, 1995). On vertisols of Coimbatore, pre-emergence application of metolachlor 1.0 kg ha^{-1} reduced dry weight of weeds by 83.4 per cent compared to control (36.2 kg ha^{-1}). Simultaneously, the NPK uptake by weeds was significantly reduced (Velu, 1995). Metolachlor applied 1.5 kg ha^{-1} PE effectively controlled *Commelina benghalensis* (100%), *Legasca mallis* (85%), *Calosia argentia* (93%), *Cleome viscosa* (100%), *Euphorbia geniculata* (80%), *Parthenium hysterophorus* 89%, *Amaranthus viridis* (100%) and *Trianthema portulacastrum* (100%) but did not effectively controlled *Cyperus rotendus* (17%) and *Penicum spp* (33%) at Rajendra Nagar (A.P.). Metolachlor reduced the weed dry matter by 72 per cent. Greengram yield increased from 233 kg ha^{-1} (under weedy check) by 79.0 per cent (Reddy *et al.*, 1998). Application of metolachlor 1.5 kg ha^{-1} significantly reduced weed dry matter over control with the weed control efficiency of 58 per cent and 69 per cent in two respective years and gave 32.2 and 164.8 per cent higher seed yield of soybean over weedy check (968 and 315 kg ha^{-1}), in two successive years of investigation (Reddy *et al.*, 1998). Seed yield of blackgram and cowpea intercropped with sorghum increased by 107.5 per cent and 72.2 per cent over and above unweeded control (201 and 169 kg ha^{-1}), respectively when metolachlor was applied @ 1.0 kg ha^{-1} PE + hand weeding 40 DAS. (Solaimalai and Muthusankarnarayanan, 1999). At Gwalior when metolachlor was applied 1.0 kg ha^{-1} in soybean it reduced the weed population and dry matter significantly at 90 DAS with weed control efficiency of 27.5 per cent. It concomitantly increased pods plant^{-1}, weight of pods plant^{-1} with increase in seed yield by 41.8 per cent over 6.46 q ha^{-1} produced under weedy check (Jain *et al.*, 2000). Pre-emergence application of metolachlor 1.0 kg ha^{-1} + one hand weeding on 40 DAS recorded significantly lower nutrient uptake by weeds irrespective of the season and was found significantly superior to rest of the weed control treatments in sorghum + cowpea and sorghum + blackgram intercropping systems. Further, the yield of intercrops (blackgram and cowpea) increased significantly from 201 kg ha^{-1} and 169 kg ha^{-1} in control to 402 kg ha^{-1} and 287 kg ha^{-1} with metolachlor + HW during corresponding years respectively. (Solaimalai and Muthusankarnarayanan, 2000). Bhuvaneshwari *et al.* (2002) reported that metolachlor 1.0 kg ha^{-1} P.E. applied with hand weeding 30 DAS in intercropping system of soybean and cowpea in maize reduced weed population and biomass effectively as compared to unweeded control. Corresponding the yield of soybean and cowpea increased by 112.8, 95.8 per cent over unweeded control. Application of metolachlor 1.0 kg ha^{-1} resulted in significant reduction in weed density and biomass in soybean at Gwalior. Significant increase in the yield was also observed. Net returns of Rs. 6028 ha^{-1} were obtained with metolachlor (Chauhan *et al.*, 2002). Malarvili (2002) from Killikulum (T.N.) also reported that application of metolachlor pre-emergence 1.0 kg ha^{-1} significantly reduced the weed density and dry matter and gave weed control efficiency of 43.3 per cent and increased the seed yield of soybean. Ponnuswamy *et al.* (2002) also observed significant bearing of weed control with metolachlor 1.0 kg ha^{-1} PE on economics of sorghum + cowpea/blackgram intercropping system at Coimbatore.

2.4 EFFECT OF INTERCROPPING SYSTEMS ON WEED CONTROL

In field trials groundnut, cowpea and melon were evaluated for their weed smoothening effect when intercropped cassava and maize. The weed dry matter at 3 and 6 weeks after sowing was reduced in the intercropping systems from 307 and 445 g m^{-2} (in sole crop) to 203-280 and 292-498 g, respectively by the presence of intercrops with the lowest weed drymatter occuring with 20,000 ha^{-1} of grondnut plants. (Zuofa *et al.*, 1992). Results of experiment conducted at Banglore on red sandy loam where sole maize and soybean were monocropped as well as intercropped indicated that weeds absorbed less nutrients and crops absorbed more in the intercropping system than in the monocrops (Channabasappa and Nanjappa, 1994). Thakur (1994) from Bajaura (H.P.) reported that in maize presence of intercrops viz. blackgram, soybean and horsegram reduced the weed population. The lowest weed number and drymatter was observed in maize + horsegram.

When *Phaseolus* was intercropped with maize, significant differences were found in weed biomass at 6 weeks stage and leaf area index and mean dry weight of phaseolus leaves (30 days after planting). Two rows of *Phaseolus* intercropped with maize gave better weed control, higher total yield and land equivalent ratio than intercropping with one row of *Phaseolus* (Maina *et al.*, 1996). In U.K., intercropping of maize with field pea suppressed weeds compared to sole maize. Weed growth and density in maize + pea intercropping system and sole peas were substantially less than in sole maize. Intercropping maize with pea in ratios of 1:1 and 1:2 resulted in similar crop dry matter yields and weed suppression. Peas were more competative than maize (Semere and Froud, 1997). Results from IARI, New Delhi indicated that among the different intercropping systems pigenopea + cowpea was most effective in suppressing weeds and significantly reduced the weed dry weight as compared to sole pigeonpea and other intercropping systems, the later also differed significantly from each other during the first year of experimentation. Pigeonpea + groundnut was the next best followed by pigeonpea + greengram and pigenonpea + soybean. Though all the later three systems were at par during the second year but were significantly superior than sole crop of pigeonpea (Ahuja *et al.*, 1998). Results of trials indicated that density and biomass of monocot weeds, either in or between the maize rows, were not affected by cultivation or intercropping at Quebec (Canada). The density and biomass of dicot weeds in maize rows were reduced by some intercropping systems. Intercrops that included soybeans were more succesful in reducing weed population than those containing lupins (Casruthers *et al.*, 1998). Weed community responses were examined in maize soybean intercrops at South Western Michigan (USA). Weed suppression was observed when intercropping was additive. The depression in above ground weed biomass was not due to synergestic effect of crop diversity, but to the effect of crop density and crop type (Gomez and Gurevitch, 1998). Results from Ludhiana indicated that unweeded pigeon pea monocrops had the largest weed population and lowest crop yields. Intercropping with greengram decreased weed numbers by 18.3 per cent and increased combined yields (Singh and Sekhon, 1998). Intercropping of cotton with blackgram or clusterbean at 2:1 ratio reduced the weed density and dry matter (Solaiappan and Chellaiah, 1998).

Rana and Mahendrapal (1999) from IARI, New Delhi reported that intercropping of pigeonpea with three rows of cowpea reduced the total number of weeds as well as dry matter accumulation by them as compared to sole cropping of pigeonpea. Total grain production in terms of pigeonpea equivalent was higher in pigeonpea + one row of cowpeas. The results of field experiment with groundnut based intercropping system on the sandy loam soils of Vridhachalam (T.N.) indicated that greengram and redgram as intercrops significantly reduced the weed density and dry matter as compared to sole groundnut. When greengram was intercropped with groundnut it reduced 15.8 per cent weed density and 14.30 per cent weed drymatter as compared to sole crop (113.15 and 72.12 g m^{-2}, respectively) with the weed control efficiency of 51.70 per cent (Manikckam *et al.*, 2000). Intercropping of sorghum and cowpea in a 2:1 ratio caused significant reduction in weed dry matter production and had a higher weed smothering efficiency than other intercropping treatments. Sole sorghum cropping recorded higher weed dry matter and lower weed smothering efficiency compared to its intercropping with cowpea (Solaimalai and Shivkumar, 2000). Solaimalai and Muthusankaranarayanan (2000) also reported that nutrient removal by weeds was significantly influenced by the intercropping systems at Killikulam (T.N.). Nitrogen, phosphorus and potassium uptake by weeds was significantly lower in sorghum + cowpea intercropping than in sorghum + blackgram and sole sorghum. Bhuvaneshwari *et al.* (2002) reported that when maize was intercropped with cowpea and soybean it significantly reduced the weed population and drymatter as compared to sole maize. Soybean as intercrop reduced 31.3 per cent weed population and 18.8 per cent weed dry matter as compared to sole maize (111.33 m^{-2} and 340.2 kg ha^{-1}, respectively) at 30 DAS. At Kumher, maize + blackgram grown in 1:1 ratio significantly reduced the weed drymatter at 15 and 45 DAS. The reduction observed at 45 DAS was 16.4 and 11.5 per cent to sole maize (202.5 and 98.8 q m^{-2}, respectively) in the two successive year of experimentation but the N uptake by weeds and maize was statistically at par with maize + blackgram to sole maize (Deshveer and Singh, 2002). Sorghum + cowpea reduced the dry matter of *Trianthema spp* (22.2%), *Cyperus rotundus* (29.7%) and other (53.9%) as compared to sorghum + greengram 2.7, 3.7 and 2.6 q ha^{-1}, respectively (Ponnuswamy *et al.*, 2202)

2.5 EFFECT OF INTERCROPPING SYSTEMS ON MAIZE

Kalra and Babooji (1980) while evaluating economics of intercropping found that grain yield of maize was significantly higher by planting maize at normal spacing intercropped with greengram (17.85 q ha^{-1}), followed by blackgram, cowpea, groundnut and soybean (16.7, 16.6, 16.1 and 14.5 q ha^{-1}, respectively) as against 14.0 q ha^{-1} recorded from solid maize at Meerut. The shoot dry weight of three morphologically different maize cultivars decreased non significantly from 150, 189 and 187 g $plant^{-1}$ in maize alone to 142, 168 and 183 g $plant^{-1}$, respectively when intercropped with cowpea (Wahua *et al.*, 1981). Number of ears $plant^{-1}$ and grains cob^{-1} in maize were not affected by intercropping with cowpea cultivars (Wanki and Fawusi, 1982). At Udaipur, legume intercrops (cowpea and greengram) had no significant effect on plant height of maize at 30 and 60 DAS and at harvest (Rao, 1985). Dhingra *et al.* (1991) from Ludhiana have reported a marginal decrease in LAI of maize under intercropping with mungbean. However, the total LAI of maize + intercrop (mungbean) was greater than sole maize. At Jabalpur, intercropping maize with soybean or blackgram didnot reduce maize yield (Sharma, 1993). Chittapur *et al.* (1994) reported that in 1:1 ratio greater maize yield was obtained under maize + cowpea intercropping system over maize + horsegram or soybean. The relative crowding coefficient showed a greater degree of non-competitive interference of 2:2 row ratio of maize and soybean intercropping system at Sehore (Vyas *et al.*, 1995). In Tanzania, maize yield was not significantly affected by intercropping (Myaka, 1995). However, Bhattacharya and Gautam (1996) from Pantnagar have reported general increase in maize yield when intercropped with soybean and blackgram. Results of an experiment conducted at Pantnagar showed that higher grain yield of maize was observed when it was intercropped with soybean (2654 and 3606 kg ha^{-1}) as compared to sole maize (2465 and 3393 kg ha^{-1}, respectively) in two respective years. (Kushwaha and Chandel, 1997). Patra *et al.* (1999) reported that higher cobs $plant^{-1}$, grains cob^{-1} and maize grain yield were observed when it was intercropped with legumes as compared to sole maize. At Shalimar (J & K) higher total leaf area index, LER, cobs $plant^{-1}$, grains cob^{-1}, 1000 grain weight and grain yield of maize were observed when maize was intercropped with french bean in 1:2 ratio as compared to sole as well as maize + greengram intercropping systems (Pandita *et al.*, 1998). Contrary to this, Sharma *et al.* (1998) from Pantnagar reported no effect of intercrops viz. cowpea, urdbean or soybean on yielding ability of maize. Higher grain yield was observed when maize was intercropped with groundnut in 1:2 ratio as compared to sole maize as well as in 2:3 row ratio (Saren and Jana, 1999). At Pantnagar it was observed that grain yield of maize increased significantly when it was intercropped with blackgram (32.5 q ha^{-1}) and soybean (30.4 q ha^{-1}) as compared to sole maize (27.2 q ha^{-1}), while increase in nitrogen uptake was also observed with intercropping as compared to sole crop (Shivay *et al.*, 1999). Three maize densities (75 x 50, 75 x 30 and 75 x 15 cm^2) were intercropped with greengram one row between maize rows. Intercropping did not affect the maize yield, but the yield of mungbean were greatly affected (Faruque *et al.*, 2000). At Nanital maize green cob yield was significantly increased when maize + blackgram 1:2 (80 cm) row ratio was adopted as compared to sole maize (Singh, 2000). Inclusion of legumes (pea or lentil) as intercrops increased the drymatter accumulation of the maize based intercropping systems. The yield attributes, length and girth of cobs, number and weight of grains cob^{-1}, cobs $plant^{-1}$ and 1000 grain weight also increased by inetercropping maize with legumes. The respective mean maize grain yields were 46.4, 54.3 and 53.5 q ha^{-1} when maize was grown as sole crop and intercropped with pea or lentil (Singh *et al.*, 2000). Results of an experiment indicated that intercropping significantly reduced plant height of soybean. Seed yield of soybean was adversely affected by intercropping with maize. Results further indicated that intercropped maize yields were at par with the sole crops in both the intercropping experiments. There was no significant effect on the plant height and days to maturity of maize in intercropping and nonocropping systems. Land equivalent ratio for intercropping systems was greater (1.499 and 1.599) than sole cropping system, indicating better land cultivation efficiency (Ahmad *et al.*, 2001). No significant effect was observed in plant height, leaf area index and 1000 grain weight of maize when intercropped with *kharif* legumes as compared to sole maize but significant increase in yield was observed. The highest grain yield of maize (46.39 q ha^{-1}) was recorded in maize + cowpea intercropping system at Palampur (Rana *et al.*, 2001).

2.6 EFFECT OF INTERCROPPING SYSTEMS ON MAIZE EQUIVALENT YIELD

At Udaipur intercropping maize with greengram and cowpea significantly increased maize equivalent yield by 34.7 and 50.5 per cent, respectively over maize alone (Rao, 1985). Experiments conducted at Shalimar (J & K) revealed that intercropping of maize either with cowpea, rajmash or soybean 2:1 ratio was most productive in terms of maize equivalent yield (Shah *et al.*, 1991). In field studies at Jabalpur, significantly higher maize equivalent yield was recorded, when maize was intercropped with soybean, over maize + greengram intercropping system (Sharma and Chubey, 1991). Under rainfed conditions of Ambikapur (M.P.), significantly higher maize equivalent yields were recorded when maize was intercropped with groundnut, soybean and blackgram over intercropping with greengram or millets (Singh and Bajpai, 1991). Mishra *et al.* (1994) reported that highest maize equivalent yield (93.9 q ha^{-1}) was observed in maize + Pigeonpea intercropping as compared to sole maize (42.18 q ha^{-1}). In the mid-hills of North-West Himalaya of Bajaura (H.P.) intercropping of blackgram and horsegram with maize with recommended fertilizer application gave 14.5 and 13.5 per cent higher main equivalent yield over maize alone (Sharma, 1994). At Bhilwara (Rajasthan), maize + blackgram inetercropping system gave 36.56 q ha^{-1} of maize equivalent yield as against 32.85 q ha^{-1} in maize + greengram system (Jain, 1996). At Pantnagar 51.27 and 30.03 per cent higher maize equivalent grain yield was recorded when maize soybean intercropping system was adopted with 100 kg N ha^{-1} as compared to sole maize (2465 and 3393 kg ha^{-1}, respectively) with 120 kg N ha^{-1} in two respective years (Kushwaha and Chandel, 1997). Results of experiment conducted at Shalimar (J & K) showed that maximum maize equivalent yield was recorded in maize + frenchbean 1:1 ratio (7.88 t ha^{-1}) as compared to maize + greengram 1:1 ratio (6.58 t ha^{-1}) and sole maize (4.95 t ha^{-1}). It was also gave the highest B:C ratio of 1.87 (Pandita *et al.*, 1998). Sharma *et al.* (1998) recorded significant increase in maize equivalent yield by intercropping maize with legumes like cowpea, blackgram and soybean. At Dehradun intercropping of cowpea and blackgram with maize gave significant higher maize equivalent yields (35.28 and 33.50 q ha^{-1}, respectively) than sole maize (28.00 q ha^{-1}). These two intercropping systems also registered greater net returns. Soybean was not found to be suitable intercrop for maize in this study (Khola *et al.*, 1999). Results of another field study showed that among the intercropping systems. Results showed that among the intercropping systems, maize + groundnut gave the highest equivalent yield followed by maize + greengram at 1:1 row ratio and these were significantly superior to normally spaced sole maize (Patra *et* *al.*, 1999). The total yield in terms of maize equivalent was highest in 1:2 row ratio of maize + groundnut which was closely followed by sole groundnut. However, total productivity in both 1:2 and 2:3 row ratio was significantly higher compared to sole maize showing 258 and 222 per cent increase on an average basis (Saren and Jana, 1999). At Pantnagar significant variation in maize equivalent yield due to various cropping systems was recorded in both the years, where in intercropping of soybean and maize resulted in higher maize equivalents than intercropping with blackgram and sole stands of maize. Averaged over two years, maize yield equivalent of maize + soybean intercropping system were 12.9, 79.3 and 70.4 per cent higher over the maize equivalent yield recorded under maize + blackgram, sole maize grown with normal row planting and paired row planting, respectively (Shivay *et al.*, 1999). Patra *et al.* (2000) reported that maize equivalent yield of all the intercropping systems was significantly higher than their respective sole crop. However, among intercropping systems maize + pea recorded significantly highest maize equivalent yield (3295 and 3083 kg ha^{-1}) planted 60 and 90 cm apart, respectively). Singh *et al.* (2000) reported that mean maize equivalents were 47.3, 115.3 and 67.6 q ha^{-1} under sole maize, maize + pea and maize + lentil intercroppings, respectively. The maize equivalent yield in an intercropping of maize + blackgram were significantly affected by 80, 60 and 30 cm spacing over sole cropping system during all the years. On pooled basis the maximum maize equivalent yield obtained from maize + blackgram 1:2 (80 cm intercropping system) was 43.8 per cent higher than the maize alone (107.5 q ha^{-1} green cob). Similarly, it also gave the maximum net returns of Rs. 13, 248 ha^{-1} with the highest B:C ratio of 2.21 (Singh, 2000). Pooled analysis of two years data revealed that maize equivalent yield obtained in maize + legume intercropping systems were higher over their corresponding sole stands. Among the intercropping systems, maize + soybean with 100% NPK gave the maximum equivalent yield (57.26 q ha^{-1}) than maize + urdbean with 100% NPK (54.11 q ha^{-1}). On an average land equivalent ratio in intercropping system increased by 33 per cent over solid maize (Rana *et al.*, 2001). Significant variation in mean maize equivalent in different intercropping patterns of maize and soybean were recorded over their respective sole stands. All intercropping patterns of maize and soybean as well as sole soybean had greater maize equivalent yield compared with sole maize. Among intercropping patterns, paired rows (30/90 cm) + soybean (2:2 row ratio) recorded the maximum maize equivalent yield (38.59 q ha^{-1}) which was at par with paired maize (45/90 cm) + soybean 2:2 row ratio (37.9 q ha^{-1}) and gave significantly higher yield (14.2, 22.6 and 10.6 per cent) than paired maize rows (30+90 cm) + soybean (2:1), one additional maize row after every two rows of soybean (1:2) and maize (60 cm) + soybean (45 cm) in 2:1 row ratio, respectively.

The paired maize rows (30/90 cm) + soybean (2:2) and paired maize was (45/90 cm) + soybean (2:2) intercropping patterns produced the maximum and statistically identical gross and net returns and benefic : cost ratio at Majhera, Uttranchal (Singh and Singh, 2001).

3. MATERIALS AND METHODS

The field experiment entitled "Effect of Weed Control on the Productivity of Maize Intercropped with Legumes" was conducted during *kharif* seasons of 2001 and 2002. The details of materials used, procedures followed and criteria adopted for evaluation of treatments during the course of investigation are given in this chapter.

3.1 EXPERIMENTAL SITE AND CLIMATE

The experiment during both the years was laid out in field B_1 of the Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, Udaipur, which is situated at 24 34' N latitude and 73 42' E longitude with an altitude of 582.17 m above mean sea level. This region falls under agro-climatic zone IV A (Sub Humid Southern Plain and Aravalli Hills) of Rajasthan. Climatically Udaipur is typical subtropical and enjoys mild winter and less intense summer. The average rainfall of the tract ranges between 600-700 mm and 90 per cent of which is received during the period of July to September. Winter shower occur occasionally. The mean weakly meteorological parameters record during the two cropping seasons are presented in appendix 1 (a & b) and depicted in Fig. 3.1.

A perusal of data shows that the maximum and minimum temperatures during the crop growth period ranged between 27.8 C to 36.6 C and 14.9 C to 25.3 C, respectively during the year 2001. The corresponding range of temperature during the year 2002 were 28.1 C to 36.4 C and 14.4 C to 25.3 C. The total rainfall received during the crop season of the year 2001 was 442.7 mm and 353.3 mm in 2002. The evaporation from the USWB class-A pan evaporimeter during the corresponding crop season ranged from 3.0 to 7.5 and 3.1 to 8.0 mm per day, respectively.

3.2 PHYSICO-CHEMICAL CHARACTERISTICS OF THE EXPERIMENTAL FIELD

Soil samples were drawn randomly before commencement of the experiment, from different spots in the field from the depth of 0-15 cm and a composite samples were prepared which were analysed for physical and chemical properties during both the years. The values of soil analysis along with methods followed have been furnished in Table 3.1.

The data (Table 3.1) show that soils of experimental site were clay loam in texture and slightly alkaline in reaction. The soils were medium in available nitrogen, phosphorus and high in potassium status.

3.3 CROPPING HISTORY

Wheat crop was taken in the experimental area in preceding *rabi* seasons followed by the present experiment in *kharif* season during both the years.

3.4 EXPERIMENTAL DETAILS

3.4.1 Treatments and Crop Details

A. Intercropping systems

(i) Sole maize

(ii) Maize + blackgram

(iii) Maize + greengram

(iv) Maize + cowpea

(v) Maize + soybean

B. Weed control

(i) Weedy check

(ii) Hand weeding at 30 DAS

(iii) Pendimethalin 1 kg ha^{-1} PE

(iv) Alachlor 2 kg ha^{-1} PE

(v) Metolachlor 1 kg ha^{-1} PE

C. **Total treatment combinations : 25**

D. **Other details of experiment**

(i) Design - Split plot design (intercropping systems in main plots and weed control in sub plots)

(ii) No. of replications - 4

(iii) Total no. of plots - 100

(iv) Plot size : Gross - 5.0 m x 3.6 m

Net - 4.5 m x 2.4 m

(v) Maize was planted in rows 60 cm apart and row of legumes were planted in between two rows of maize (alternate row arrangement). Plant to plant distance within row for maize was kept as 25 cm and for legumes as 10 cm.

(vi) Crops and varieties

Maize crop : Maize (*Zea mays* L.) var. Deccan 103

Intercrops : Blackgram [*Vigna mungo* (L.) Hepper] var. T-9

Greengram [*Vigna radiata* (L.) Wilczek] var. K-851

Cowpea [*Vigna unguiculata* (L.) Walp.] var. C-152

Soybean [*Glycine max* (L.) Merill] var. JS-335

3.5 DETAILS OF CROP RAISING

Details of field operations carried out during the course of investigation have been given in Table 3.2.

3.5.1 Field Preparation

The experimental field was prepared giving one ploughing with tractor mounted M.B. plough and subsequently by harrowing followed by planking. Then all the plots were prepared according to the layout with the provision of irrigation channels and paths.

3.5.2 Fertilizer Application

N and P_2O_5 were applied to maize crop at the rate of 100 kg and 40 kg ha^{-1} respectively, using DAP and urea. Basal application of full dose of P_2O_5 and 1/3 N was made uniformly. Remaining 2/3 N was applied in two equal splits, first at knee high stage and second at tasselling stage close to maize rows during both the years.

3.5.3 Seed and Sowing

Sowing was done manually after opening the furrows at 30 cm distance. Alternate rows were sown with maize and intercrop seeds. The adopted seed rates for sowing were 20 kg, 8 kg, 8 kg, 10 kg and 40 kg ha^{-1} for maize, blackgram, green gram, cowpea and soybean during both the years, respectively.

3.5.4 Irrigation

Two irrigations were applied to the crops (16 and 27 July during 2002 and one irrigation on 30 August during 2001).

3.5.5 Weed Control

As per treatment details, the herbicides were sprayed one day after sowing (as pre-emergence sprays). The list of herbicides and their formulation used has been given in Table 3.3. The herbicides were sprayed with the help of Knapsack sprayer using 700 litres of water ha^{-1}. In the plots involving hand weeding as the treatment, weeds were manually removed 30 days after sowing.

Table 3.3 Details of herbicides used

S.No.	Common name	Trade Name	Chemical name
1.	Pendimethalin	Stomp 30 EC	N-(1-ethylpropyl)-2,6-dinitro-3, 4-xylidine
2.	Alachlor	Lasso 50 EC	2 chloro-2', 6'-diethyl-N-(methoxymethyl) acetanilide
3.	Metolachlor	Dual 50 EC	2-chloro-N-(2-ethyl-6 methylphenyl) - N - (2-methoxy-1-methylethyl) acetamide.

3.5.6 Thinning

Thinning was done in order to maintain plant to plant distance of 10 cm in case of intercrop and 25 cm in case of maize.

3.5.7 Harvesting

Cobs of matured maize crop were separated and plants were tied in bundles to record the stover yield.

Pods of blackgram, greengram and cowpea were hand picked as per in Table 3.2. Later the plants were pulled out, tied in bundles, sun dried and weighed to record stover yield.

Soybean crop was harvested when plants turned golden yellow and the produce of net plot was tied in bundles and taken to the threshing floor. After proper drying, the bundles were weighed to record the biological yield. Threshing was done manually and the produce of each plot was winnowed and cleaned. The seed weight was recorded and converted in q ha^{-1}.

3.5.8 Threshing

The intercrops were threshed manually and produce of each plot was winnowed and cleaned. The weight was recorded and converted into q ha^{-1}.

Maize cobs were shelled with single cob sheller and produce of each plot was winnowed. The weight was recorded and converted into q ha^{-1}.

3.6 TREATMENT EVALUATION

3.6.1 Weed Studies

Each plot in the experiment was surveyed at two places using 0.25 m^2 quadrate for studying weed composition in the experiment. A list of dominant weed species found during the period of investigation has been presented in Table 3.4.

3.6.1.1 Weed density

The weeds were counted at 30, 60 days after sowing and at harvest. Two spots were selected randomly in each plot using 0.25 m^2 quadrate to mark the area at 30, 60 days after sowing and at harvest. Separate counts were recorded for monocot and dicot weeds. Weed count was expressed as number m^{-2}. The data were subjected to X + 0.5 transformation to normalise their distribution (Gomez and Gromez, 1984).

3.6.1.2 Weed dry matter

All the weeds were collected at 30 and 60 days after sowing from two place in 0.25 m^{-2} area from each plot of this experiment as explained above. The samples were dried at 70 C for 24 hours and weighed, the dry matter was then computed in terms of kg ha^{-1}. At harvest all the weeds of net plot were harvested and categorised before sun drying and weighing.

3.6.1.3 NPK content and uptake by weeds

The dry matter of weeds (monocot and dicot) at harvest was subjected to grinding separately and were analysed for NPK contents. The NPK drains by the weeds was calculated by the formula.

Uptake~of~N/P/K~by~weeds~(kg~ha sup {-1})~=~{N/P/K~\in~weeds~(%)~
TIMES~Total~dry~weight~of~weeds~(kg~ha sup {-1})} over {100}

3.7 CROP STUDIES

3.7.1 Crop Stand and Plant Growth (Maize and Intercrops)

3.7.1.1 Plant population

Number of plants per net plot was recorded at harvest and convert into number ha^{-1}.

3.7.1.2 Plant height

Five plants were randomly selected from net area of each plot for both the crops. Height of tagged plants was taken from ground level to the tip of the plant at harvest and the mean height was calculated and expressed in cm.

3.7.1.3 Leaf area index

Leaves of five randomly selected plants for dry matter studies at 30, 50 and 70 DAS were detached after plant removal from field and fed to leaf area meter to workout total leaf area of five plants. The leaf area index was then calculated by using the formula (Sestale *et al.*, 1971)

LAI~=~{Total~leaf~area} over {Total~land~area}

3.7.1.4 Dry matter accumulation

Five plants were sampled out randomly from the sampling rows at 30, 50, 70 days after sowing and at harvest stages from each plot for both the crops. The samples were chopped and oven dried at 70 C for 24 hours, later these were weighed and average for recording dry matter accumulation in g plant^{-1}.

3.7.2 Yield Attributes and Yield

3.7.2.1 Main crop (maize)

3.7.2.1.1 Number of cobs per plant : Number of cobs of five tagged plants were counted at harvest and the mean value per plant under each experimental unit was worked out.

3.7.2.1.2 Grain yield per cob : The grain of five cobs were weighed and then the average of these was worked out to determine grain yield cob^{-1}.

3.7.2.1.3 1000 grain weight : A composite grain sample was drawn from the produce of each plot, from this 1000 seeds were taken out weighed on electric top pan balance.

3.7.2.1.4 Grain yield : Total grain/seed produce from each net plot was cleaned and weighed. It was then converted into q ha^{-1}.

3,7.2.1.5 Stover yield : The stover left after removing the cobs was harvested, sundried and weighed to obtain the stover yield. It was convert to q ha^{-1}.

3.7.2.1.5 Biological yield : Grain yield and stover yield obtained per plot were added and converted to q ha^{-1}.

3.7.2.1.6 Harvest index : Harvest index was calculated by using the formula (Donald and Hamblim, 1976)

$$HI = \frac{Grain\ yield\ (q\ ha^{-1})}{Biological\ yield\ (q\ ha^{-1})} \times 100$$

3.7.2.2 Intercrops

3.7.2.2.1 Seed yield : Weight of seed per net plot area was recorded and converted into q ha^{-1}.

3.7.2.2.2 Stover yield : In case of greengram, blackgram and cowpea the bundles of stover as explained in 3.5.7 were weighed and converted into q ha^{-1} for stover yield. While for soybean stover yield was obtained by subtracting seed yield from biological yield and converted to q ha^{-1}

3.7.2.2.3 Biological yield : For soybean the produce from each net plot was sundried weighed and converted to q ha^{-1}. For blackgram, greengram and cowpea the biological yield was derived by suming up seed and stover yields.

3.7.2.2.4 Harvest index : Harvest index was calculated by using the same formula as in case of maize.

3.7.2.2.5 Maize equivalent yield : Maize equivalent yield it terms of grain and stover were obtained by the sum of actual grain/stover yield of maize in the mixture and the grain/stover yield of the intercrop converted into maize equivalent on price value basis:

$$Maize\ equivalent = \frac{Grain/stover\ yield\ of\ intercrops\ (q\ ha^{-1})}{market\ price\ of\ maize\ (Rs.\ q^{-1})} \times Market\ price\ of\ intercrop\ (Rs.\ q^{-1})$$

3.7.2.3 Chemical analysis (Maize and intercrops)

3.7.2.3.1 Nitrogen content in grain and stover : Estimate of total nitrogen in grain and stover at the time of harvesting was made in terms of per cent nitrogen by "Nessler's calorimetric method" (Lendner, 1954)

3.7.2.3.2 Phosphorus content of grain and stover : Phosphorus in grain and stover was determined by Vanadomolybdo-phosphoric yellow colour method in H_2SO_4 medium (method no. 61, USDA Handbook No. 60, Richards, 1968) using blue filter.

3.7.2.3.3 Potassium content in grain and stover : Potassium estimation was done by flame photometer method No. 23-1 (Chapman and Pratta, 1961)

3.7.2.4 N, P and K uptake

Nitrogen, phosphorus and potassium uptake by the crops at harvest was computed from the data of per cent N, P and K content in grain and stover yield from each plot by using the relationship

Uptake~of~N/P/K~(kg~ha sup {-1})~=~{N/P/K~content~%~TIMES~Grain~\or~stover~yield~(kg~ha sup {-1})} over {100}

3.8 ECONOMICS

To find out the most profitable treatment, economics of different treatments were worked out in terms of net return ha^{-1} and B:C ratio.

3.9 STATISTICAL ANALYSIS

All the data collected during present investigation were subjected to statistical analysis by adopting appropriate method of analysis of variance as described by Gomez and Gomez (1984). Wherever, the variance ratio (F-value) were found significant at 5 per cent level probability, the critical difference (C.D.) values were computed for making comparison among treatment means. Interaction effects have been discussed wherever found significant.

Table 3.1 Physico-chemical properties of soil of the experimental field

Properties	Content		Method of analysis	Reference
	2001	2002		
A. Mechanical analysis				
Sand (%)	38.17	37.20	Hydrometer method	Bouyoucos (1962)
Silt (%)	26.54	27.37		
Clay (%)	35.29	35.43		
Textural class	Clay loam	Clay loam	Triangular diagram	Brady (1983)
B. Physical analysis				
Bulk density (Mg m^{-3})	1.54	1.55	Core sampler method	Piper (1950)
Particle density (Mg m^{-3})	2.42	2.43		Black (1965)
C. Chemical analysis				
Organic carbon (%)	0.91	0.90	Rapid titration method	Walkey and Black (1947)
Available nitrogen (N kg ha^{-1})	261.0	270.1	Alkaline $KMnO_4$ method	Subbiah and Asija (1956)
Available phosphorus (P_2O_5 kg ha^{-1})	16.6	17.3	Olsen's method	Olsen *et al.* (1954)
Available potassium (K_2O kg ha^{-1})	373.2	382.6	Flame photometer method	Richards (1968)
Electrical conductivity (ds m^{-1} at 25 C)	0.96	0.99	Using solubridge	Richard (1968)
pH (1:2, soil : water suspension)	8.10	8.08	Blackman's pH meter	Piper (1950)

Table 3.2 Details of field operations done during crop growing period of *kharif* 2001 and 2002

S.No.	Operations	Date	
		2001	2002
1.	Field preparation	20 June	25 June
2.	Field layout	25 June	29 June
3.	Bunding & levelling	27 June	30 June
4.	Furrow opening	30 June	30 June
5.	Fertilizer drilling & sowing	1 July	1 July
6.	Herbicide spray (as per treatment)	2 July	2 July
7.	Thinning	27 July	29 July
8.	Hand weeding (as per treatment)	31 July	31 July
9.	Irrigation	30 Aug.	16 and 27 July
10.	Picking of greengram and blackgram	22 Sept.	25 Sept.
11.	Picking of cowpea	05 Sept.	8 Oct.
12.	Harvesting of soybean	10 Oct.	15 Oct.
13.	Harvesting of maize	25 Oct.	27 Oct.
14.	Threshing and winnowing of intercrops	10 Nov.	11 Nov.
15.	Maize cob shelling	15 Nov.	15 Nov.

Table 3.4 Weed flora of the experimental site

Botanical name	English name	Family	Growth habit*
1. *Amranthus viridis* L.	Slender amaranth	*Amaranthaceae*	ADRs
2. *Commelina benghalensis* L.	Day flower	*Commelinaceae*	ADRs
3. *Convolvulus arvensis* L.	Field Bind weed	*Conuvolvulaceae*	PDRsRV
4. *Cynodon dactylon* (L.) Pers.	Bermuda grass	*Gramineae*	PMRsRV
5. *Cyperus esculentus* L.	Yellow nutsedge	*Cyperaceae*	PMRsRV
6. *Cyperus rotundus* L.	Purple nutsedge	*Cyperaceae*	PMRsRV
7. *Digera arvensis* Forsk.	Amaranth	*Amaranthaceae*	ADRs
8. *Echnochloa colonum* (L.) Link.	Jangle rice	*Gramineae*	AMRs
9. *Echinochloa crusgalli* (L.) Beauv	Barn yard grass	*Gramineae*	AMRs
10. *Parthenium hysterophorus* L.	Carrot grass	*Asterceae*	ADRs
11. *Phyllanthus niruri* Hook F.	Niruri	*Euphorbiaceae*	ADRs
12. *Portulaca oleraceac* L.	Common purslane	*Portulaceae*	ADRs
13. *Trianthema portulacstrum* L.	Horse purslane	*Aizoaceae*	ADRs

* Asterisk details :

A = Annual P = Perennial

D = Dicot Rs = Reproduction by seeds

M = Monocot Rv = Reproduction by vegetative means

4. RESULTS

The results of field experiment entitled "Effect of Weed Control on the Productivity of Maize Intercropped with Legumes" conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur during two consecutive years, 2001 and 2002 are being presented in this chapter. The data pertaining to the effects of different treatments on weeds and crop were statistically analysed and after evaluating them for test of significance, observed results have been presented in this chapter with the help of suitable tables. Analysis of variance for these data have been given in the appendices at the end, wherein significance at 5 per cent level of significance have been indicated by asterisks.

4.1 WEED STUDIES

4.1.1 Weed Flora of the Experimental Plot

Major weeds species that appeared in the experimental plots during the crop seasons have been mentioned in Table 3.4.

4.1.2 Weed Density

4.1.2.1 Weed density at 30 DAS

Intercropping systems : Different intercropping systems did not significantly influence the weed count at 30 DAS during both the years of investigation (Table 4.1).

Weed control : It is evident from the data presented in table 4.1 that application metolachlor, alachlor and pendimethalin proved statistically superior over weedy check in reducing monocot weed density during both the years. Application of metolachlor gave the lowest monocot weed density which was statistically at par with alachlor but both the herbicides were significantly superior over pendimethalin during both the years. On mean basis, reduction in population of monocot weeds with the application of metolachlor, alachlor and pendimethalin were 75.5, 73.2 and 58.3 per cent in comparison to weedy check, respectively.

The density of dicot weeds was found to be significantly lower in herbicide treated plots. However, herbicidal treatments were statistically at par with each other in both the years. Compared to weedy check reduction in dicot weed population on mean basis were 66.75, 64:23 and 68.21 with the application of pendimethalin, alachlor and metolachlor, respectively.

Herbicidal weed control proved effective in reducing the density of total weeds during both the years, though these herbicides differed with respect to their weed control efficiency. Application of metolachlor was at par with alachlor but both these herbicides were significantly superior to pendimethalin in controlling weeds during both the years. On mean basis 57.0, 72.3 and 75.1 per cent reduced weeds population were registered by pendimethalin, alachlor and metolachlor application, respectively over weedy check (164.84 m^{-2}).

4.1.2.2 Weed density at 60 DAS

Intercropping systems : The figures in Table 4.2 show that maize + soybean and maize + cowpea intercropping significantly reduced the monocot weed population in both the years as compared to sole maize and other of intercropping systems. On mean basis, 47.9 and 50.5 per cent lower weed population were recorded in maize + cowpea and maize + soybean intercropping systems as compared to sole maize.

All the intercropping systems tended to reduce the dicot weed population significantly compared to sole maize during both the years intercropping of maize with soybean and cowpea gave significantly lower weed population as compared to other intercropping systems and sole maize. On mean basis the lowest dicot weed density was registered in maize + soybean (10.61 m^{-2}). Significantly lower total weed density was registered in maize + soybean and maize + cowpea intercropping in comparison to rest of intercrops and sole maize in both the years. These two intercropping system were observed to be statistically at par with each other. On mean basis the lowest total weed density was recorded in maize + soybean (71.47 m^{-2}) intercropping system followed by maize + cowpea (76.78 m^{-2}) while the highest weed number was recorded in sole maize (141.45 m^{-2}) plots.

Weed control : An assessment of data (Table 4.2) indicates that handweeding as well as metolachlor and alachlor were statistically at par with each other in reducing monocot weed population and recorded significantly lower weed density compared to weedy check and pendimethalin during both the years of study. However, pendimethalin was statistically superior to weedy check. On mean basis application of metolachlor, alachlor pendimethalin and hand weeding done at 30 DAS registered 83.4, 82.3, 69.6 and 84.3 per cent lower monocot weed density, respectively compared to weedy check.

Maximum reduction in dicot weed number was recorded with hand weeding, followed by metolachlor, pendimethalin and alachlor during both years. But these treatments were statistically at par with each other in the first year of experimentation while in the second year alachlor gave significantly poorer dicot weed control as compared to other weed control treatments, but stood statistically superior to weedy check. On mean basis the dicot weed density was reduced by 67.3, 64.6, 58.8 and 66.7 per cent with hand weeding, pendimethalin, alachlor and metolachlor, respectively compared to weedy check.

All the weed control treatments recorded significantly lower total weed density compared to weedy check in both the years. Hand weeding was at par with metolachlor but it was statistically superior over alachlor and pendimethalin during first year. In the second year hand weeding, metolachlor and alachlor were at par with each other but significantly superior over pendimethalin. On mean basis the reduction in weed density varied between 69.1-82.5 per cent over weedy check (327.18 m^{-2}) by applying various options of weed control.

Interaction : The monocot weed density at 60 DAS was significantly influenced by combined effect of intercropping and weed control (Table 4.2.1). A clear trend emerged during both the years in which minimum count was recorded with hand weeding and maize + soybean intercropping system. However, this treatment combination was at par with maize + cowpea and hand weeding, maize + soybean and maize + cowpea with either alachlor or metolachlor. On an average 92.0 per cent reduction in weed density was registered by hand weeding maize + soybean intercropping system as against weedy sole maize.

Over the years of study dicot weed density at 60 DAS was variably affected by intercropping and weed control. All treatment combination involving maize + soybean and maize + cowpea with hand weeding and all herbicides were at par in reducing the dicot weed count except maize + cowpea with alachlor in first year and maize + cowpea and maize + soybean with alachlor during second year. On mean basis minimum dicot weed count (6.97) was recorded with maize + soybean intercropping system with weed control through either hand weeding or metolachlor application. (Table 4.2.2).

The figures presented in Table 4.2.3 indicate that across the years differential response of intercropping systems and weed control on total weed number was achieved. During first year minimum weed number (36.5) was recorded under combined influence of maize intercropped with soybean and hand weeding while in second year the same intercropping system with metolachlor registered minimum density (36.6). However in both the years, all treatment combination having maize intercropped with either soybean or cowpea with either hand weeding, metolachlor or alachlor registered equivalent results in this regard.

On mean basis maize + soybean with hand weeding and metolachlor lowered down the weed population by 91.2 per cent compared to unweeded sole maize.

4.1.2.3 Weed density at harvest

Intercropping systems : The maize + soybean and maize + cowpea intercropping systems were statistically superior over other systems and sole maize. Both these intercrops were at par with each other in both years in reducing monocot weed density (Table 4.3). On mean basis maize + soybean and maize + cowpea registered 45.5 and 42.7 per cent lower monocot weed density, respectively as compared to sole maize. The dicot weed density was also lower in maize + soybean and maize + cowpea intercropping during both the years. It can be inferred from the mean data that lowest dicot weed density (19.67 m^{-2}) was observed in maize + soybean intercropping system followed by maize + cowpea (21.42 m^{-2}).

The total weed density was brought down significantly by intercropping maize with soybean and cowpea as compared to others in both the years. Maize + soybean and maize + cowpea were statistically at par with each other. Maize + soybean gave the lowest weed density in respective years of investigation (87.90 and 98.03 m^{-2}).

Weed control : An examination of data (Table 4.3) reveals that all weed control treatments tended to reduce the monocot weed density compared to weedy check during both the years of investigation. Handweeding and application of alachlor and metolachlor were at par with each other and were found statistically superior over weedy check and pendimethalin. On mean basis hand weeding, pendimethalin, alachlor and metolachlor applications registered 79.7, 68.2, 80.5 and 80.2 per cent reduction in monocot weeds number in comparison to weedy check. The dicot weed density was significantly reduced by all weed control treatments which stood at par with each other in both the years of experimentation. On mean basis the lowest density was registered with metolachlor (21.33 m^{-2}), followed by pendimethalin (21.87 m^{-2}), handweeding (22.00 m^{-2}) and alachlor (22.76 m^{-2}).

Maximum total weed density was recorded in weedy check. The weed control treatments significantly reduced the total number of weeds. Handweeding, metolachlor and alachlor were at par with each other statistically superior over pendimethalin in both the years of investigation. On mean basis 76.2, 66.3, 76.7 and 77.8 per cent by reduction in total weed number were accounted by hand weeding, pendimethalin, alachlor and metolachlor, respectively compared to weedy check.

Interaction : An appraisal of figures (Table 4.3.1) reveals that across the years of investigation monocot weed density at harvest was lowered down significantly by various treatment combinations. However, data are explicative of the fact that all combinations involving either soybean or cowpea as intercrop along with either hand weeding, alachlor or metolachlor were statistically equivalent in lowering down the weed population. On mean basis maize + soybean with alachlor, metolachlor and hand weeding recorded 88.8 - 89.4 per cent reduction in monocot weed density at harvest.

The interactive effect of intercropping and weed control was significant only during first year wherein minimum dicot weed density at 60 DAS was observed when weeds were controlled by either hand weeding or metolachlor in maize + soybean intercropping system (Table 4.3.2). However, statistical equivalence of all herbicides and hand weeding with maize intercropped with either soybean or cowpea is evident from the figures.

Table 4.3.2 Interaction effect of intercropping systems and weed control on dicot weed density* (No. m^{-2}) at harvest

Intercropping systems	2001				
	Weed Control				
	Weedy check	HW 30 DAS	Pendimethalin 1 kg ha^{-1}	Alachlor 2 kg ha^{-1}	Metolachlor 1 kg ha^{-1}
Sole maize	8.16	4.78	4.93	4.99	4.90
	(66.13)	(22.35)	(23.78)	(24.44)	(23.56)
Maize+blackgram	7.11	5.15	5.00	4.98	4.98
	(50.09)	(26.07)	(24.54)	(24.31)	(24.33)
Maize+greengram	7.09	4.89	4.95	4.94	4.94
	(49.73)	(23.37)	(23.95)	(23.91)	(23.94)
Maize+cowpea	5.98	4.18	4.22	4.23	4.22
	(35.23)	(16.99)	(17.32)	(17.42)	(17.33)
Maize+soybean	5.64	4.00	4.09	4.12	4.00
	(31.32)	(15.48)	(16.22)	(16.46)	(15.48)
S.Em. ±	0.20				
C.D. (P=0.05)	0.56				

* Data subjected to $\sqrt{x + 0.5}$ transformation.
Data in parentheses are original value.

Figures on interaction effect of intercropping systems and weed control on total weed density at harvest clearly indicate that minimum weed count was recorded with weeds being controlled by metolachlor in maize + soybean intercropping system. However, maize + soybean and maize + cowpea with metolachlor alachlor and hand weeding were at par during both the years. In second year maize + soybean with pendimethalin also stood at par with these treatment combinations. Compared to unweeded sole maize, the maize + soybean intercropping system with metolachlor tended to reduce the weed density by 87.5 per cent (Table 4.3.3).

4.1.3 Weed dry matter

4.1.3.1 Weed dry matter at 30 DAS

Intercropping systems : The data presented in Table 4.4 indicate that intercrops did not affect dry matter accumulation by weeds significantly in either years of study.

Weed control : It is obvious from the data (Table 4.4) that application of metolachlor and alachlor were at par to each other and statistically superior over weedy check and pendimethalin application in reducing monocot weed dry matter during both years. However, pendimethalin was statistically superior to weedy check in this regard during both the years. On mean basis, 63.6, 75.0 and 76.5 per cent lower weed dry matter were recorded in pendimethalin, alachlor and metolachlor treated plots, respectively, in comparison to weedy check. Dicot weed dry matter was reduced significantly with all weed control treatments. All herbicides were at par with each other in both the years in this respect. On mean basis the lowest dicot weed dry matter was registered with metolachlor application followed by pendimethalin and alachlor accounting for 61.8, 61.0 and 57.6 per cent reduction compared to weedy check.

Application of metolachlor and alachlor were at par with each other and proved statistically superior in reducing total weed dry matter compared to weedy check and pendimethalin application while pendimethalin was significantly superior to weedy check in both the years of experimentation. On mean basis application of metolachlor, alachlor and pendimethalin tended to reduce total weed dry matter by 63.4, 73.5 and 75.2 per cent, respectively in comparison to weedy check (52.7 g m^{-2}).

4.1.3.2 Weed dry matter at 60 DAS

Intercropping systems : Maize + soybean and maize + cowpea proved statistically superior over sole maize and other intercropping systems in reducing monocot weed dry matter in first year but in second year only maize + soybean was statistically significant over sole maize. On mean basis lowest monocot weed dry matter at 60 DAS was registered in maize + soybean followed by maize + cowpea and highest in sole maize. The dry matter of dicot weeds were reduced significantly in maize + soybean and maize + cowpea intercropping systems as compared to sole maize and other intercropping systems in both the years (Table 4.5). On mean basis the range of dry matter was 4.6 g m^{-2} in maize + soybean (lowest) to 6.2 g m^{-2} in sole maize (highest).

Significant reduction in total weed dry matter at 60 DAS was observed in maize + soybean and maize + cowpea intercropping systems over other systems only in first year but in second year the significant reduction was observed only in maize + soybean over maize + blackgram and sole maize while rest of treatments were at par with each other. On mean basis reduction in weed dry matter was 22.1 and 25.2 per cent in maize + cowpea and maize + soybean compared to sole maize (44.48 g m^{-2}).

Weed control : Minimum monocot weed dry matter accumulation was recorded in hand weeded plots followed by metolachlor and alachlor, however, they remained statistically at par. All these treatments were significantly superior in reducing monocot weed dry matter over pendimethalin and weedy check in both the years. Whereas pendimethalin was statistically superior over weedy check. On mean basis, compared to weedy check reduction in dry matter to the magnitude of 84.3, 72.0, 83.3 and 83.7 per cent were obtained with hand weeding, pendimethalin, alachlor and metolachlor, respectively (Table 4.5).

All the weed control treatments recorded significantly lower dicot weed dry matter compared to weedy check and they remained statistically at par with each other in both the years of study. On mean basis lowest dicot weed dry matter was recorded in hand weeding (4.5 g m^{-2}) which was 52.3 per cent less than weedy check (9.44 g m^{-2}).

Application of metolachlor, alachlor and hand weeding were at par with each other and proved statistically superior in reducing total weed dry matter compared to weedy check and pendimethalin application but pendimethalin was statistically superior over weedy check in both the years. On mean basis, hand weeding, pendimethalin, alachlor and metolachlor tended to reduce dry matter by 81.5, 70.1, 80.3 and 80.9 per cent compared to weedy check (105.72 g m^{-2}).

Interaction: The dry matter accumulation of monocot weeds was significantly affected by different treatment combination during both the years of investigation (Table 4.5.1). During 2001, minimum dry matter was recorded in maize + soybean intercropping system with metolachlor while in 2002 it was minimum with same intercropping system and hand weeding. However, the treatment combinations involving soybean and cowpea with hand weeding, alachlor and metolachlor were at par during both the years. On mean basis these combinations tended to reduce the monocot weed dry matter by 87.5 to 88.7 per cent in comparison to control (unweeded sole maize).

A perusal of data (Table 4.5.2) reveals that during both the years of study maize intercropped with soybean and cowpea with any weed control measures viz. hand weeding, pendimethalin, alachlor and metolachlor were at par in reducing the dicot weed dry matter at 60 DAS. The mean figures indicate reduction to the time of 60.6 to 66.1 per cent by these eight treatment combinations as compared to sole maize without any weed control measure.

An examination of statistics presented in Table 4.5.3 indicate variability of interactive effect of treatments on total weed dry matter accumulation during the course of two years of study : However, during first year minimum dry matter was registered in maize + soybean with pre-emergence application of metolachlor (12.65 g m^{-2}) while in second year the same intercropping under the influence of hand weeding produced the minimum dry weight (20.13 g m^{2}). The figures indicate maximum reduction (86.7 per cent) in dry matter accumulation by total weeds by hand weeding in maize + soybean intercropping system.

4.1.3.2 Weed dry matter at harvest

Intercropping systems : The analysis of figures in Table 4.6 divulge the fact that maize + cowpea and maize + soybean were at par with each other during both years and were found statistically superior over maize + blackgram, maize + green gram and sole maize in reducing monocot, dicot and total weed dry matter. On mean basis maize + cowpea and maize + soybean reduced the monocot, dicot and total weed dry matter by 33.4 & 37.5; 32.2 & 37.4 and 33.2 & 37.5 per cent, respectively compared to weed check.

Weed control : It is evident from data (Table 4.6) that hand weeding as well as alachlor and metolachlor were at par and they significantly reduced dry matter accumulation by monocot weeds as compared to weedy check and pendimethalin but pendimethalin was found to be significantly superior over weedy check during both the years of study. On mean basis hand weeding, pendimethalin, alachlor and metolachlor reduced dry matter of monocot weeds by 77.4, 68.0 77.0 and 77.6 per cent, respectively as compared to weedy check.

The dry matter of dicot weeds at harvest tended to reduce significantly by all herbicides and handweeding, all of which were at par statistically. On mean basis 54.2-56.9 per cent reduction in dicot weed dry matter was observed by adopting different weed control measures as compared to weedy check.

The total dry matter of weeds at harvest reduced significantly by adopting herbicidal weed control as well as hand weeding during both the years of investigation. Hand weeding, metolachlor and alachlor were par with each other and showed statistical superiority over pendimethalin. On mean basis the reduction in weed dry matter at harvest due to hand weeding, pendimethalin, alachlor and metolachlor were 75.0, 66.5, 74.3 and 75.0 per cent, respectively in comparison to weed check.

Interaction : All the weed control practices and intercrops were found efficient in reducing monocot weed dry matter during either years of study. However, distinct variability existed amongst various treatment combinations in the significance of the extent of such reduction. During first year maize + soybean with hand weeding registered the minimum dry matter (18.35 g m^{2}) while in second year same intercropping system with metolachlor accounted for minimum dry matter (19.95 g m^{2}). The mean figures reveal that weed control with metolachlor in maize + soybean intercropping system accounted for greatest reduction (85.1 per cent) in monocot weed dry matter at harvest in comparison to unweeded sole maize (Table 4.6.1).

Figures on interaction effect of intercropping systems and weed control clearly indicate that minimum dicot weed dry matter at harvest was recorded in hand weeded maize + soybean system. The date further establish that dry matter of dicot weeds at this stage was statistically equivalent in all treatment combination involving soybean or cowpea as intercrops with hand weeding and all the three herbicides used. On mean basis these eight treatment combinations brought about 72.2 to 78.7 per cent reduction in dry matter in comparison to sole maize unweeded (Table 4.6.2).

The data explicate that across years, total weed dry matter was significantly affected by interaction between intercropping systems and weed control. However, variability did exist between the treatment combinations. During first year maize + soybean with hand weeding resulted in minimum dry weight (22.58 g m^{2}) which was statistically equivalent to maize + soybean or cowpea with hand weeding or any herbicide. In the second year minimum dry matter (25.45 g m^{2}) was recorded in maize + soybean with metolachlor However, it was at par with results obtained with maize + soybean or cowpea with hand weeding and all herbicides except pendimethalin. On mean basis 79.9 to 84.4 per cent reduction in dry matter was brought about by different weed control measures in maize + soybean or cowpea intercropping system compared to unweeded sole maize (Table 4.6.3).

4.1.4 Nutrient Content in Weeds

4.1.4.1 Nitrogen content

Intercropping systems had no significant influence on nitrogen content of monocot and dicot weeds in both the years of experimentation.

The data (Table 4.7) show that nitrogen content in monocot weeds was significantly affected by weed control treatments in first year of study. Hand weeding, alachlor and metolachlor resulted in significantly higher nitrogen content of weeds as compared to weedy check and pendimethalin but significant increase was not established in second year. In dicot weeds nitrogen content was not significantly affected by weed control treatments.

4.1.4.2 Phosphorus content

All intercropping control as well as weed treatment had no any significant effect on phosphorus content of monocot as well as dicot weeds in both the years investigation. (Table 4.7)

4.1.4.3 Potassium content

The data presented in Table 4.7 show that none of the treatments had significant bearing on potassium content of monocot and dicot weeds.

4.1.5 Nutrient Uptake by Weeds

4.1.5.1 Nitrogen uptake

Intercropping systems : The data (Table 4.8) unveil the fact that maize + cowpea and maize + soybean were statistically superior in reducing nitrogen depletion by both categories of weeds in both the years in comparison to sole maize, maize + blackgram and maize + green gram. On mean basis maize + cowpea and maize + soybean accounted for 31.1 & 37.4; 31.7 & 37.1 and 32.8 and 37.4 per cent reduction in N uptake by monocot, dicot and total weeds, respectively in comparison to sole maize.

Weed control : An examination of data (Table 4.8) indicates that compared to weedy check, all weed control treatment reduced nitrogen uptake by both categories of weeds during both years of study. Metolachlor, alachlor and handweeding significantly reduced the nitrogen deplation by monocot weeds compared to weedy check and pendimethalin. On mean basis, 77.0, 67.7, 76.6 and 77.2 per cent less nitrogen deplation was observed by controlling weeds through hand weeding, pendimethalin, alachlor and metolachlor compared to weedy check.

All the weed control treatments significantly reduced nitrogen uptake by dicot weeds as compared to weedy plots and they were statistically at par with each other. But in total weeds, nitrogen removal by pendimethalin was significantly higher over rest of the weed control measure but lower than weedy check. On mean basis hand weeding, pendimethalin, alachlor and metolachlor tended to reduce nitrogen depletion by dicot and total weeds by 56.0 and 74.0; 54.4 and 65.8; 53.4 and 73.3 and 55.0 and 74.0 per cent, respectively compared to weedy check.

Interaction : Over the years combined effect of intercropping system and weed control was observed with respect to N uptake by monocot weed. Though variability did exist in the results but trends of results remained almost the same. On mean basis maize + soybean with metolachlor accounted for maximum reduction (85.5 per cent) nitrogen uptake by monocot weeds (Table 4.8.1).

It is evident from data presented in Table 4.8.2 that though weed control measures tented to reduce the N uptake by weeds in all cropping system but their efficacy was significant higher under maize + soybean and maize + cowpea intercropping system compared to others during both the years. On an average 71.6 to 75.3 per cent reduction in N uptake by dicot weeds was observed with hand weeding or herbicide application to these two intercropping systems.

The total N uptake under interactive effect of intercropping systems and weed control followed the same pattern as under different categories of weeds viz. monocot and dicot. The mean figures of two years indicate that maize + soybean and maize + cowpea intercropping systems under various weed control measures gave lowest N drain by weeds in comparison to weedy maize crop (Table 4.8.3).

4.1.5.2 Phosphorus uptake

Intercropping systems : An assessment of data (Table 4.8) on intercropping systems reveals that they differed significantly in phosphorus depletion by weeds during both years. Sole maize except maize + blackgram and maize + green gram. While maize + soybean and maize + cowpea were at par with each other but found statistically superior over rest of the treatments. On mean basis maize + cowpea and maize + soybean reduced phosphorus removal by 33.4 & 37.7; 32.4 & 37.7 and 32.7 and 37.3 per cent, respectively monocot, dicot and total weeds compared to sole maize.

Weed control : All the weed control treatments significantly reduced phosphorus uptake by monocot, dicot and total weeds (Table 4.8). Metolachlor as well as alachlor application and hand weeding were at par and reduced phosphorus uptake by monocot weeds statistically compared to weedy check and pendimethalin. On mean basis hand weeding, pendimethalin, alachlor and metolachlor tended to reduce phosphorus removed by monocot weeds by 76.8, 67.8, 76.7 and 77.1 per cent over weedy check, respectively. All weed control treatments reduced phosphorus depletion significantly by dicot and total weeds compared to weedy check. In dicot, all treatments were at par but in total weeds phosphorus uptake in pendimethalin treated plots was inferior to rest of the treatments but superior over weedy check. On mean basis different weed control treatments tended to reduced phosphorus depletion by dicot and total weeds by 65.8 - 75.0 and 66.0 - 74.2 per cent, respectively compared to weedy check.

Interaction : An examination of data presented in Table 4.8.4 reveals that during both years, minimum P uptake by monocot weeds was observed under combined influence of maize + soybean and metolachlor application. Although statistical analysis of data of two years gives a picture of differential response of interaction effect of treatments, the mean figures are indicative of 50.5 to 85.6 per cent reduction in P uptake by monocot weeds in maize + soybean or cowpea intercropping system in comparison to weedy sole maize crop.

The results indicate that maize + soybean with hand weeding resulted in minimum P uptake by dicot weeds during both the years. However, the results obtained by maize intercropped with other soybean or cowpea with all weed control measures were at par in this respect and accounted for almost 75.7 per cent reduction in P uptake as compared to unweeded sole maize (Table 4.8.5).

A perusal of figures indicate that total P uptake by weeds was significantly affected by interactive effect of various treatments (Table 4.8.6). Variability of results existed between different treatment combination but on mean basis greatest reduction of 83.9 per cent in P drain by weeds was achieved by maize + soybean intercropping system with metolachlor. However, other combinations with maize + soybean or cowpea with different weed control measures were also efficient in this respect.

4.1.5.3 Potassium uptake

Intercropping systems : Differential response of intercropping systems was observed in respect of potassium uptake by weeds at harvest. Minimum potassium uptake by monocot, dicot and total weeds were recorded under the influence of maize + soybean followed by maize + cowpea and they were statistically superior over rest of the systems. On mean basis maize + soybean and maize + cowpea resulted in 38.0 and 33.8 per cent reduction in potassium uptake by total weeds, respectively over sole maize.

Weed control : The data (Table 4.8) reveal that hand weeding and pre-emergence application of alachlor and metolachlor significantly reduced potassium removal by categories of weeds compared to weedy check and pendimethalin except dicot weeds in both the years. The above three weed control treatments were statistically at par with each other in respect of potassium uptake by monocot and total weeds but all the weed control treatments were at par with each other in potassium uptake by dicot weeds. On mean basis handweeding, pendimethalin, alachlor and metolachlor tended to reduce potassium uptake by 73.6, 56.2 and 74.5; 67.5, 54.6 and 66.0; 76.6, 53.6 and 73.9 and 77.1, 55.3 and 74.6 per cent, respectively compared to weedy check by monocot, dicot and total weeds.

Interaction : Potassium uptake by monocot weeds was significantly reduced by intercropping and weed control. During first year minimum K uptake was observed in maize + soybean intercropping system with hand weeding (3.09 kg ha^{-1}) while in second year it was minimum with same intercropping system with metolachlor. Great variability in significance results of different treatment combination during two years of study is evident from the figures. On mean basis 85.7 present reduction in K uptake by monocot weeds was recorded in maize + soybean intercropping system with metolachlor (Table 4.8.7).

A perusal of figures in Table 4.8.8 indicate differential response of various treatment combinations on K uptake by dicot weeds. Although minimum K uptake was observed when maize was intercropped with soybean and weeds were controlled by hand weeding during both the years. On an average K uptake by dicot weeds decreased by 72.00 to 75.6 per cent in maize + soybean or cowpea intercropping system with any weed control measure.

A perusal of data (Table 4.8.9) reveals that total potassium uptake by weeds was significantly affected by interaction effect of intercropping systems and weed control. Across the years combination of treatments exerted differential effect but all combination involving soybean and cowpea as intercrops with hand weeding and all herbicides were at par in reducing K uptake except maize + cowpea with pendimethalin in 2002. On an average these eight combination tended to reduce total K uptake by 79.9 to 84.3 per cent in comparison to weedy sole maize.

4.2 CROP STUDIES (MAIZE)

4.2.1 Plant Population

A perusal of data in Table 4.9 shows that intercropping systems and weed control practices had no significant effect on plant population at harvest during both the years of experimentation.

4.2.2 Plant Height

Intercropping systems : It can be inferred from data (Table 4.9) that intercropping systems had no significant bearing on maize plant height.

Weed control : A perusal of data in Table 4.9 shows that plant height of maize at harvest was significantly affected by all weed control treatments as compared to weedy check. Hand weeding, metolachlor and alachlor recorded significant by greater maize plant height over pendimethalin and they were at par with each other in both the years. On mean basis 12.7, 4.9, 9.9 and 11.6 per cent increase in plant height were observed with handweeding, pendimethalin, alachlor and metolachlor, respectively over weedy check (188.55 cm).

4.2.3 Leaf Area Index

4.2.3.1 Leaf area index at 30 DAS

Intercropping systems : The data in Table 4.10 show that intercrops did not bring about any significant difference in respect of leaf area index of maize in both the years.

Weed control : An insight of data (Table 4.10) reveals that all herbicides significantly increased LAI over weedy check during both the years and they remained at par with each other. LAI on mean basis recorded with metolachlor, by alachlor and pendimethalin showed 27.9, 26.9 and 26.9 per cent improvement over weedy check.

4.2.3.2 Leaf area index at 50 DAS

Intercropping systems : The data presented in Table 4.10 indicate that intercrops did not affect leaf area index of maize significantly in both the years of experimentation.

Weed control : An examination of the data in Table 4.10 shows that leaf area index of maize under influence of hand weeding, metolachlor and alachlor were statistically at par with each other and significantly higher over weedy check in both the years of experimentation but LAI of maize in pendimethalin treated plots was significant lower than hand weeding in first year and handweeding and metolachlor in second year. On mean basis highest leaf area index of maize was registered in when weeds were controlled by hand weeding (3.15) and lowest in weedy check (2.28).

4.2.3.3 Leaf area index at 70 DAS

Intercropping systems : The data (Table 4.10) show that different intercropping systems did not show significant effect on leaf area index of maize at 70 DAS during both years of experimentation.

Weed control : An examination of the data in Table 4.10 shows that maximum leaf area index was recorded under hand weeding followed by metolachlor and alachlor. These treatments were statistically superior over weedy check and pendimethalin but at par with each other during both the years of experimentation. Whereas pendimethalin was significantly superior over weedy check and at par with only alachlor in both the years. On mean basis leaf area index recorded under hand weeding, pendimethalin, alachlor and metolachlor were 53.4, 42.2, 46.5 and 51.3 per cent higher than that observed under weedy check (2.75).

4.2.4 Crop Dry Matter

4.2.4.1 Dry matter at 30 DAS

Intercropping systems : The data Table 4.11 show that intercrops did not cause any significant variation in dry matter accumulation by maize during both the years.

Weed control : All the tested herbicides significantly increased dry matter of maize crop during both the years of study (Table 4.11). Highest dry matter was recorded with metolachlor which was at par with alachlor and pendimethalin. On mean basis weed control through pre-emergence application of pendimethalin, alachlor and metolachlor resulted in 29.6, 31.8 and 34.7 per cent increase in crop dry matter, respectively over weedy check.

4.2.4.2 Dry matter at 50 DAS

Intercropping systems : Intercropping systems did differ significantly with respect to dry matter accumulation by maize at 50 DAS (Table 4.11).

Weed control : All the weed control treatments were statistically superior in respect of dry matter accumulation of maize crop over weedy check during both the years of investigation (Table 4.11). Hand weeding, metolachlor and alachlor proved statistically superior over pendimethalin application but they were at par with each other in both the years. On mean basis the dry matter accumulation by maize crop was increased by 34.1, 20.5, 29.5 and 33.2 per cent by controlling weeds through hand weeding, pendimethalin, alachlor and metolachlor, respectively over weedy check.

4.2.4.3 Dry matter at 70 DAS

Intercropping systems : The data (Table 4.11) show that intercropping systems were statistically equivalent to each other and sole maize during both the years of study.

Weed control : The data presented in Table 4.11 indicate that dry matter accumulation by maize crop was significantly enhanced by controlling weeds by any method in comparison to weedy check. Highest dry matter was recorded under hand weeding during both the years which was significantly greater than weedy check and pendimethalin but at par with alachlor and metolachlor. On mean basis dry matter production under hand weeding, pendimethalin, alachlor and metolachlor were 29.2, 15.5, 24.8 and 25.8 per cent higher over weedy check.

4.2.4.4 Dry matter at harvest

Intercropping systems : It can be inferred from the data (Table 4.11) that intercropping had no significant bearing on maize crop dry matter accumulation.

Weed control : It is clear from evaluation of the data in Table 4.11 that all weed control treatments resulted in significantly increased dry matter of maize crop at harvest over weedy check. Hand weeding gave highest dry matter. However, it was at par with alachlor and metolachlor but statistically superior over pendimethalin application during both the years. On mean basis weed control by hand weeding, pendimethalin, alachlor and metolachlor registered 30.2, 16.4, 24.3 and 26.6 per cent increase in dry matter accumulation, respectively over weedy check.

4.2.5 Yield Attributes

4.2.5.1 Number of cobs per plant

Intercropping systems : The data in Table 4.12 show that in comparison to sole maize crop, intercrops failed to bring about any significant difference in number of cobs per plant during both the years of investigation.

Weed control : A perusal of data (Table 4.12) indicates that weed control through hand weeding, metolachlor and alachlor significantly increased cob per plant over weedy check and they were at par with each other. In the first year pendimethalin was at par with weedy check and alachlor but in second year it was significantly different from both of them. Hand weeding and metolachlor gave statistically higher cobs per plant over pendimethalin in both the years. On mean basis hand weeding, pendimethalin, alachlor and metolachlor increased number of cobs per plant by 16.4, 6.4, 14.5 and 17.3 per cent, respectively over weedy check.

4.2.5.2 Grain yield per cob

Intercropping systems : The data (Table 4.12) show that intercrops did not have any significant effect on grain yield per cob compared to sole maize crop.

Weed control : A perusal of data (Table 4.12) reveals that all weed control treatments significantly increased grain yield per cob over weedy check during both the years. Hand weeding, alachlor and metolachlor were at par with each other and proved superior over pendimethalin in this respect. On mean basis 38.3, 24.4, 33.7 and 31.1 per cent increase in grain yield per cob was observed under handweeding, pendimethalin, alachlor and metolachlor, respectively over weedy check.

4.2.5.3 1000 grain weight

Intercropping systems : Intercropping systems were found statistically equivalent to each other and sole maize during both the years (Table 4.12).

Weed control : It is obvious from the data (Table 4.12) that all weed control treatments were superior in respect of 1000-grain weight over weedy check during both the years of experimentation and they remained at par with each other. On mean basis hand weeding recorded maximum (235.1 g) 1000 grain weight followed by metolachlor (234.8 g) and alachlor (234.2 g) and lowest was recorded in weedy check (208.6 g).

4.2.6 Yield and harvest index

4.2.6.1 Grain yield

Intercropping systems : The data (Table 4.13) show that intercrops had no significant effect on grain yield of maize in both the years.

Weed control : All the treatment applied to control weeds in maize crop resulted in significant enhancement in grain yield over weedy check during both years of experimentation (Table 4.13). It can be further noted from the data that hand weeding, alachlor and metolachlor gave significantly higher grain yield over pendimethalin application but they remained statistically at par with each other in both the years. Weed control through hand weeding, pendimethalin, alachlor and metolachlor gave 73.4, 53.0, 66.4 and 72.3 per cent higher grain yield in first year and 72.4, 54.6, 67.7 and 71.4 per cent in second years, respectively over weedy check. On mean basis 53.8 to 72.9 per cent increase in grain yield of maize was recorded by applying different weed control measures over weedy check (28.61 q ha^{-1})

4.2.6.2 Stover yield

Intercropping systems : Different intercropping systems had no significant impact on stover yield of maize during either year of study (Table 4.13).

Weed control : The figures on stover yield of maize (Table 4.13) divulge the fact that hand weeding, metolachlor and alachlor as weed control treatments, significantly increased stover yield over weedy check and pendimethalin and they were at par with each other. Although pendimethalin also significantly increased the stover yield over weedy check in both the years of experimentation but it was significantly inferior to hand weeding, metolachlor and alachlor. On mean basis the stover yield increased by 47.6, 31.0, 42.6 and 44.5 per cent with weed control through handweeding, pendimethalin, alachlor and metolachlor, respectively over weedy check (71.17 q ha^{-1}).

4.2.6.3 Biological yield

Intercropping systems : The data (Table 4.13) show that intercrops failed to bring out any significant difference in biological yield of maize during both the years in comparison to sole maize.

Weed control : The data (Table 4.13) are explanatory of the fact that all weed control treatments significantly increased the biological yield over weedy check during both the years. However, these treatments varied insignificantly with each other in both the years of study. The mean figures indicate that among the weed control treatments handweeding recorded highest biological yield (154.55 q ha^{-1}) but it was followed by alachlor and metolachlor.

4.2.6.4 Harvest index

Intercropping systems : Different intercropping systems had no significant impact on harvest index during either year of study (Table 4.13).

Weed control : All the weed control treatments tended to increase the harvest index significantly over unweeded check during both the years (Table 4.13), but no significant differences were observed within these treatments. The mean data of H.I. indicate that compared to weedy check (28.79), various weed control treatment registered increase in H.I. 32.02 to 32.44 per cent.

4.2.4 Nutrient Content

4.2.4.1 Nitrogen content

Intercropping systems : Intercropping did not show any significant effect on nitrogen content in seed and stover of maize during both years of experimentation (Table 4.14).

Weed control : A perusal of data in Table 4.14 reveals that nitrogen content in seed as well as stover of maize increased significantly by adopting different weed control practices in comparison to weedy check during both the years of experimentation. The nitrogen content in seed was maximum under hand weeding during first year. It was significantly higher over pendimethalin but at par with other herbicides. While in second year all weed control practices were at par with each other. Nitrogen content in stover was significantly inferior with pendimethalin than rest of the treatments in both the years study and they were at par with each other. On mean basis maximum nitrogen content in seed was higher when weeds were controlled by hand weeding (1.74 per cent) while in stover metolachlor gave highest nitrogen content (0.64 per cent).

4.2.4.2 Phosphorus content

Intercropping systems : The data in Table 4.14 reveal that intercrops did not show any significant effect on phosphorus content in seed and stover of maize during both the years of experimentation.

Weed control : Hand weeding and all herbicidal treatments increased phosphorus content in seed as well as stover significantly over weedy check during both the years. Weed control by hand weeding, alachlor and metolachlor resulted in significantly superior phosphorus content in seed over pendimethalin in both the years. In stover, during first year weed control through hand weeding, metolachlor and alachlor gave significantly high P content over pendimethalin (Table 4.14).

4.2.4.3 Potassium content

Intercropping systems : Intercropping had no significant effect on potassium content in grain and stover of maize in either year of study (Table 4.14).

Weed control : A perusal of figures in Table 4.14 reveals that weed control practices influenced the potassium content in grain and stover of maize during both the years of investigation. Hand weeding resulted in maximum potassium content in grain and stover of maize and tended to remain statistically at par with all herbicidal treatments during both the years except pendimethalin which was significantly inferior to hand weeding and metolachlor in potassium content in stover during first year. On mean basis hand weeding, pendimethalin, alachlor and metolachlor increased potassium content in grain by 27.0, 25.6, 25.8 and 26.1 per cent and in stover 14.4, 12.7, 13.8 and 14.1 per cent, respectively over control.

4.2.5 Nutrient Uptake

4.2.5.1 Nitrogen uptake by grain

Intercropping systems : No significant differences were observed with respect to N uptake by maize grain under the influence of intercropping systems during both the years as compared to sole maize. (Table 4.15).

Weed control : It is evident from data (Table 4.15) that compared to weedy check all weed control practices significantly increased nitrogen uptake by maize grain during both the years. Hand weeding, alachlor and metolachlor were at par with each other but they were statistically superior over pendimethalin application in this respect. On mean basis hand weeding, pendimethalin, alachlor and metolachlor tended to increase nitrogen uptake by maize grain by 91.6, 68.0, 82.7 and 89.4 per cent over weedy check, respectively.

4.2.5.2 Nitrogen uptake by stover

Intercropping systems : Intercropping of maize with either blackgram, greengram, cowpea or soybean did not differ with sole maize with regard to nitrogen uptake by maize stover (Table 4.15).

Weed control : All herbicidal weed control treatments increased nitrogen uptake by maize stover during both the years and all these were at par with each other except pendimethalin which was inferior to rest of the treatments but significantly superior over weedy check. On mean basis hand weeding, pendimethalin, alachlor and metolachlor tended to increase in nitrogen uptake by stover by 64.0, 41.0, 58.4 and 61.3 per cent, respectively over weedy check (Table 4.15).

4.2.5.3 Nitrogen uptake by crop

Intercropping systems : In comparison to sole maize, intercropping treatments did not show any significant effect on nitrogen up take by crop during both the years of study. (Table 4.15).

Weed control : The data (Table 4.15) explict that hand weeding and all herbicidal treatments significantly increased the nitrogen uptake by crop over weedy check during both the years of study. Hand weeding was superior over pendimethalin and alachlor during first year but in second year all weed control practices were at par with each other except pendimethalin. On mean basis 78.5, 55.2, 71.1 and 76.0 per cent increase in nitrogen uptake by maize crop were observed with hand weeding, pendimethalin, alachlor and metolachlor, respectively over weedy check.

4.2.5.4 Phosphorus uptake by grains

Intercropping system : The data in table 4.15 indicate that intercrops did not show any significant effect on phosphorus uptake by maize grains.

Weed control : Phosphorus uptake by grain increased significantly with all weed control treatments over weedy check (Table 4.15). Hand weeding, alachlor and metolachlor were at par with each other and statistically superior over pendimethalin during both years study. On mean basis phosphorus uptake by maize grain increased by 57.6 to 84.4 per cent by controlling weedy by adopting different practices over weedy check.

4.2.5.5 Phosphorus uptake by stover

Intercropping systems : Phosphorus uptake by maize stover was not affected significantly by various intercropping systems (Table 4.15).

Weed control : All weed control treatments recorded higher phosphorus uptake over weedy check during both the years. All these treatments were at par except pendimethalin. On mean basis the weed control treatments tended to increase phosphorus uptake by 43.6 - 62.8 per cent over weedy check (Table 4.15).

4.2.5.6 Phosphorus uptake by crop

Intercropping systems : Sole maize and different intercropping systems were statistically at par with each other in respect to phosphorus uptake by crop during both the years (Table 4.15).

Weed control : The data on phosphorus uptake by crop (Table 4.15) clearly show statistical significance of different weed control measures over unweeded conditions. Hand weeding was superior over alachlor and pendimethalin during first year but in second year it was at par with alachlor and metolachlor. On mean basis hand weeding, pendimethalin, alachlor and metolachlor registered 73.9, 50.8, 66.4 and 70.7 per cent greater phosphorus uptake, respectively compared to weedy check.

4.2.5.7 Potassium uptake by grain

Intercropping systems : Intercropping systems failed to influence K uptake by maize grain during both the years of study (Table 4.15).

Weed control : The potassium uptake pattern was similar to phosphorus uptake (Table 4.15). On mean basis hand weeding recorded maximum potassium uptake followed by metolachlor and alachlor and these three registered 119.4, 116.7 and 110.3 per cent increased, respectively over weedy check.

4.2.5.8 Potassium uptake by stover

Intercropping system : All the intercropppings and sole maize were statistically at par with regard to potassium uptake by maize stover during both the years of experimentations (Table 4.15).

Weed control : All weed control treatments increased potassium uptake by maize stover over weedy check during both the years. Except pendimethalin, all other treatment were at par with each other. On mean basis hand weeding recorded highest potassium uptake followed by metolachlor, alachlor and pendimethalin, showing 68.9, 65.2, 62.2 and 48.8 per cent higher K uptake, over weedy check.

4.2.5.9 Potassium uptake by crop

Intercropping systems : It can be inferred from data (Table 4.15) that intercropping had no significant bearing on potassium uptake by crop.

Weed control : The data clearly indicate that hand weeding and all herbicidal treatments increased potassium uptake by maize crop over weedy check during both the years. Hand weeding, alachlor and metolachlor were at par with each other and statistically superior over pendimethalin. On mean basis, the minimum (52.5 per cent) and maximum (73.6 per cent) increase in potassium uptake were recorded with pendimethalin and hand weeding, respectively over weedy check.

4.3 CROP STUDIES (INTERCROPS)

4.3.1 Plant Population at Harvest

Intercropping systems : The different intercrops viz., blackgram, greengram, cowpea and soybean did not vary with each other in respect of plant population (Table 4.16).

Weed control : A perusal of data (Table 4.16) reveal that all weed control treatments had only a marginal bearing on plant population of intercrops. Yet it is clear from figures that under weedy situation the population of intercrops was less than all the weed control measures.

4.3.2 Plant Height at Harvest

Intercropping systems : The data (Table 4.16) show that different intercrops varied with each other in respect to plant height. Plant height of soybean was highest among the all intercrops and followed by cowpea and green gram. Blackgram had lowest plant height.

Weed control : A perusal of data in Table 4.16 show that weed management practices affected the plant height in both the years. On mean basis the maximum average plant height of intercrops was recorded under weedy check (66.6 cm) and lowest in the hand weeded plot (60.25 cm).

4.3.3 Leaf area index

4.3.3.1 Leaf area index at 30 DAS

Intercropping systems : The mean data in table 4.17 indicate that leaf area index of soybean recorded 33.3, 29.2 and 7.7 per cent increase over blackgram, greengram and cowpea, respectively.

Weed control : All the herbicides tried in the experiment increased the leaf area index of intercrops over weedy check during both years study (Table 4.17). On mean basis metolachlor alachlor and pendimethalin resulted in 30.6, 25.8 and 27.4 per cent increase in leaf area index, respectively over weedy check.

4.3.3.2 Leaf area index at 50 DAS

Intercropping systems : Data presented in Table 4.17 show that different intercrops had different leaf area index. On mean basis blackgram recorded the minimum leaf area index (1.40) and soybean recorded highest leaf area index (1.79) at 50 DAS.

Weed control : A perusal of statistics in table 4.17 shows that maximum leaf area index was observed under metolachlor followed by alachlor, pendimethalin and hand weeding during both the years of experimentation. Hand weeding, pendimethalin, alachlor and metolachlor recorded 36.7, 41.7, 44.2 and 45.0 per cent increase in mean leaf area index, respectively over weedy check.

4.3.3.3 Leaf area index at 70 DAS

Intercropping systems : It can be seen from figures of LAI at 70 DAS (Table 4.17) that cowpea and soybean had very high leaf area index in comparison to blackgram and greengram.

Weed control : A perusal of data (Table 4.17) reveals that all weed control treatments increased the leaf area index of intercrops in comparison to weedy check. Highest LAI was recorded in handweeding which was very close to metolachlor during both the years. On mean basis leaf area index under hand weeding, pendimethalin, alachlor and metolachlor were 56.1, 46.3, 48.8 and 55.3 per cent higher at 70 DAS, respectively over weedy check.

4.3.4 Dry Matter Accumulation

4.3.4.1 Dry matter accumulation 30 DAS

Intercropping systems : The data (Table 4.18) show that maximum dry matter accumulation was recorded by soybean in both years study but it was slightly more as compared to cowpea. On mean basis soybean registered 29.7, 18.3 and 4.6 per cent higher dry matter as compared to blackgram, green gram and cowpea, respectively.

Weed control : All the herbicidal weed control treatments increased dry matter by intercrops over weedy check during both the years study (Table 4.18). The highest dry matter was recorded with metolachlor in both years. On mean basis pendimethalin, alachlor and metolachlor resulted in 59.1, 61.9 and 65.3 per cent increase in leaf area index over weedy check, respectively.

4.3.4.2 Dry matter accumulation 50 DAS

Intercropping systems : The data (Table 4.18) explicate that blackgram recorded lower dry matter compared to other intercrops. The mean figures indicate that soybean, cowpea and greengram recorded 72.6, 67.9 and 7.7 per cent higher dry matter accumulation as compared to blackgram.

Weed control : All weed control treatments were numerably superior in respect of dry matter accumulation by intercrops over weedy check during both the years and mean basis (Table 4.18). Metolachlor gave the highest dry matter among the all weed control treatments followed by alachlor and pendimethalin. On mean basis the dry matter accumulation increased by 75.8, 65.6, 59.5 and 33.4 per cent with weed control through metolachlor, alachlor, pendimethalin and hand weeding, respectively.

4.3.4.3 Dry matter accumulation 70 DAS

Intercropping systems : The perusal of data in table 4.18 reveals that soybean recorded highest dry matter accumulation followed by cowpea and green gram and lowest was recorded by blackgram in both the years of experimentation.

Weed control : A perusal of data (Table 4.18) reveals that all weed control treatments increased the dry matter accumulation in intercrops in comparison to weedy check. On mean basis the dry matter accumulation under hand weeding, pendimethalin, alachlor and metolachlor were 87.1, 74.1, 83.9 and 91.9 per cent higher over weedy check, respectively.

4.3.4.4 Dry matter accumulation at harvest

Intercropping systems : The data presented in (Table 4.18) show that numerically slight differences were observed in dry matter accumulation by blackgram and green gram but it was very low as compare to soybean and cowpea. On mean basis soybean and cowpea recorded 91.8 and 72.5 and 81.8 and 63.5 per cnet higher dry matter accumulation as compare to blackgram and greengram, respectively.

Weed control : All herbicides as well as hand weeding increased dry matter of intercrops at harvest over weedy check in both the years study. On mean basis the hand weeding, pendimethalin, alachlor and metolachlor registered 76.1, 66.9, 72.2 and 88.4 per cent increase in dry matter accumulation, respectively over weedy check.

4.3.5 Yield and harvest index

4.3.5.1 Seed yield

Intercropping systems : A clear trend with respect to seed yield of intercrops emerged on account of the different intercrops tried in the present experiment. Soybean exhibited its superiority over rest of intercrops. Out of remaining three intercrops cowpea was superior over greengram and blackgram during both the years of study. Analysis of mean data indicate that soybean resulted in 68.9 and 35.4 per cent greater yield, while cowpea gave 46.4 and 17.4 per cent higher yield over blackgram and green gram, respectively (Table 4.19).

Weed control : All the treatments applied to control weeds in intercrops resulted in enhanced the seed yield of intercrops over weedy check during either years of experimentation (Table 4.19). On mean basis hand weeding, pendimethalin, alachlor and metolachlor resulted in 68.3, 58.2, 66.4 and 75.6 per cent enhancement in seed yield of intercrops, respectively over weedy check.

4.3.5.2 Stover yield

Intercropping systems : An appraisal of the data (Table 4.19) shows that soybean was close with cowpea but sufficiently superior over blackgram and green gram in both the years of study. On mean basis the soybean registered 60.9, 44.0 and 9.2 per cent increase in stover yield over blackgram, green gram and cowpea, respectively.

Weed control : The data (Table 4.19) are explanatory of the fact that all weed control measures increased the stover yield over weedy check during both years and mean basis, however, the weed control treatments varied amongst each other in both the years of study. The mean figure indicate that among herbicides metolachlor recorded highest stover yield but it was very close with hand weeding and alachlor. The mean stover yield increased by 29.5, 21.4, 27.1 and 32.2 per cent with weed control through hand weeding, pendimethalin alachlor and metolachlor, respectively.

4.3.5.3 Biological yield

Intercropping systems : It is evident from (Table 4.19) the data that all intercrops were different to each other in producing biological yield. However, soybean registered 63.0, 41.6 and 10.9 per cent yield increment over blackgram, greengram and cowpea, respectively.

Weed control : A perusal of figures in Table 4.19 reveals that all weed control treatments increased the biological yield of intercrops compared to weedy check. Amongst these treatments metolachlor gave the highest mean biological yield (20.07 q ha^{-1-1}) followed by hand weeding (19.53 q ha^{-1}) and alachlor (19.20 q ha^{-1}).

4.3.5.4 Harvest index

Intercropping systems : The data Table 4.19 reveal that maximum harvest index was observed in green gram followed by soybean, cowpea and blackgram in both the years of investigation, but the difference was slightly.

Weed control : An insight of figures clearly indicates that weed control treatments had no large differences in harvest index but they increased the harvest index over weedy check in both the years of experimentation.

4.3.6 Nutrient Content

4.3.6.1 Nitrogen content in seed and stover

Intercropping systems : Amongst various intercrops soybean had the highest N content of seeds as well as stover during both the years (Table 4.20).

Weed control : A perusal of data in Table 4.20 reveals that weed control treatments tended to increase the nitrogen content of seed and stover during both the years study. However, various herbicides and hand weeding did not vary much amongst themselves.

4.3.6.2 Phosphorus content in seed and stover

Intercropping systems : The data (Table 4.20) explict that no differences were observed under different intercrops in respect to the phosphorus content of seed and stover. However, soybean had very slightly high phosphorus content on mean basis.

Weed control : Compared to weedy check, the P content of seeds and stover of intercrops enhanced by controlling weeds, through herbicides and hand weeding. On mean basis the quantum of increase were 1.3 to 4.6 per cent in seed and 5.8 to 8.6 per cent in stover, respectively (Table 4.20).

4.3.6.3 Potassium content in seed and stover

Intercropping systems : The data (Table 4.20) explicit that no distinct difference was observed under different intercrops in respect to the potassium content in seed and stover. However, soybean had slightly higher potassium content in seed and stover on mean basis.

Weed control : A perusal of data in Table 4.20 reveals that weed control treatments increased the potassium content in seed and stover in both the years of study but there was no distinct difference among the different weed control treatments. On mean basis the maximum potassium content was recorded in hand weeding in seed (0.566 %) and in stover (1.608 %).

4.3.7 Nutrient Uptake

4.3.7.1 Nitrogen uptake by seed stover and crop

Intercropping systems : A reference of data in table 4.21 reveals that maximum nitrogen uptake was recorded by soybean in seed, stover and total and followed by cowpea in both the years of study. On mean basis soybean accounted for 192.8, 136.7 and 107.1 per cent higher nitrogen drain by seed, 104.7, 79.7 and 22.5 per cent higher nitrogen uptake by stover and 156.5, 114.3 and 68.7 per cent higher total uptake over blackgram, greengram and cowpea, respectively.

Weed control : The data (Table 4.21) show that weed control treatments influenced the nitrogen uptake by seed and stover as well as total nitrogen uptake during both the years of experimentation. Maximum uptake of nitrogen was recorded under metolachlor during both the years in seed, stover and total. The mean nitrogen uptake under hand weeding, pendimethalin, alachlor and metolachlor were 71.8, 36.6 & 57.8; 61.1, 24.6 & 46.6; 69.5, 32.8 & 54.9 and 79.4, 37.8 & 63.4 per cent higher in seed, stover and total, respectively over weedy check.

4.3.7.2 Phosphorus uptake by seed, stover and crop

Intercropping systems : No great differences were observed in phosphorus uptake by intercrops under different intercropping but soybean registered highest drain of phosphorus on mean basis. In seed uptake was observed 3.62 kg ha^{-1} stover 3.78 kg ha^{-1} and total 7.30 kg ha^{-1} (Table 4.21).

Weed control : The data Table 4.21 show that weed control practices increased the phosphorus uptake by intercrops during either years of study. The maximum uptake of phosphorus by intercrops in seed, stover as well as total was observed under metolachlor followed by hand weeding and alachlor. On mean basis the nitrogen uptake under hand weeding, pendimethalin, alachlor and metolachlor were 74.8, 39.2 and 54.5, 60.1, 28.4 and 42.2, 72.2, 35.0 and 51.1 and 82.9, 43.6 and 60.5 per cent higher in seed, stover and as well as total, respectively over weedy check.

4.3.7.3 Potassium uptake by seed, stover and crop

Intercropping systems : A reference of data in Table 4.21 reveals that maximum potassium uptake was recorded by soybean in seed, stover and total and followed by cowpea, in both the years of study. On mean basis the soybean registered 3.43 kg ha^{-1} in seed, 26.3 kg ha^{-1} in stover and 29.7 kg ha^{-1} Potassium drained by the total crop.

Weed control : The data (Table 4.21) show that weed control treatments influenced the potassium uptake by seed and stover as well as total potassium uptake during both the years of experimentation. Maximum uptake of potassium was recorded under metolachlor during both the years in seed, stover and total. The mean potassium uptake under hand weeding, pendimethalin alachlor and metolachlor were 102.0, 47.7 & 52.5; 88.4, 37.4 & 41.9; 98.2, 44.3 & 49.0 & 109.0, 50.2 & 55.4 per cent higher in seed, stover and total, respectively over weedy check.

4.4 CROP STUDIES (TOTAL OF MAIZE AND INTERCROPS)

4.4.1 Total Leaf Area Index of Maize and Intercrops

4.4.1.1 Leaf area index at 30 DAS

Intercropping systems : It is evident from data (Table 4.22) that maize + soybean and maize + cowpea stood at par with each other but proved superior over maize + blackgram. The all intercropping systems were statistically superior over sole maize. On mean basis maize + soybean, maize + cowpea, maize + greengram and maize + blackgram gave 66.1, 57.5, 48.8 and 45.7 per cent higher leaf area index, respectively as compare to sole maize.

Weed control : A perusal of data (Table 4.22) indicates that application of herbicides for weed control significantly increased leaf area index over weedy check during both the years but they were statistically at par with each other. An mean basis the maximum leaf area index was recorded under metolachlor (2.01) and followed by alachlor (1.98).

4.4.1.2 Leaf area index at 50 DAS

Intercropping systems : It is obvious from the data (Table 4.22) that all the intercropping systems increased the leaf area index significantly as compared to sole maize. Maximum leaf area index was recorded with maize + soybean and it was statistically superior over maize + blackgram and maize + greengram but at par with maize + cowpea. On mean basis the range of leaf area index was 2.85 in sole maize to 4.74 in maize + soybean intercropping system.

Weed control : A perusal of data (Table 4.22) reveals that all weed control treatments significantly increased leaf area index over weedy check. During both the years, all the weed control treatments were statistically at par with each other during first year of experimentation but in second year pendimethalin was inferior as compared to rest of the treatments. On mean basis the increase in leaf area index were enhanced by 40.3, 35.0, 38.1 and 41.9 per cent with hand weeding, pendimethalin, alachlor and metolachlor, respectively over weedy check.

4.4.1.3 Leaf area index at 70 DAS

Intercropping systems : An evaluation of data (Table 4.22) indicate that maize + soybean and maize + cowpea were at par with each other and proved superior over rest of the intercropping systems. However, maize + greengram and maize + blackgram were also superior over sole maize. On mean basis maize + soybean and maize + cowpea registered 76.3 and 68.8 per cent higher leaf area index, respectively as compare to sole maize.

Weed control : The data (Table 4.22) show that all weed control treatments were statistically superior over weedy check in respect of combined leaf area index of maize and intercrops. However, among the weed control treatments hand weeding gave the maximum LAI (5.76) and followed by metolachlor (5.69) on mean basis and lowest was recorded in weedy check (3.74).

4.4.2 Total Biological Yield of Maize and Intercrops

Intercropping systems : It is evident (Table 4.23) from the data that all intercropping treatments were statistically superior over sole maize in producing total biological yield. However, they were at par with each other. On mean basis 8 - 10.6 per cent increase were recorded in different intercropping systems as compared to sole maize.

Weed control : The data (Table 4.23) are explanatory of the fact that all weed control treatments significantly increased the total biological yield over weedy check during both the years. However, the weed control treatments varied in significance amongst each other. The mean figures indicate that hand weeding recorded highest biological yield (170.19 q ha^{-1})

4.4.3 Nutrient Uptake by Maize and Intercrops

4.4.3.1 Nitrogen uptake

Intercropping systems : During both the years maize + soybean recorded maximum nitrogen uptake which was statistically superior over rest of the systems (Table 4.23). Although all other intercropping systems were statistically superior over sole maize but they were at par with each other. On mean basis maize + soybean, maize + cowpea, maize + greengram and maize + blackgram registered 37.5, 22.1, 18.5 and 17.1 per cent increase in nitrogen uptake, respectively over sole maize.

Weed control : A perusal of data (Table 4.23) indicates that all weed control treatments increased nitrogen uptake by maize and intercrops during both the years. Although hand weeding, metolachlor and alachlor were at par with each other and statistically superior over pendimethalin in second year but in first year alachlor was inferior to hand weeding. On mean basis hand weeding, pendimethalin, alachlor and metolachlor tended to increase N uptake by 74.5, 53.6, 68.1 and 73.6 per cent, respectively.

4.4.3.2 Phosphorus uptake

Intercropping systems : The data (Table 4.23) show that all the intercropping systems recorded significantly higher phosphorus uptake over sole maize in both the years of investigation. On mean basis maximum phosphorus uptake was registered in maize + soybean (39.52 kg ha^{-1}) and followed by maize + cowpea intercropping system (39.18 kg ha^{-1}).

Weed control : All weed control treatments recorded statistically higher phosphorus uptake over weedy check during both the years. Among the weed control treatments under hand weeding recorded the maximum phosphorus uptake and it was statistically superior over pendimethalin and alachlor in first year but in second year it was at par with alachlor and metolachlor. On mean basis the weed control tended to increase phosphorus up take by 49.8 - 71.5 per cent over weedy check (Table 4.23).

4.4.3.3 Potassium uptake

Intercropping systems : Intercropping systems did not show any significant variation in potassium uptake (Table 4.23).

Weed control : The data (Table 4.23) clearly indicate that all weed control treatments increased potassium uptake over weedy check during both the years of study. However, hand weeding, alachlor and metolachlor were at par with each other and proved statistically superior over pendimethalin in both the years. On mean basis, minimum (51.3 per cent) and maximum (71.3 per cent) increase in potassium uptake were recorded in pendimethalin and hand weeding over weedy check, respectively.

4.5 MAIZE EQUIVALENT YIELD

4.5.1 Maize Equivalent Grain Yield

Intercropping systems : An evaluation of data (Table 4.24) indicates that all intercropping systems were at par with each other and proved statistically superior over sole maize. On mean basis maize + blackgram, maize + greengram, maize + cowpea and maize + soybean were gave 23.4, 27.7, 31.0 and 24.6 per cent higher maize equivalent yield, respectively as compared to sole maize.

Weed control : All the treatments applied to control weeds resulted in significant enhancement in maize equivalent yield over weedy check during both the years of experimentation (Table 4.2.4 & Fig. 4.2). It can be further noted from the figures that hand weeding, alachlor and metolachlor gave significantly higher maize equivalent yield over pendimethalin application but they remained statistically at par with each other in both the years. On mean basis weed control through hand weeding, pendimethalin, alachlor and metolachlor gave 75.5, 55.1, 67.4 and 73.1 per cent higher maize equivalent yield, respectively as compared to weedy check.

4.5.2 Maize Equivalent Stover Yield

Intercropping systems : The data (Table 4.24) explicit that maize + soybean and maize + cowpea gave significantly higher maize stover equivalent yield as compared to sole maize in both the years study but maize + blackgram gave significant differences only in second years. On mean basis maximum stover equivalent yield was recorded under maize + cowpea (108.48 q ha^{-1}) which was followed by maize + soybean (108.17 q ha^{-1}).

Weed control : All the weed control treatments increased maize stover equivalent yield over weedy check during both the years (Table 4.24). Hand weeding recorded maximum equivalent yield which was at par with alachlor and metolachlor. On mean basis hand weeding, pendimethalin, alachlor and metolachlor registered 45.7, 30.0, 41.0 and 43.1 per cent higher maize stover equivalent yield, respectively over weedy check.

4.6 NET RETURNS AND B:C RATIO

4.6.1 Net Returns

Intercropping systems : A close look into the figures of both the years of investigation reveals that maize intercropped with legume was significantly more profitable than the sole maize but they were statistically at par with each other in both the years (Table 4.24). On mean basis the maximum net returns was obtained by maize + cowpea intercropping systems (32024 Rs ha^{-1}).

Weed control : It can be observed from the figures that all the weed control treatments gave significantly greater net returns in comparison to weedy check (Table 4.24). However, further analysis of data clearly indicate that application of pendimethalin through significant over weedy check, lagged behind other treatments in terms of net returns during both the years of assessment. The highest net returns were obtained by controlling weeds by the application of metolachlor. However, it was at par with alachlor and hand weeding in both the years. On mean basis the weed control treatments enhanced net returns by 61.1 - 8.2 per cent, over weedy check.

4.6.2 B:C Ratio

Intercropping systems : Though highest B:C ratio was obtained by adopting maize + cowpea intercropping systems but it was at par with other systems during first year and significantly superior over sole maize during second year. (Table 4.24).

Weed control : An appraisal of data (Table 4.24) indicates that in comparison to weedy check, weed control treatments was associated with significantly higher B:C ratio. Though variability exist between treatments in both the years statistical inferiority of pendimethalin over rest of the treatments was observed during both the years study. Maximum B:C ratio (2.54 and 3.07) was obtained by metolachlor in two respective years.

5. DISCUSSION

In the preceding chapter, while presenting the results of field experiment entitled "Effect of Weed Control on the Productivity of Maize Intercropped with Legumes", significant variations in number of weed and crop characters were recorded on account of different treatments. Under most of the characters, clear and uniform trends of effects emerged out.

In the present chapter it is contemplated to discuss these significant variations in weed and crop characters which arose due to treatment effects. While doing so, reference to the findings of previous workers of similar fields has also been made to justify, support and substantiate the present findings.

5.1 EFFECT OF WEED CONTROL

5.1.1 Weeds

All the weed control treatments in question reduced the number of both the categories of weed viz. monocot and dicot at 30 DAS except hand weeding in comparison to weedy check. In case of hand weeding treatment, the weeding was done 30 DAS after taking the observation. Pre-emergence herbicides on the other hand kept the weed seed germination under check during this time because of their soil activity. Similar results with maize and associated legumes have been reported by Thakur (1994), Yaduraju *et al.* (1986).

Studies on total weed dry matter 30 DAS revealed that all other treatments were significantly superior to weedy check. Amongst herbicides, metolachlor performed the best. Metolachlor is a chloracetamide herbicide and found to inhibit seed germination and early seedling growth. The substituted acetamide inhibit radicle growth and at cellular level it affects root growth by inhibiting protein synthesis (Rao, 2000 and Gupta, 1984). Deal *et al.* (1980) also observed that metolachlor inhibit protein synthesis without showing any effect on the rates of polypeptide elongation on the synthesis of specific polypeptide. Wilkinson (1982) found that metolachlor backs conversion of gernalgernyl pyrophosphate (G.R.P.) to ent-Kaurense during the process of inhibition of gibberlin synthesis - chloraacetamides is the only herbicide group for which there is documentation of a profound effect on phenolic metabolism. Reports described drastically reduced lignification in metolachlor treated plants (Hickey and Krueger, 1974; Ebert, 1980 and Molin *et al.*, 1986). On the basis of evidences presented here it may be said that inhibition in protein synthesis is the primary mechanism of metolachlor action in susceptible species. The effects of metolachlor on weeds in present investigation could thus be the inhibitory effect of chloracetamide on protein synthesis of weeds and thereby reducing the number and growth of weeds. Similar were the findings of Shaban *et al.* (1991), Jat (1996) in maize + soybean intercropping system. Though alachlor is also a chloroacetamide and is expected to behave much in the fashion of metolachlor. It inhibits the seed germination of inhibiting GA_3 induced alpha-amylase and protease production in susceptible species during germination (Rao, 2000). It has been suggested that this herbicide acts as repressor of gene action preventing the normal expression of the hormonal effect of GA through the synthesis of DNA dependent RNA. Rao and Duke (1976) have suggested that the effect of acetamides on alpha - amylase and protease are secondary and these herbicides possibly act on biosynthesis reaction required for the synthesis of these hydrolytic enzymes. Rao and Duke (1974) conclude that Chain initiation process was the primary target of these herbicides during protein synthesis, whereas, Deol *et al.* (1980) reported that alachlor inhibit protein synthesis in vivo but not the polypeptide elongation process. Efficacy of alachlor and metolachlor in present study are in cognizance of few previous studies (Thakur, 1994 and Prasad and Rafey, 1996). Pendimethalin is known to be absorbed by germinating weeds and inhibits cell division in the meristematic tissues so that most of the weeds die within a few days of their emergence (Eshel *et al.*, 1979). Pendimethalin has also a role to play in microtubal disruption and stops mitosis because it blacks synthesis of protein nucleic acid or any other requisites for mitosis (Devine *et al.*, 1993). This can be reasoned for reduced weeds dry matter accumulation under the effect of pendimethalin. The results of pendimethalin in this investigation are in close agreement with the obtained by Verma and Dutta (1984), Sharma *et al.* (1992), Madhu and Nanjappa (1993) and Porwal (1993). By the time of crop reached 60 days stage, effect of hand weeding was more pronounced in term of weed count and growth in comparison to all the herbicides. The results are quite self explanatory in light of the fact that weeding in this treatment was done at 30 days stage, whereas, herbicides might have started dissipating from the soil. Difference in weed dry matter 60 DAS amongst herbicidal treatments can be attributed to their persistence in soil.

At harvest, least biomass was harvested from the plot where hand weeding was performed but weed count in the metolachlor treated plots. Since, weeding was performed at 30 DAS, the results are under the range of expectations. Rest of the treatments continued their order of merit as of 60 days stage. The results are in close conformity with the findings of Jat (1996) with maize + soybean intercropping system.

The data in Table 4.8 reveal that N, P and K uptake pattern by weeds almost followed the footsteps of weed biomass in trend. The lowest N, P and K drain was recorded by metolachlor but it was very close to hand weeding. Amongst herbicides the next best performance was of alachlor and pendimethalin. Nutrient uptake is the product of per cent nutrient content and biomass, thus similarly in the trend of uptake and total weed biomass, production is a very much expected outcome. It can further be substantiated by strong positive correlation coefficient values between N, P and K uptake and weed biomass. Reduced nutrient uptake by weeds under the influence of different weed control measures in maize, kharif legumes and their intercropping systems have also been reported by Thakur *et al.* (1990), Velu (1995) and Tewari *et al.* (1990).

5.2 EFFECT OF WEED CONTROL ON CROP

5.2.1 Growth parameters

All the weed control measures increased the periodical dry matter production of crop at various growth stages (Table 4.11 & 4.18). The increase in dry matter yield of maize and associated legumes with these treatments was due to significant reduction in dry matter yield of weeds. Consequently it resulted in better plant growth. Greater dry matter accumulation by maize and intercrop legumes under weeded crop seems to be a direct effect of greater penetration of solar radiation in the crop canopy which can be reasoned for greater rate of photosynthesis and more accumulation of dry matter (Duncan, 1971). In a potential situation where light, temperature and physiological and morphological characters determine the growth of plants, they compete only for light (Kropff, 1993). Gupta (1992) has also concluded that for getting maximum yield, leaf area of crop should expand to reach its maximum as early as possible, which can be done by restoring early weed control. Van Acker *et al.* (1993) while experimenting with soybean also emphasized the role of initial capture of space and establishment of maximum leaf area index. The fact can further be explained in terms of significant negative correlation between weed dry matter and maize crop dry matter at harvest (r = -0.815). Similarly, negative correlation at harvest existed between weed dry matter and intercrop dry matter (r = -0.430). The results are in close cognizance with the findings of Maurya *et al.* (1990) and Jat (1996).

A greater variation in leaf area index of maize and intercrops were observed with different weed control treatments (Table 4.10 & 4.17). Leaf area index seems to be the function of reduction in weed spread due to these treatments. This could have provided more space for the plants to extend the foliage and branches, thereby providing for more leaves per unit area of land. Similar sort of findings have been reported by Singh (1993).

5.2.2 Yield Attributes and Yield

By controlling weeds with the use of different measures, significantly higher seed, stover and biological yields were recorded (Table 4.12 &). Hand weeding, metolachlor and alachlor treatments were found superior in this regard. Maize plants in weedy check could not bear adequate number of cobs plant^{-1} and grain yield cob^{-1} under stress afford by heavy weed infestation. Test weight was also significantly reduced by this stress which is generally considered as stable character, thus weeds suppressed the vegetative growth as well as reproductive phase of the crop. A strong negative correlation between crop yield and weed dry matter substantiate the fact (Table 5.1). The increased seed and stover yields and thereby biological yield were obviously the results of better weed control which rendered favourable conditions like increased availability of nutrients, moisture, light and other factors to the crop plants, which resulted in better growth and higher dry matter production of plants. Enhanced values of yield attributing characters were the outcome of these effects. Correlation coefficient between grain yield and number of cobs plant^{-1}, grain yield cob^{-1} and thousand grain weight (r = 0.903, 964 and 0.908, respectively) validate profound effects of these parameters on yield. Hand weeding gave higher maize yields over herbicidal treatments which can be attributed to removal of weeds at 30 days stage which is considered an important stage in view of critical crop weed competition period (Varshney, 1991). The highest intercrop yields were obtained with the use of metolachlor. Kharif legumes are short season crops in comparison to maize hence pre-emergence herbicides like metolachlor did not allow the weeds to grow even in the initial thirty day, by the time of which the legumes could extend their foliage. Since hand weeding was performed at 30 DAS, the results of pre-emergence herbicides like metolachlor could be expected to have better influence on leave intercrops. The increase in intercrop yields could also be ascribed to greater availability of nutrient, moisture, light etc. to them due to weed suppression. The results of enhanced yield of maize and intercrops in the present investigation are in close agreement of the results obtained by Thakur (1994), Porwal (1993) and Prasad and Rafey (1996).

5.2.3 Nutrient Uptake

Weed control measures tended to improves the uptake of nitrogen, phosphorus and potassium by seeds, stover significantly, compared to weedy crop (Table 4.15 & 4.21). Nutrient uptake by any crop is primarily a function of yield and nutrient concentration. In the present study positive correlation was documented between seed and stover yield and N, P and K uptake of maize based intercropping systems by various weed control methods. Vishnoi (1988) and Jat (1996) and also reported similar results of nutrient uptake in previous studies.

5.3 EFFECT OF INTERCROPPING SYSTEMS ON WEED CONTROL

Studies on total weed count and biomass 60 DAS and at harvest (Table 4.8) revealed that maize + cowpea and maize + soybean were significantly superior to sole maize and rest of the intercrops. The minimum weed population and biomass were recorded under maize + soybean and followed by maize + cowpea systems. The weed growth in maize was controlled effectively by developing a canopy sufficient for weed suppression in intercropped maize with soybean and cowpea. Similar effect due to intercropping was also reported by Bhuvaneshwari *et al.* (2002).

The data in Table 4.8 reveals that nitrogen, phosphorus and potassium uptake pattern by weeds almost followed the footsteps of weed biomass in trend because uptake is the function of nutrient concentration and biomass. The lowest N, P and K drain was recorded by maize + soybean intercropping system which was at par with maize + cowpea. Similar findings were also reported by Solaimalai and Muthusankarnarayanan (2000).

5.4 EFFECT OF INTERCROPPING SYSTEMS ON CROP

5.4.1 Growth Parameters

The data (Table 4.9 to 4.11 and 4.16 to 4.18) explicitly show that legume intercrops did not influence the plant growth characters of maize significantly viz., plant height, dry matter accumulation and leaf area index. Such results were also observed in respect of plant height by Wanki and Fuwuri (1982) and Faris *et al.* (1983), dry matter per plant by Walwa *et al.* (1981) and leaf area index by Edje (1986). Non-significant effect of legume intercrops on maize might be due to the fact that they grew to mutual benefit of each other. Thus, different legumes as intercrop with maize did not exert any depressing effect on growth and development of maize. Such benefits of maize + legume intercropping might be ascribed to the efficient photosynthesis with greater amount of CO_2 made available through the photorespiring legumes (soybean, blackgram, greengram and cowpea), maize being a tropical grass plant with C_4 photosynthetic pathway, is not susceptible to photorespiration, as a matter of fact needs more CO_2, where light is not a limiting factor (Zeilitch, 1971). Partly the beneficial effect of maize + legume intercropping might be due to some extent of symbiotic nitrogen fixation by legumes, which might have synergistic effect on growth of maize due to diffusion of nitrogen from legume roots (Dusad and Morey, 1979).

5.4.2 Yield Attributes and Yield

Like the plant growth characters, legume intercrops did not significantly influenced the yield attributes and yield of maize, although there was a slight reduction in grain yield of maize intercropped with legumes as compared to sole maize (Table 4.12). Further, the grain yield, stover yield and harvest index of maize which did not differ significantly between different intercropping systems suggest convincingly that legumes did not work to the disadvantage of maize in any way under intercropping of maize with either soybean, cowpea, blackgram or greengram. These results are in close conformity with those of Patra *et al.* (1999) and Singh (2000).

As mentioned earlier, non-significant effect of legume intercrops on yield and yield attributes of maize might be due to the fact that maize and legumes grew well for mutual benefit of each other. Such effects of intercropping seem to have resulted because of negligible plant competition for growth factors, presumably at later part of life cycle. This is evidenced by the fact that in intercropping system the legume intercrops by utilizing wider space create favourable environment and give more growth by way of alleviating severe crop competition. This might also be on account of the fact that legumes flower and mature earlier than the maize thereby leaving little or no scope of competition for light and nutrients (Remison, 1978) at the cost of maize crop.

5.4.3 Nutrient Uptake

An examination of data (Table 4.15) reveals that legume intercrops did not cause any significant difference in nitrogen, phosphorus and potassium uptake by maize crop. This might be due to the fact that maize being shallow rooted crop, absorbs comparatively more nutrients from top soil whereas, legumes like blackgram, greengram, cowpea and soybean, being deep rooted crops, absorb comparatively more nutrients from sub-soil in similar fashion. Thus, their might have been practically no competition for nutrients between maize and different legume intercrops. Regarding nitrogen, there might have been no competition at all the latter stages of growth as legume obtained nitrogen from symbiotic fixation of atmospheric nitrogen. These findings were also in close conformity with Shivay *et al.* (1999).

5.5 EFFECT OF INTERCROPPING SYSTEMS ON MAIZE EQUIVALENT YIELD

Results showed that among the intercropping systems maize equivalent yield did not differ significantly but all intercropping systems tried in the present study were statistically superior over sole maize (Table 4.24). It is obviously resulted because of additional yield of legumes as a bonus by utilizing their inter-row spaces of main crop. It thus becomes convincing that incident solar radiation on base interspace of solitary maize could be profitably utilized by furnishing a crop cover of legumes, which than resulted in an increased accumulation of photosynthates per unit area and hence increased total grain production.

Thus, analyzing the whole spectrum of maize intercrop association, it appears that with less competition and increased photosynthetic activity along with the benefits of symbiotically fixed nitrogen maize in intercropping system could make as advantage of favourable environmental factors and hence maize equivalent yield was increased. Several others workers have also reported such findings Sharma *et al.* (1998), Patra *et al.* (1999) and Rana *et al.* (2001).

5.6 INTERACTION EFFECT OF

The data on interactive effect of intercropping systems and weed control reveal profound influence of these factors on density and dry matter of weeds at 60 DAS and at harvest. The NPK uptake by weeds was also affected significantly by their interactive effect.

Intercropping itself is a weed control measure as the subsidiary crop (legume in this case) covers the wide inter row spaces quickly and do not allow the weeds to utilize the resources particularly the solar radiation (Altieri and Liebman, 1986). However, intercropping alone is not sufficient to overpower weeds during *kharif* season because rains provide a congenial environment for weeds. Under such circumstance weed control needs a special attention when two methods of weed control viz. intercropping and hand weeding or herbicides work in tandem some kinds of interaction is an expected outcome. In the present investigation all herbicides in question and hand weeding alone with cowpea or soybean as intercrops were found better combinations than with other intercrops in suppressing the weeds.

6. SUMMARY

The results of the field experiment entitled "Effect of Weed Control on the Productivity of Maize Intercropped with Legumes" conducted during *Kharif*, 2001 and 2002, presented and discussed in the preceding chapters are summarised below:

6.1 EFFECT OF INTERCROPPING SYSTEMS

6.1.1 On Weeds

* Maize + soybean and maize + cowpea recorded significantly lower monocot, dicot and total weed density and dry matter over rest of the intercropping systems and sole maize at 60 DAS and at harvest.

* Maize + soybean and maize + cowpea recorded significantly lower total N, P and K depletion by weeds compared to sole maize.

6.1.2 Effect on Maize

* Intercropping system did not exhibit any depressing effect in respect of growth parameter, yield altributes, yield and nutrient uptake of the main crop (maize) as compared to sole maize.

6.1.3 Effect on Crop (Maize and Intercrops)

* All the intercropping systems had significantly higher leaf area index as compared to sole maize at all growth stages in both the years. On mean basis maximum LAI were recorded in maize + soybean intercropping system at all growth stages.

* The highest biological yield was obtained in maize + soybean intercropping system.

* The N and P uptake by both crops were significantly higher over sole maize in both the years but all the intercropping systems were at par with each other. On mean basis the maximum uptake was recorded in maize + soybean (N 188.06 and P 39.52 kg ha^{-1}).

6.1.4 Effect on Maize Equivalent Yield, and Net Returns

* All the intercropping systems were significantly superior over sole maize in terms of maize equivalent grain yield but they remained at par with each other in both the

years. On mean basis maximum maize equivalent grains yield was recorded with maize + cowpea (55.89 q ha^{-1}) intercropping system.

* Significantly higher net returns were obtained maize intercropping with legumes as compared to sole maize. On mean basis the maximum net returns was obtained by maize + cowpea (32024 Rs ha^{-1}). The maximum value of B:C ratio was also obtained with maize + cowpea intercropping system (3.0).

6.2 EFFECT OF WEED CONTROL

6.2.1 Effect on Weeds

* In weedy cheek plots, maize and intercrops were infested heavily with mixed flora weeds, chiefly *Echinochloa crusgali* (L.) Beauv, *Echinochloa colonum* (L.) Link *Portulaca oleraceac* L., *Commelina benghalensis* L., *Convolvulus arvensis* L., *Cynodon daetylon* (L.) Pers., *Cyperus esculentus* L. and *Digera arvensis* L., etc. The annual monocot weed dominated the weed flora through out the crop growth season.

* Hand weeding, metolachlor and alachlor provided significantly lower monocot and total weed density and dry matter compared to weedy cheek and pendimethalin at all stages except 30 days. But in case of dicot weeds all weed control treatments were at par with each other and significantly superior over weedy cheek. Significant decrease in total N, P and K depletion by weeds were recorded with all weed control treatments over weedy cheek. The minimum N, P and K depletion were obtained with hand weeding which was statistically at par with alachlor and metolachlor.

6.2.2 Effect on Crop (Maize)

* All weed control treatments had no significant influence on plant population but plant height was significantly increased by all these treatments as compared to weedy cheek during both the years.

* Weed control treatments were found statistically superior in improving leaf area index over weedy cheek during both the years. On mean basis maximum LAI at 60 DAS and at harvest were registered by controlling weeds with hand weeding but at 30 DAS metolachlor was the best.

* Dry matter production by crop plants increased significantly by applying all weed control treatments over weedy cheek at all crop growth stages during both the years.

Hand weeding, alachlor and metolachlor were statistically superior over pendimethalin at 60 DAS and at harvest.

* All the yield attributing characters increased significantly by different weed control practices over weedy cheek. Hand weeding, alachlor and metolachlor were significantly superior over pendimethalin in number of cobs plant^{-1} and grain yield cob^{-1}. All weed control treatments were at par in case of 1000 grain weight.

* During both the years grain yield increased significantly by all weed control treatments. Maximum grain yield was registered in hand weeding which was at par with alachlor and metolachlor but pendimethalin was inferior to them. On mean basis, hand weeding and metolachlor increased grain yield by 72.9 and 71.9 per cent over weedy cheek.

* The stover and biological yields also increased significantly by different weed control measures. Amongst different treatments, hand weeding gave the best results but it was at par with alachlor and metolachlor during both the years.

* All weed control treatments significantly influenced the harvest index but among the treatments the differences were non significant during both the years.

* The result indicate that all weed control treatments significantly increased N, P and K uptake by crop over weedy cheek. On mean basis maximum uptake was registered under hand weeding followed by metolachlor.

6.2.3 Effect of Crops (Inter Crops)

* Mean population of intercrops was not affected by weed control treatments but the highest plant height was recorded in weedy check plots.

* Leaf area index of intercrops increased at all stages with the use of weed control treatments. On mean basis the maximum LAI was registered in metolachlor treated plots at 30, 50 and 70 days, respectively.

* Highest dry matter accumulation by intercrops was recorded with metolachlor at all growth stages followed by hand weeding at 50, 70 days and at harvest.

* Highest seed, stover and biological yields were recorded under metolachlor treated plots in both the years. On mean basis hand weeding, pendimethalin, alachlor and

metolachlor increased in seed yield by 68.3, 58.2, 16.4 and 75.6 per cent and stover yield by 29.5, 21.4, 27.1 and 32.3 per cent, respectively over weedy check.

* There was no significant difference in harvest index among the different weed control treatments.

* All the weed control treatments increased the N, P and K uptake by the intercrops. On mean basis maximum nitrogen (40.63 kg ha^{-1}), phosphorus (6.45 kg ha^{-1}) and Potassium (26.35 kg ha^{-1}) was recorded under the metolachlor treated plots.

6.2.4 Effect on Crop (Maize and Intercrops)

* Total leaf area index of both the crops increased significantly by all weed control treatments in both the years.

* All the weed control treatments increased biological yields of maize and intercrops significantly. Amongst different treatments hand weeding, metolachlor and alachlor were at par with each other and significantly superior over pendimethalin in both the years.

* The result indicate that weed control treatments significantly increased N, P and K uptake by both the crops. On mean basis maximum total nitrogen (184.63 kg ha^{-1}), Phosphorus (43.25 kg ha^{-1}) and Potassium (209.66 kg ha^{-1}) were recorded under hand weeding.

6.2.5 Effect on Maize Equivalent Yield and Net Returns

* All the weed control treatments significantly increased the maize equivalent grain yield. Among the treatments, hand weeding, metolachlor and alachlor were at par with each other. On mean basis maximum equivalent grain yield was recorded under metolachlor (61.32 9ha^{-1}).

* Net returns and B: C ratio significantly increased with all weed control treatments over weedy cheek during both the years of study. On mean basis metolachlor recorded maximum net return and B:C ratio (Rs 34063 and 3.24) which showed increase of 88.2 and 68.7 per cent over weedy check (Rs 18097 and 1.92, respectively).

CONCLUSION

Results of two year experimentation entitled "Effect of Weed Control on the Productivity of Maize Intercropped with Legumes" conducted during *kharif* 2001 and 2002 clearly establish that significantly higher maize equivalent, net returns and B:C ratio were obtained by intercropping maize with cowpea, greengram, blackgram and soybean. Though numerically maize + cowpea recorded better economics than other systems, however, all these systems were at par. A comparison of various weed control measures indicated that hand weeding and all herbicides gave significantly superior results and economics over weed check but weed control with metolachlor, alachlor and hand weeding in terms of maize equivalent yield, net returns and B:C ratio were significantly superior over weedy check and pendimethalin. Therefore, it is concluded that maize should be intercropped with *kharif* legumes viz cowpea, greengram, soybean or blackgram and weed control should be restored by either pre-emergence application of metolachlor 1.0 or alachlor 2.0 kg ha^{-1} or hand weeding at 30 DAS as per the availability of resources and prevailing conditions. However, based on overall economics of treatments (Appendix XXI), it can be infered that maize + cowpea with weed control through pre-emergence application of metolachlor is the most beneficial practice for the farmers.

Effect of Weed Control on the Productivity of Maize Intercropped with Legumes

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ABSTRACT

A field experiment entitled "Effect of Weed Control on the Productivity of Maize Intercropped with Legumes" was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur during *Kharif* 2001 and 2002. The experiment consisted of 25 treatment combinations comparising of five intercropping treatments (sole maize, maize + blackgram, maize + greengram, maize + cowpea and maize + soybean) and five weed control treatments (weedy cheek, hand weeding 30 DAS, pendimethalin 1 kg ha^{-1}, alachlor 2 kg ha^{-1} and metolachlor 1 kg ha^{-1}). The experiment was conducted in split plot design with intercropping systems in main plot and weed control in subplots and it was replicated four times.

All the weed control treatments reduced density, dry matter and nutrient deplition by weeds at all stages. Hand weeding, alachlor and metolachlor were significantly superior in weed density, dry matter and nutrient deplatien by monocat and total weeds at 60 DAS and at harvest over pendimethalin but these were at par in dicot weeds. The lowest dry matter was recorded matter hand weeding and followed by metolachor at 60 days and at harvest.

All the weed control treatments significantly increased plant height, LAI, dry matter accumulation, yield attributes and yield of maize over weedy cheek during both the years. Among different weed control treatments hand weeding gave the highest value of these parameter except harvest index which was

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statistically at par with alachlor and metolachor. On mean basin hand weeding and metolachor gave 72.9 and 71.9 per cent higher grain yield of maize over weedy cheek. The N P and K content and uptake were also significantly increased by different weed control treatments.

Dry matter accumulation by intercrops was highest in metolachlor followed by hand weeding at 60 days and at harvest. Metolachlor also gave the greatest leaf area index, yield and nutrient uptake by intercrops. On mean basis 75.6 per cent higher seed yield was obtained with metolachlor as compared to weedy cheek.

Total Leaf area index, biological yield an N, P and K uptake of maize and intercrops were also significantly increased by different weed control treatments.

Maize + soybean and maize + cowpea intercropping system significantly reduced the weed density and dry matter at 60 days and at harvest. The N, P and K depletion by weeds in both the years. Whereas intercropping systems did not exert significant effect on maize growth and yield but total leaf area index, biological yield and nutrient uptake by maize and intercrops increased significantly by intercropping of different legumes with maize.

All the intercropping systems and weed control treatments significantly increased maize equivalent yield, net returns and B: C ratio. Highest maize equivalent yield, net returns and B:C ratio were obtained with maize + cowpea intercropping system but the results were at par with other intercropping systems. Amongst weed control treatments, highest values of these parameters were obtained by metolachlor, however, alachlor and hand weeding were at par with it.

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Table 4.1 Effect of intercropping systems and weed control on weed density* (No. m^{-2}) 30 DAS

Treatments	Monocot			Dicot			Total		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems									
Sole maize	9.66 (92.89)	8.77 (76.51)	9.21 (84.70)	3.29 (10.37)	2.79 (7.29)	3.04 (8.83)	10.19 (103.40)	9.18 (83.87)	9.68 (93.63)
Maize+blackgram	9.57 (91.07)	8.76 (76.31)	9.16 (83.69)	3.21 (9.80)	2.70 (6.83)	2.95 (8.31)	10.07 (101.06)	9.15 (83.27)	9.61 (92.16)
Maize+greengram	9.35 (87.06)	8.49 (71.66)	8.92 (79.36)	3.26 (10.17)	2.72 (6.94)	2.99 (8.55)	9.90 (97.67)	8.90 (78.82)	9.40 (88.24)
Maize+cowpea	9.30 (85.99)	8.33 (68.96)	8.81 (77.47)	3.21 (9.85)	2.71 (6.86)	2.96 (8.35)	9.83 (96.16)	8.75 (76.07)	9.29 (86.11)
Maize+soybean	9.14 (83.14)	8.25 (67.70)	8.69 (75.42)	3.14 (9.37)	2.63 (6.44)	2.88 (7.90)	9.66 (92.86)	8.65 (74.35)	9.15 (83.60)
S.Em. ±	0.23	0.22	-	0.09	0.07	-	0.23	0.22	-
C.D. (P = 0.05)	NS	NS	-	NS	NS	-	NS	NS	-
Weed Control									
Weedy check	12.85 (164.84)	11.61 (134.43)	12.22 (149.63)	4.22 (17.31)	3.65 (12.83)	3.93 (15.07)	13.52 (182.33)	12.16 (147.36)	12.84 (164.84)
H.W. 30 DAS**	12.79 (163.12)	11.34 (128.12)	12.06 (145.62)	4.15 (16.77)	3.60 (12.50)	3.87 (14.63)	13.43 (180.08)	11.88 (140.78)	12.65 (160.43)
Pendimethalin 1 kg ha^{-1}	8.32 (68.73)	7.95 (62.73)	8.13 (65.73)	2.57 (6.15)	2.09 (3.87)	2.33 (5.01)	8.69 (75.02)	8.20 (66.74)	8.44 (70.88)
Alachlor 2 kg ha^{-1}	66.67 (44.07)	6.03 (35.88)	6.35 (39.97)	2.65 (6.52)	2.18 (4.26)	2.41 (5.39)	7.16 (50.88)	6.38 (40.25)	6.77 (45.65)
Metolachlor 1 kg ha^{-1}	6.39 (40.32)	5.68 (31.84)	6.03 (36.08)	2.53 (5.90)	2.04 (3.69)	2.28 (4.79)	6.85 (46.50)	6.01 (35.70)	6.43 (41.10)
S.Em. ±	0.21	0.18	-	0.09	0.07	-	0.20	0.18	-
C.D. (P = 0.05)	0.59	0.53	-	0.26	0.21	-	0.56	0.51	-

* Values are
sqrt {x~+~0.5} transformed and actual values are in parentheses. ** H W done after taking observation.

Table 4.2 Effect of intercropping systems and weed control on weed density* (No. m^{-2}) 60 DAS

Treatments	Monocot			Dicot			Total		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems									
Sole maize	11.01 (120.91)	11.12 (123.244)	11.06 (222.07)	4.31 (18.11)	14.48 (19.59)	4.39 (18.85)	11.83 (139.45)	11.99 (143.46)	11.91 (141.45)
Maize+blackgram	10.44 (108.50)	10.52 (110.26)	10.48 (109.38)	4.04 (15.88)	14.27 (17.80)	4.15 (16.84)	11.20 (125.01)	11.37 (128.89)	11.28 (126.95)
Maize+greengram	10.37 (107.08)	10.45 (108.77)	10.41 (107.92)	4.00 (15.53)	14.21 (17.28)	4.10 (16.40)	11.12 (123.24)	11.28 (126.74)	11.20 (124.99)
Maize+cowpea	8.02 (63.89)	7.98 (63.27)	8.00 (63.58)	3.51 (11.85)	3.70 (13.22)	3.60 (12.53)	8.76 (76.32)	8.81 (77.25)	8.78 (76.78)
Maize+soybean	7.82 (60.79)	7.77 (59.93)	7.79 (60.36)	3.21 (9.83)	3.45 (11.40)	3.33 (10.61)	8.45 (71.01)	8.51 (71.93)	8.48 (71.47)
S.Em. ±	0.23	0.24	-	0.08	0.09	-	0.20	0.24	-
C.D. (P = 0.05)	0.71	0.75	-	0.25	0.30	-	0.64	0.74	-
Weed control									
Weedy check	16.99 (288.36)	17.35 (300.73)	17.17 (294.54)	5.62 (31.16)	5.85 (33.82)	5.73 (32.49)	17.89 (319.63)	18.30 (334.73)	18.09 (327.18)
H.W. 30 DAS	6.68 (44.15)	7.00 (48.49)	6.84 (46.32)	3.28 (10.27)	3.38 (10.96)	3.33 (10.61)	7.42 (54.60)	7.75 (59.64)	7.58 (57.12)
Pendimethalin 1 kg ha^{-1}	9.58 (91.33)	9.38 (87.57)	9.48 (89.45)	3.41 (11.17)	3.50 (11.81)	3.45 (11.49)	10.15 (102.67)	10.00 (99.53)	10.07 (101.10)
Alachlor 2 kg ha^{-1}	7.26 (52.29)	7.23 (51.78)	7.24 (52.03)	3.46 (11.47)	3.97 (15.30)	3.71 (13.38)	8.62 (63.97)	8.24 (67.47)	8.13 (65.72)
Metolachlor 1 kg ha^{-1}	7.15 (50.74)	6.89 (46.97)	7.02 (48.85)	3.30 (10.44)	3.40 (11.08)	3.35 (10.76)	7.87 (61.54)	4.67 (58.35)	7.77 (59.94)
S.Em. ±	0.21	0.22	-	0.07	0.07	-	0.20	0.21	-
C.D. (P = 0.05)	0.61	0.64	-	0.21	0.21	-	0.58	0.611	-

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

Table 4.3 Effect of intercropping systems and weed control on weed density* (No. m^{-2}) at harvest

Treatments	Monocot			Dicot			Total		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems									
Sole maize	11.30 (127.30)	11.78 (138.43)	11.54 (132.89)	5.55 (30.34)	5.94 (34.80)	5.74 (32.57)	12.61 (158.56)	13.21 (174.14)	12.91 (166.35)
Maize+blackgram	10.95 (119.51)	11.20 (125.04)	11.07 (122.27)	5.44 (39.16)	5.66 (31.53)	5.55 (35.34)	12.26 (149.99)	12.59 (158.11)	12.42 (154.05)
Maize+greengram	10.90 (118.33)	11.18 (124.66)	11.04 (121.49)	5.36 (28.23)	5.56 (30.42)	5.46 (29.32)	12.17 (147.64)	12.53 (156.49)	12.35 (152.06)
Maize+cowpea	8.52 (72.15)	8.97 (80.10)	8.74 (76.12)	4.56 (20.36)	4.79 (22.48)	4.67 (21.42)	9.68 (93.25)	10.20 (103.65)	9.94 (98.45)
Maize+soybean	8.31 (68.60)	8.76 (76.27)	8.53 (72.43)	4.36 (18.58)	4.61 (20.77)	4.48 (19.67)	9.40 (87.90)	9.92 (98.03)	9.66 (92.96)
S.Em. ±	0.22	0.25	-	0.15	0.12	-	0.22	0.23	-
C.D. (P = 0.05)	0.69	0.80	-	0.47	0.39	-	0.68	0.71	-
Weed control									
Weedy check	17.20 (294.43)	17.89 (319.73)	17.54 (307.08)	6.79 (45.69)	7.14 (50.50)	6.96 (48.09)	18.48 (341.25)	19.26 (370.53)	18.87 (355.89)
H.W. 30 DAS	7.80 (60.46)	8.04 (64.19)	7.92 (62.32)	4.60 (20.66)	4.88 (23.34)	4.74 (22.00)	9.05 (81.46)	9.41 (88.11)	9.23 (84.78)
Pendimethalin 1 kg ha^{-1}	9.80 (95.71)	9.98 (99.26)	9.89 (97.48)	4.63 (21.00)	4.82 (22.74)	4.72 (21.87)	10.84 (117.09)	11.08 (122.43)	10.96 (119.76)
Alachlor 2 kg ha^{-1}	7.64 (57.92)	7.87 (61.56)	7.75 (59.74)	4.65 (21.15)	4.98 (24.37)	4.81 (22.76)	8.93 (79.30)	9.31 (86.32)	9.12 (82.81)
Metolachlor 1 kg ha^{-1}	7.53 (56.25)	8.11 (65.38)	7.82 (60.81)	4.61 (20.75)	4.73 (21.92)	4.67 (21.33)	8.81 (77.27)	9.39 (87.68)	9.10 (82.47)
S.Em. ±	0.19	0.22	-	0.08	0.11	-	0.17	0.20	-

C.D. (P = 0.05)	0.55	0.63	-	0.24	0.32	-	0.50	0.56	-

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

Table 4.4 Effect of intercropping systems and weed control on weed drymatter (gm^{-2}) at 30 DAS

Treatments	Monocot			Dicot			Total		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems									
Sole maize	30.65	25.97	28.31	3.45	2.92	3.18	34.10	28.89	31.49
Maize+blackgram	30.03	24.68	27.35	3.26	2.86	3.06	33.29	27.54	30.41
Maize+greengram	28.86	24.77	26.81	3.27	2.74	3.00	32.14	27.52	29.83
Maize+cowpea	28.88	24.72	26.80	3.27	2.73	3.00	32.15	27.45	29.80
Maize+soybean	28.51	24.22	26.36	3.21	2.69	2.95	31.72	26.92	29.32
S.Em. ±	0.84	0.68	-	6.10	0.08	-	0.88	0.71	-
C.D. (P = 0.05)	NS	NS	-	NS	NS	-	NS	NS	-
Weed control									
Weedy check	50.00	45.57	47.78	5.31	4.24	4.77	55.31	49.81	52.56
H.W. 30 DAS*	49.53	45.19	47.36	5.27	4.17	4.72	54.80	49.36	52.08
Pendimethalin 1 kg ha^{-1}	21.11	13.63	17.37	1.93	1.80	1.86	23.04	15.43	19.23
Alachlor 2 kg ha^{-1}	13.69	10.16	11.92	2.07	1.97	2.02	15.76	12.13	13.94
Metolachlor 1 kg ha^{-1}	12.61	9.83	11.22	1.88	1.76	1.82	14.49	11.59	13.04
S.Em. ±	0.78	0.65	-	0.09	0.08	-	0.77	0.64	-
C.D. (P = 0.05)	2.20	1.86	-	0.26	0.23	-	2.17	1.83	-

* H. W. done after taking observation.

Table 4.5 Effect of intercropping systems and weed control on weed drymatter (gm^{-2}) at 60 DAS

Treatments	Monocot			Dicot			Total		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems									
Sole maize	37.64	38.66	38.15	4.96	7.50	6.23	42.60	46.16	44.38
Maize+blackgram	36.30	37.86	37.08	4.89	7.31	6.10	41.19	45.17	43.18
Maize+greengram	35.96	37.38	36.67	4.77	7.09	5.93	40.73	44.47	42.60
Maize+cowpea	22.76	36.44	29.60	3.57	6.40	4.98	26.33	42.84	34.58
Maize+soybean	21.72	35.36	28.54	3.20	6.10	4.65	24.92	41.46	33.19
S.Em. ±	0.89	0.97	-	0.13	0.16	-	0.92	1.08	-
C.D. (P = 0.05)	2.76	2.98	-	0.43	0.51	-	2.86	3.33	-
Weed control									
Weedy check	86.72	105.84	96.28	7.75	11.13	9.44	94.47	116.97	105.72
H.W. 30 DAS	13.00	17.18	15.09	3.28	5.72	4.50	16.29	22.91	19.60
Pendimethalin 1 kg ha^{-1}	26.32	27.55	26.93	3.47	5.78	4.62	29.79	33.33	31.56
Alachlor 2 kg ha^{-1}	14.35	17.75	16.05	3.54	6.01	4.77	17.89	23.77	20.83
Metolachlor 1 kg ha^{-1}	13.98	17.37	15.67	3.36	5.76	4.56	17.34	23.13	20.23
S.Em. ±	0.60	0.86	-	0.11	0.12	-	0.62	0.95	-
C.D. (P = 0.05)	1.71	2.44	-	0.33	0.36	-	1.76	2.70	-

Table 4.6 Effect of intercropping systems and weed control on weed drymatter (gm^{-2}) at harvest

Treatments	Monocot			Dicot			Total		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems									
Sole maize	46.43	55.31	50.87	7.99	11.16	9.57	54.43	66.47	60.45
Maize+blackgram	45.26	54.01	49.63	7.69	10.78	9.23	52.95	64.79	58.87
Maize+greengram	44.83	53.33	49.08	7.65	10.63	9.14	52.49	63.96	58.22
Maize+cowpea	30.40	37.33	33.86	5.60	7.38	6.49	36.00	44.71	40.35
Maize+soybean	28.75	34.82	31.78	5.14	6.84	5.99	33.89	41.66	37.77
S.Em. ±	1.08	1.27	-	0.19	0.25	-	1.07	1.36	-
C.D. (P = 0.05)	3.35	3.92	-	0.61	0.77	-	3.31	4.21	-
Weed control									
Weedy check	98.40	116.92	107.66	12.15	16.96	14.55	110.55	133.83	122.21
H.W. 30 DAS	21.25	27.33	24.29	5.35	7.19	6.27	26.60	34.53	30.56
Pendimethalin 1 kg ha^{-1}	31.89	36.89	34.39	5.51	7.54	6.52	37.40	44.43	40.91
Alachlor 2 kg ha^{-1}	22.24	27.23	24.73	5.61	7.71	6.66	27.86	34.94	31.40
Metolachlor 1 kg ha^{-1}	21.89	26.42	24.15	5.46	7.38	6.42	27.35	33.80	30.57
S.Em. ±	0.93	1.09	-	0.14	0.22	-	0.94	1.13	-
C.D. (P = 0.05)	2.64	3.09	-	0.41	0.62	-	2.67	3.22	-

Table 4.7 Effect of intercropping systems and weed control on N, P and K content of weeds at harvest

Treatments	N content (%)						P content (%)						K content (%)					
	Monocot			Dicot			Monocot			Dicot			Monocot			Dicot		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems																		
Sole maize	1.328	1.317	1.322	1.662	1.654	1.658	0.301	0.291	0.296	0.336	0.329	0.332	1.684	1.656	1.670	1.648	1.622	1.635
Maize+blackgram	1.341	1.327	1.334	1.687	1.678	1.682	0.302	0.293	0.297	0.336	0.329	0.332	1.676	1.648	1.662	1.641	1.613	1.627
Maize+greengram	1.340	1.326	1.333	1.685	1.675	1.680	0.303	0.291	0.297	0.334	0.328	0.331	1.678	1.650	1.664	1.642	1.612	1.627
Maize+cowpea	1.338	1.325	1.331	1.680	1.670	1.675	0.302	0.293	0.297	0.333	0.331	0.332	1.673	1.646	1.659	1.640	1.612	1.626
Maize+soybean	1.333	1.322	1.327	1.674	1.664	1.669	0.300	0.292	0.296	0.332	0.330	0.331	1.676	1.648	1.662	1.637	1.610	1.623
S.Em. ±	0.009	0.010	-	0.011	0.011	-	0.002	0.002	-	0.003	0.002	-	0.012	0.011	-	0.011	0.009	-
C.D. (P = 0.05)	NS	NS	-	NS	NS	-	NS	NS	-	NS	NS	-	NS	NS	-	NS	NS	-
Weed control																		
Weedy check	1.320	1.307	1.313	1.651	1.643	1.647	0.297	0.288	0.292	0.327	0.324	0.325	1.651	1.623	1.637	1.621	1.596	1.608
H.W. 30 DAS	1.340	1.331	1.340	1.686	1.677	1.681	0.306	0.296	0.301	0.337	0.332	0.334	1.685	1.661	1.673	1.648	1.623	1.635
Pendimethalin 1 kg ha^{-1}	1.333	1.321	1.327	1.683	1.672	1.677	0.299	0.290	0.294	0.334	0.328	0.331	1.682	1.653	1.667	1.645	1.612	1.628
Alachlor 2 kg ha^{-1}	1.340	1.329	1.334	1.683	1.674	1.678	0.302	0.292	0.297	0.336	0.330	0.333	1.683	1.657	1.670	1.646	1.617	1.631
Metolachlor 1 kg ha^{-1}	1.338	1.328	1.333	1.685	1.675	1.680	0.303	0.295	0.299	0.336	0.332	0.334	1.685	1.655	1.670	1.647	1.619	1.633
S.Em. ±	0.006	0.006	-	0.010	0.010	-	0.002	0.002	-	0.002	0.002	-	0.010	0.011	-	0.007	0.008	-
C.D. (P = 0.05)	0.017	NS	-	NS	NS	-	NS	NS	-	NS	NS	-	NS	NS	-	NS	NS	-

Table 4.8 Effect of intercropping systems and weed control on N, P and K uptake by weeds at harvest

Treatments	N uptake (kg ha^{-1})						P uptake (kg ha^{-1})						K uptake (kg ha^{-1})					
	Monocot			Dicot			Monocot			Dicot			Monocot			Dicot		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems																		
Sole maize	6.156	7.267	6.711	1.329	1.843	1.586	1.391	1.607	1.499	0.270	0.367	0.318	7.795	9.132	8.463	1.317	1.810	1.563
Maize+blackgram	6.032	7.129	6.580	1.296	1.801	1.548	1.357	1.573	1.465	0.259	0.353	0.306	7.535	8.835	8.185	1.259	1.733	1.496
Maize+greengram	5.975	7.034	6.504	1.285	1.775	1.530	1.345	1.545	1.445	0.254	0.347	0.300	7.473	8.738	8.105	1.254	1.710	1.482
Maize+cowpea	4.054	4.923	4.488	0.938	1.228	1.083	0.912	1.084	0.998	0.186	0.244	0.215	5.054	6.119	5.586	0.918	1.187	1.052
Maize+soybean	3.818	4.579	4.198	0.858	1.136	0.997	0.857	1.011	0.934	0.170	0.226	0.198	4.793	5.702	5.247	0.839	1.100	0.969
S.Em. ±	0.150	0.200	-	0.041	0.044	-	0.034	0.041	-	0.008	0.008	-	0.228	0.223	-	0.034	0.039	-
C.D. (P = 0.05)	0.462	0.619	-	0.126	0.136	-	0.107	0.128	-	0.025	0.024	-	0.702	0.689	-	0.106	0.122	-
Weed control																		
Weedy check	13.002	15.292	14.147	2.010	2.787	2.398	2.925	3.364	3.144	0.401	0.550	0.475	16.260	19.003	17.631	1.973	2.710	2.341
H.W. 30 DAS	2.866	3.636	3.251	0.902	1.208	1.055	0.651	0.809	0.730	0.181	0.240	0.210	13.587	4.543	4.665	0.883	1.168	1.025
Pendimethalin 1 kg ha^{-1}	4.253	4.873	4.563	0.928	1.259	1.093	0.954	1.072	1.013	0.184	0.248	0.216	5.371	6.095	5.733	0.908	1.217	1.062
Alachlor 2 kg ha^{-1}	2.983	3.621	3.302	0.944	1.292	1.118	0.670	0.795	0.732	0.189	0.254	0.221	3.743	4.512	4.127	0.925	1.248	1.086
Metolachlor 1 kg ha^{-1}	2.930	3.510	3.220	0.921	1.237	1.079	0.663	0.780	0.721	0.185	0.245	0.215	3.689	4.373	4.031	0.899	1.196	1.047
S.Em. ±	0.130	0.156	-	0.029	0.037	-	0.033	0.037	-	0.006	0.007	-	0.159	0.204	-	0.025	0.036	-
C.D. (P = 0.05)	0.368	0.443	-	0.084	0.105	-	0.095	0.106	-	0.017	0.022	-	0.451	0.579	-	0.071	0.104	-

Table 4.8 (Continued) Effect of intercropping systems and weed control on total N, P and K uptake by weeds at harvest

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems									
Sole maize	7.484	9.111	8.297	1.660	1.974	1.817	9.112	10.942	10.027
Maize+blackgram	7.326	8.930	8.128	1.616	1.925	1.770	8.794	10.567	9.680
Maize+greengram	7.259	8.811	8.035	1.599	1.892	1.745	8.726	10.447	9.586
Maize+cowpea	4.992	6.152	5.572	1.098	1.328	1.213	5.972	7.306	6.639
Maize+soybean	4.675	5.715	5.195	1.027	1.237	1.132	5.632	6.802	6.217
S.Em. ±	0.145	0.221	-	0.038	0.044	-	0.216	0.234	-
C.D. (P = 0.05)	0.449	0.682	-	0.117	0.137	-	0.667	0.722	-
Weed control									
Weedy check	15.010	18.081	16.545	3.325	3.914	3.619	18.233	21.713	19.973
H.W. 30 DAS	3.767	4.846	4.306	0.831	1.049	0.940	4.469	5.711	5.090
Pendimethalin 1 kg ha^{-1}	5.181	6.132	5.656	1.138	1.320	1.229	6.278	7.311	6.794
Alachlor 2 kg ha^{-1}	3.927	4.913	4.420	0.858	1.049	0.953	4.668	5.760	5.214
Metolachlor 1 kg ha^{-1}	3.851	4.747	4.299	0.847	1.024	0.935	4.588	5.568	5.078
S.Em. ±	0.132	0.169	-	0.035	0.037	-	0.162	0.210	-
C.D. (P = 0.05)	0.374	0.479	-	0.100	0.107	-	0.459	0.596	-

Table 4.9 Effect of intercropping systems and weed control on plant population and plant height of maize at harvest

Treatments	Plant population ('000 ha^{-1})			Plant height (cm)		
	2001	2002	Mean	2001	2002	Mean
Intercropping systems						
Sole maize	63.58	64.46	64.02	202.98	211.13	207.05
Maize+blackgram	62.87	64.31	63.59	201.38	207.75	204.56
Maize+greengram	63.60	64.28	63.94	201.95	205.32	203.63
Maize+cowpea	63.34	64.02	63.68	200.21	202.41	201.31
Maize+soybean	63.14	63.88	63.51	197.41	202.65	200.03
S.Em. ±	0.72	0.70	-	2.90	3.23	-
C.D. (P = 0.05)	NS	NS	-	NS	NS	-
Weed control						
Weedy check	61.95	62.83	62.39	185.87	191.24	188.55
H.W. 30 DAS	64.13	65.56	64.84	210.15	1215.02	212.58
Pendimethalin 1 kg ha^{-1}	63.51	64.40	63.95	195.26	200.44	197.85
Alachlor 2 kg ha^{-1}	63.34	64.29	63.81	204.76	209.75	207.25
Metolachlor 1 kg ha^{-1}	63.59	64.88	64.23	207.89	212.82	210.35
S.Em. ±	0.65	0.64	-	2.87	2.84	-
C.D. (P = 0.05)	NS	NS	-	8.13	8.04	-

Table 4.10 Effect of intercropping systems and weed control on leaf area index of maize

Treatments	30 DAS			50 DAS			70 DAS		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems									
Sole maize	1.25	1.30	1.27	2.80	2.91	2.85	3.70	3.80	3.75
Maize+blackgram	1.19	1.25	1.22	2.98	3.10	3.04	3.82	4.01	3.91
Maize+green gram	1.22	1.27	1.24	2.78	2.86	2.82	3.65	3.87	3.76
Maize+cow pea	1.18	1.25	1.21	2.87	2.92	2.89	3.71	3.92	3.81
Maize+soybean	1.23	1.29	1.26	2.88	3.02	2.95	3.77	3.94	3.85
S.Em. ±	0.03	0.03	-	0.07	0.06	-	0.101	0.08	-
C.D. (P = 0.05)	NS	NS	-	NS	NS	-	NS	NS	-
Weed control									
Weedy check	1.04	1.13	1.08	2.25	2.32	2.28	2.60	2.91	2.75
H.W. 30 DAS	1.05	1.12	1.08	13.11	3.19	3.15	4.16	4.29	4.22
Pendimethalin 1 kg ha^{-1}	1.32	1.36	1.34	2.91	3.01	2.96	3.85	3.98	3.91
Alachlor 2 kg ha^{-1}	1.32	1.36	1.34	2.98	3.09	3.03	3.95	4.12	4.03
Metolachlor 1 kg ha^{-1}	1.34	1.39	1.36	3.05	3.21	3.13	4.09	4.23	4.16
S.Em. ±	0.02	0.03	-	0.06	0.05	-	0.08	0.08	-
C.D. (P = 0.05)	0.08	0.08	-	0.17	0.15	-	0.23	0.22	-

Table 4.11 Effect of intercropping systems and weed control on dry matter accumulation (g plant^{-1})

Treatments	30 DAS			50 DAS			70 DAS			At harvest		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems												
Sole maize	11.40	11.73	11.56	70.98	73.02	72.00	112.54	118.63	115.58	196.92	199.46	198.19
Maize+blackgram	11.10	11.24	11.17	66.79	71.10	68.94	107.75	113.48	110.61	187.65	194.89	191.27
Maize+green gram	11.24	11.38	11.31	67.63	71.98	69.80	108.93	114.68	111.80	189.80	192.62	191.36
Maize+cow pea	10.48	11.16	10.82	67.60	69.94	68.77	107.97	112.70	110.33	184.05	190.79	187.42
Maize+soybean	10.93	11.01	10.97	68.95	67.09	68.02	110.13	111.10	110.61	185.52	190.38	187.95
S.Em. ±	0.32	0.30	-	1.79	1.94	-	2.49	2.88	-	4.96	5.59	-
C.D. (P = 0.05)	NS	NS	-	NS	NS	-	NS	NS	-	NS	NS	-
Weed control												
Weedy check	9.23	9.44	9.33	55.98	57.20	56.59	92.65	95.14	93.89	157.76	162.24	160.00
H.W. 30 DAS	9.38	9.68	9.53	74.81	76.72	75.76	118.43	124.23	121.33	206.52	210.11	208.31
Pendimethalin 1 kg ha^{-1}	12.00	12.19	12.09	66.62	68.95	67.78	105.75	111.17	108.46	184.28	188.24	186.26
Alachlor 2 kg ha^{-1}	12.11	12.49	12.30	71.29	74.07	72.68	115.09	119.20	117.14	196.39	201.26	198.82
Metolachlor 1 kg ha^{-1}	12.42	12.72	12.57	73.25	76.18	74.71	115.41	120.84	118.12	198.99	206.30	202.64
S.Em. ±	0.29	0.25	-	1.54	1.77	-	2.18	2.29	-	4.06	4.32	-
C.D. (P = 0.05)	0.83	0.72	-	4.38	5.02	-	6.19	6.48	-	11.50	12.22	-

Table 4.12 Effect of intercropping systems and weed control on yield attributes of maize

Treatments	Number of cobs plant ha^{-1}			Grain yield cob^{-1} (g)			1000 grain weight (g)		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems									
Sole maize	1.18	1.27	1.22	79.21	83.86	81.53	228.07	233.55	230.81
Maize+blackgram	1.18	1.23	1.20	76.87	81.72	79.29	227.14	233.11	230.12
Maize+greengram	1.20	1.25	1.22	77.94	82.38	80.16	226.88	232.86	229.87
Maize+cowpea	1.20	1.26	1.23	76.42	81.37	78.89	225.77	231.27	228.52
Maize+soybean	1.22	1.23	1.22	76.32	80.67	78.49	224.15	228.64	226.39
S.Em. ±	0.03	0.02	-	1.38	1.81	-	3.50	3.51	-
C.D. (P = 0.05)	NS	NS	-	NS	NS	-	NS	NS	-
Weed control									
Weedy check	1.09	1.11	1.10	60.58	65.41	62.99	207.14	210.16	208.65
H.W. 30 DAS	1.27	1.30	1.28	84.85	89.27	87.06	233.15	237.07	235.11
Pendimethalin 1 kg ha^{-1}	1.15	1.20	1.17	75.94	80.76	78.35	230.23	235.46	232.84
Alachlor 2 kg ha^{-1}	1.22	1.30	1.26	82.06	86.39	84.22	230.23	238.46	234.23
Metolachlor 1 kg ha^{-1}	1.25	1.33	1.29	83.34	88.16	85.75	231.27	238.50	234.88
S.Em. ±	0.02	0.02	-	1.24	1.41	-	3.22	2.76	-
C.D. (P = 0.05)	0.07	0.07	-	3.52	4.01	-	9.11	7.81	-

Table 4.13 Effect of intercropping systems and weed control on yield (q ha^{-1}) and HI (%) of maize

Treatments	Grain yield (q ha^{-1})			Stover yield (q ha^{-1})			Biological yield (q ha^{-1})			Harvest index (%)		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems												
Sole maize	44.14	45.57	44.85	96.57	99.36	97.96	140.72	144.94	142.83	31.34	31.39	31.36
Maize+blackgram	43.33	44.81	44.07	95.25	98.04	96.64	138.58	142.85	140.71	31.11	31.18	31.14
Maize+greengram	43.28	44.56	43.92	93.30	95.49	94.39	136.58	140.05	138.31	31.52	31.63	31.57
Maize+cowpea	42.88	44.01	43.44	92.51	94.10	93.30	135.39	138.12	136.75	31.62	31.80	31.71
Maize+soybean	42.21	43.29	42.75	90.77	92.38	91.58	133.01	135.68	134.34	31.57	31.72	31.64
S.Em. ±	1.21	1.36	-	2.74	2.46	-	3.09	3.13	-	0.89	0.76	-
C.D. (P = 0.05)	NS	NS	-	NS	NS	-	NS	NS	-	NS	NS	-
Weed control												
Weedy check	28.21	29.01	28.61	69.75	72.60	71.17	97.96	101.61	99.78	28.94	28.64	28.79
H.W. 30 DAS	48.92	50.02	49.47	104.08	106.09	105.08	153.00	156.11	154.55	31.98	32.06	32.02
Pendimethalin 1 kg ha^{-1}	43.16	44.86	44.01	92.32	94.22	93.27	135.48	139.08	137.28	31.92	32.35	32.13
Alachlor 2 kg ha^{-1}	46.94	48.64	47.79	100.48	102.58	101.53	147.43	151.28	149.33	31.89	32.20	32.04
Metolachlor 1 kg ha^{-1}	48.62	49.72	49.17	101.79	103.89	102.84	150.41	153.61	152.01	32.43	32.46	32.44
S.Em. ±	1.03	1.01	-	2.15	2.25	-	2.33	2.46	-	0.76	0.72	-
C.D. (P = 0.05)	2.93	2.86	-	6.10	6.37	-	6.61	6.96	-	2.15	2.04	-

Table 4.14 Effect of intercropping systems and weed control on N, P and K content of maize

Treatments	N content (%)						P content (%)						K content (%)					
	Grain			Stover			Grain			Stover			Grain			Stover		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems																		
Sole maize	1.676	1.690	1.683	0.611	0.622	0.616	0.412	0.423	0.417	0.156	0.169	0.162	0.430	0.432	0.431	1.556	1.559	1.557
Maize+blackgram	1.721	1.728	1.724	0.625	0.628	0.626	0.408	0.422	0.415	0.156	0.167	0.161	0.423	0.426	0.424	1.532	1.545	1.538
Maize+greengram	1.718	1.700	1.709	0.623	0.624	0.623	0.407	0.420	0.413	0.154	0.168	0.161	0.423	0.426	0.424	1.535	1.541	1.538
Maize+cowpea	1.689	1.695	1.692	0.620	0.622	0.621	0.405	0.417	0.411	0.154	0.166	0.160	0.419	0.430	0.424	1.531	1.539	1.535
Maize+soybean	1.687	1.686	1.686	0.615	0.619	0.617	0.403	0.412	-	0.153	0.166	0.159	0.421	0.429	0.425	1.525	1.537	1.531
S.Em. ±	0.017	0.011	-	0.005	0.005	-	0.004	0.004	-	0.001	0.001	-	0.003	0.003	-	0.011	0.013	-
C.D. (P = 0.05)	NS	NS	-	NS	NS	-	NS	NS		NS	NS	-	NS	NS	-	NS	NS	-
Weed control																		
Weedy check	1.565	1.584	1.574	0.568	0.578	0.573	0.393	0.400	0.396	0.145	0.154	0.149	0.346	0.359	0.352	1.383	1.392	1.387
H.W. 30 DAS	1.755	1.734	1.744	0.639	0.635	0.637	0.415	0.431	0.423	0.160	0.171	0.165	0.445	0.449	0.447	1.583	1.591	1.587
Pendimethalin 1 kg ha^{-1}	1.714	1.724	1.719	0.618	0.618	0.618	0.403	0.410	0.406	0.151	0.170	0.160	0.438	0.446	0.442	1.554	1.572	1.563
Alachlor 2 kg ha^{-1}	1.727	1.717	1.722	0.633	0.639	0.636	0.412	0.425	0.418	0.157	0.170	0.163	0.443	0.444	0.443	1.577	1.580	1.578
Metolachlor 1 kg ha^{-1}	1.731	1.739	1.735	0.635	0.645	0.640	0.412	0.427	0.419	0.158	0.171	0.164	0.443	0.445	0.444	1.581	1.586	1.583
S.Em. ±	0.012	0.010	-	0.004	0.005	-	0.002	0.003	-	0.001	0.001	-	0.003	0.002	-	0.008	0.010	-
C.D. (P = 0.05)	0.034	0.028	-	0.013	0.014	-	0.008	0.008	-	0.004	0.005	-	0.008	0.008	-	0.025	0.029	-

Table 4.15 Effect of intercropping systems and weed control on N, P and K uptake of maize

Treatments	N uptake (kg ha^{-1})						P uptake (kg ha^{-1})						K uptake (kg ha^{-1})					
	Seed			Stover			Seed			Stover			Seed			Stover		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems																		
Sole maize	74.712	77.483	76.097	59.332	62.065	60.698	18.255	19.367	18.811	15.257	16.905	16.081	19.339	19.952	19.645	150.576	155.906	153.241
Maize+blackgram	75.133	77.848	76.490	59.854	61.772	60.813	17.726	19.006	18.366	15.016	16.432	15.724	18.603	19.372	18.987	147.249	152.561	149.905
Maize+greengram	74.817	76.285	75.551	58.423	59.899	59.161	17.662	18.758	18.210	14.496	16.168	15.332	18.628	19.232	18.930	144.615	148.089	146.352
Maize+cowpea	72.868	75.032	73.950	57.704	58.780	58.242	17.396	18.406	17.901	14.396	15.726	15.061	18.258	19.165	18.711	143.154	145.71	144.562
Maize+soybean	71.637	73.404	72.520	56.180	57.502	56.841	17.083	17.908	17.495	14.038	15.410	14.724	18.046	18.836	18.441	139.917	142.879	141.398
S.Em. ±	2.48	2.23	-	1.78	1.76	-	0.501	0.555	-	0.414	0.454	-	0.640	0.598	-	4.455	4.810	-
C.D. (P = 0.05)	NS	NS	-	NS	NS	-	NS	NS	-	NS	NS	-	NS	NS	-	NS	NS	-
Weed control																		
Weedy check	44.138	45.955	45.046	39.610	42.005	40.807	11.094	11.604	11.349	10.146	11.174	10.660	9.774	10.394	10.084	96.482	101.037	98.759
H.W. 30 DAS	85.802	86.795	86.298	66.498	67.391	66.944	20.291	21.565	20.928	16.542	18.173	17.357	21.801	22.455	22.128	164.870	168.824	166.847
Pendimethalin 1 kg ha^{-1}	73.926	77.404	75.665	57.054	58.064	57.559	17.387	18.395	17.891	14.562	16.052	15.307	18.912	19.980	19.446	144.760	148.293	146.526
Alachlor 2 kg ha^{-1}	81.115	83.482	82.298	63.705	65.545	64.625	19.334	20.662	19.998	15.821	17.447	16.634	20.823	21.590	21.206	158.430	161.995	160.212
Metolachlor 1 kg ha^{-1}	84.185	86.416	85.300	64.626	67.013	65.819	20.016	21.218	20.617	16.132	17.795	16.963	21.564	22.138	21.851	160.969	165.258	163.113
S.Em. ±	1.812	1.808	-	1.44	1.33	-	0.414	0.419	-	0.364	0.436	-	0.472	0.453	-	3.38	3.855	-
C.D. (P = 0.05)	5.126	5.116	-	4.090	3.76	-	1.172	1.187	-	1.029	1.236	-	1.335	1.283	-	9.58	10.906	-

Table 4.15 (Continued) Effect of intercropping systems and weed control on Total N, P and K uptake of maize

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems									
Sole maize	134.045	139.546	136.795	33.512	36.272	34.892	169.913	175.857	172.885
Maize+blackgram	134.986	139.620	137.303	32.742	35.437	34.089	165.851	171.931	168.891
Maize+greengram	133.240	136.183	134.711	32.156	34.928	33.542	163.243	167.323	165.283
Maize+cowpea	130.572	133.811	132.191	31.794	34.130	32.962	161.414	165.136	163.275
Maize+soybean	127.816	130.906	129.361	31.121	33.318	32.219	157.966	161.717	159.841
S.Em. ±	3.22	3.21	-	0.657	0.850	-	4.693	5.139	-
C.D. (P = 0.05)	NS	NS	-	NS	NS	-	NS	NS	-
Weed control									
Weedy check	83.747	87.961	85.854	21.240	22.778	22.009	106.256	111.431	108.843
H.W. 30 DAS	152.300	154.183	153.241	36.834	39.739	38.286	186.671	191.279	188.975
Pendimethalin 1 kg ha^{-1}	130.979	135.467	133.233	31.949	34.446	33.197	163.674	168.273	165.973
Alachlor 2 kg ha^{-1}	144.820	149.026	146.923	35.156	38.109	36.632	179.252	183.583	181.417
Metolachlor 1 kg ha^{-1}	148.812	153.428	151.12	36.147	39.103	37.580	182.534	187.397	184.965
S.Em. ±	2.188	2.195	-	0.513	0.604	-	3.386	3.859	-
C.D. (P = 0.05)	6.190	6.210	-	1.454	1.711	-	9.579	10.91	-

Table 4.16 Effect of intercropping systems and weed control on plant population (lacs ha^{-1}) and plant height (cm) of intercrops at harvest

Treatments	Plant population ('000/ha)			Plant height (cm)		
	2001	2002	Mean	2001	2002	Mean
Intercropping systems						
Sole maize	-	-	-	-	-	-
Maize+blackgram	1.58	1.60	1.59	37.34	39.11	38.22
Maize+greengram	1.60	1.60	1.60	57.74	55.25	54.49
Maize+cowpea	1.59	1.60	1.59	77.01	80.83	78.92
Maize+soybean	1.59	1.59	1.59	78.06	82.14	80.10
Weed control						
Weedy check	1.53	1.54	1.53	64.50	68.71	66.60
H.W. 30 DAS	1.58	1.60	1.59	60.16	60.35	60.25
Pendimethalin 1 kg ha^{-1}	1.60	1.61	1.60	60.93	63.12	62.02
Alachlor 2 kg ha^{-1}	1.61	1.62	1.61	63.60	64.78	64.19
Metolachlor 1 kg ha^{-1}	1.62	1.62	1.62	63.50	64.70	64.10

Table 4.17 Effect of intercropping systems and weed control on leaf area index of intercrops

Treatments	30 DAS			50 DAS			70 DAS		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems									
Sole maize	-	-	-	-	-	-	-	-	-
Maize+blackgram	0.63	0.64	0.63	1.42	1.39	1.40	0.78	0.84	0.81
Maize+greengram	0.64	0.66	0.65	1.50	1.49	1.49	0.86	0.90	0.88
Maize+cowpea	0.77	0.80	0.78	1.74	1.70	1.72	2.48	2.55	2.51
Maize+soybean	0.82	0.86	0.84	1.80	1.78	1.79	2.71	2.80	2.75
Weed control									
Weedy check	0.61	0.63	0.62	1.17	1.23	1.20	1.20	1.26	1.23
H.W. 30 DAS	0.61	0.64	0.62	1.63	1.65	1.64	1.90	1.95	1.92
Pendimethalin 1 kg ha^{-1}	0.78	0.81	0.79	1.70	1.70	1.70	1.78	1.83	1.80
Alachlor 2 kg ha^{-1}	0.77	0.79	0.78	1.74	1.72	1.73	1.79	1.87	1.83
Metolachlor 1 kg ha^{-1}	0.79	0.83	0.81	1.74	1.75	1.74	1.88	1.95	1.91

Table 4.18 Effect of intercropping systems and weed control on dry matter accumulation by intercrops (g/plant)

Treatments	30 DAS			50 DAS			70 DAS			At harvest		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping system												
Sole maize	-	-	-	-	-	-	-	-	-	-	-	-
Maize+blackgram	2.05	2.13	2.09	4.46	4.59	4.52	10.07	10.23	10.15	9.12	9.28	9.20
Maize+greengram	2.22	2.36	2.29	4.80	4.95	4.87	10.57	10.74	10.65	10.09	10.37	10.23
Maize+cowpea	2.53	2.65	2.59	7.50	7.68	7.59	13.74	14.52	14.13	16.69	16.77	16.73
Maize+soybean	2.68	2.75	2.71	7.74	7.87	7.80	15.20	14.40	14.80	17.53	17.77	17.65
Weed control												
Weedy check	1.75	1.77	1.76	4.10	4.34	4.22	7.29	7.71	7.50	8.23	8.51	8.37
H.W. 30 DAS	1.75	1.80	1.77	5.56	5.74	5.63	13.95	14.11	14.03	14.65	14.83	14.74
Pendimethalin 1 kg ha^{-1}	2.72	2.88	2.80	6.69	6.77	6.73	12.90	13.23	13.06	13.93	14.01	13.97
Alachlor 2 kg ha^{-1}	2.79	2.91	2.85	6.98	7.00	6.99	13.60	13.98	13.79	14.31	14.51	14.41
Metolachlor 1 kg ha^{-1}	2.83	2.99	2.91	7.31	7.53	7.42	14.23	14.56	14.39	15.67	15.88	15.77

Table 4.19 Effect of intercropping systems and weed control on yield (q ha^{-1}) and harvest index (%) of intercrops

Treatments	Seed yield (q ha^{-1})			Stover yield (q ha^{-1})			Biological yield (q ha^{-1})			Harvest index (%)		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping system												
Sole maize	-	-	-	-	-	-	-	-	-	-	-	-
Maize+blackgram	3.43	3.77	3.60	10.13	10.47	10.30	13.57	14.24	13.90	24.81	26.08	25.44
Maize+greengram	4.23	4.75	4.49	11.27	11.75	11.51	15.51	16.50	16.08	26.95	28.53	27.74
Maize+cowpea	5.09	5.45	5.27	14.71	15.64	15.17	19.80	21.09	20.44	25.57	25.70	25.63
Maize+soybean	5.83	6.33	6.08	16.06	17.09	16.57	21.90	23.43	22.66	26.49	26.91	26.70
Weed control												
Weedy check	2.90	3.42	3.16	10.50	11.44	10.97	13.40	14.87	14.13	21.28	22.83	22.05
H.W. 30 DAS	5.11	5.53	5.32	13.87	14.55	14.21	18.98	20.09	19.53	26.97	27.67	27.32
Pendimethalin 1 kg ha^{-1}	4.87	5.14	5.00	12.99	13.66	13.32	17.87	18.80	18.33	27.31	27.41	27.36
Alachlor 2 kg ha^{-1}	5.03	5.49	5.26	13.60	14.28	13.94	18.63	19.78	19.20	27.00	27.84	27.42
Metolachlor 1 kg ha^{-1}	5.33	5.78	5.55	14.27	14.75	14.51	19.60	20.54	20.07	27.20	28.26	27.73

Table 4.20 Effect of intercropping systems and weed control on N, P and K content of intercrops

Treatments	N content (%)						P content (%)						K content (%)					
	Seed			Stover			Seed			Stover			Seed			Stover		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems																		
Sole maize	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maize+blackgram	3.72	3.69	3.70	0.896	0.929	0.912	0.548	0.552	0.550	0.217	0.220	0.218	0.523	0.526	0.524	1.537	1.545	1.541
Maize+greengram	3.70	3.67	3.68	0.914	0.946	0.930	0.552	0.560	0.556	0.215	0.221	0.218	0.573	0.576	0.574	1.540	1.541	1.540
Maize+cowpea	3.59	3.58	3.58	1.021	1.053	1.037	0.550	0.557	0.553	0.214	0.219	0.216	0.529	0.540	0.534	1.566	1.572	1.569
Maize+soybean	6.48	6.43	6.45	1.156	1.170	1.163	0.573	0.582	0.577	0.224	0.231	0.227	0.541	0.549	0.545	1.575	1.587	1.581
Weed control																		
Weedy check	4.20	4.19	4.19	0.936	0.971	0.953	0.543	0.544	0.543	0.207	0.210	0.208	0.464	0.477	0.470	1.399	1.410	1.404
H.W. 30 DAS	4.43	4.39	4.41	1.016	1.048	1.032	0.562	0.571	0.566	0.221	0.227	0.224	0.564	0.569	0.566	1.548	1.608	1.603
Pendimethalin 1 kg ha^{-1}	4.40	4.37	4.38	0.996	1.018	1.007	0.552	0.554	0.553	0.218	0.223	0.220	0.558	0.565	0.561	1.588	1.591	1.589
Alachlor 2 kg ha^{-1}	4.41	4.38	4.39	1.011	1.039	1.025	0.560	0.570	0.550	0.219	0.224	0.221	0.561	0.563	0.562	1.592	1.600	1.596
Metolachlor 1 kg ha^{-1}	4.43	4.40	4.41	1.024	1.045	1.034	0.563	0.574	0.568	0.222	0.231	0.226	0.560	0.565	0.562	1.596	1.599	1.597

Table 4.21 Effect of intercropping systems and weed control on N, P and K uptake of intercrops

Treatments	N uptake (kg ha^{-1})						P uptake (kg ha^{-1})						K uptake (kg ha^{-1})					
	Seed			Stover			Seed			Stover			Seed			Stover		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems																		
Sole maize	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maize+blackgram	12.894	14.011	13.452	9.128	9.751	9.439	1.891	2.094	1.992	2.207	2.310	2.258	1.829	2.016	1.922	15.675	16.285	15.980
Maize+greengram	15.742	17.538	16.640	10.351	11.155	10.753	2.343	2.666	2.504	2.430	2.612	2.521	2.464	2.763	2.613	17.468	18.212	17.840
Maize+cowpea	18.406	19.625	19.015	15.050	16.500	15.775	2.808	3.042	2.925	3.153	3.440	3.296	2.731	2.969	2.850	23.146	24.699	23.922
Maize+soybean	37.934	40.844	39.389	18.608	20.032	19.320	3.355	3.696	3.625	3.603	3.959	3.781	3.191	3.508	3.349	25.414	27.226	26.320
Weed control																		
Weedy check	13.030	15.266	14.148	10.073	11.363	10.718	1.584	1.876	1.730	2.175	2.411	2.293	1.351	1.640	1.495	14.722	16.196	15.459
H.W. 30 DAS	23.449	25.174	24.311	14.346	15.524	14.935	2.881	3.170	3.025	3.074	3.313	3.193	2.886	3.153	3.019	22.214	23.471	22.842
Pendimethalin 1 kg ha^{-1}	22.268	23.319	22.793	13.178	14.154	13.666	2.696	2.859	2.777	2.836	3.054	2.945	2.720	2.912	2.816	20.659	21.823	21.241
Alachlor 2 kg ha^{-1}	23.016	24.939	23.977	13.993	15.092	14.542	2.827	3.143	2.985	2.987	3.204	3.095	2.829	3.098	2.963	21.686	22.928	22.307
Metolachlor 1 kg ha^{-1}	24.456	26.324	25.390	14.831	15.662	15.246	3.007	3.323	3.165	3.169	3.419	3.294	2.982	3.267	3.124	22.846	23.609	23.227

Table 4.21 (Continued) **Effect of intercropping systems and weed control on total N, P and K uptake of intercrops**

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems									
Sole maize	-	-	-	-	-	-	-	-	-
Maize+blackgram	22.021	23.762	22.891	4.098	4.405	4.251	17.505	18.302	17.903
Maize+greengram	26.092	28.693	27.392	4.772	5.278	5.025	19.932	20.975	20.453
Maize+cowpea	33.456	36.124	34.790	5.961	6.481	6.221	25.877	27.668	26.772
Maize+soybean	56.540	60.874	58.707	6.959	7.655	7.307	28.604	30.733	29.668
Weed control									
Weedy check	23.101	26.629	24.865	3.760	4.288	4.024	16.074	17.834	16.954
H.W. 30 DAS	37.794	40.698	39.246	5.956	6.483	6.219	25.102	26.623	25.862
Pendimethalin 1 kg ha^{-1}	35.444	37.473	36.458	5.530	5.914	5.722	23.378	24.737	24.057
Alachlor 2 kg ha^{-1}	37.009	40.030	38.519	5.814	6.346	6.080	24.511	26.024	25.267
Metolachlor 1 kg ha^{-1}	39.288	41.986	40.637	6.175	6.740	6.457	25.831	26.878	26.354

Table 4.22 Effect of intercropping systems and weed control on total leaf area index of maize and intercrops

Treatments	30 DAS			50 DAS			70 DAS		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems									
Sole maize	1.25	1.30	1.27	2.80	2.91	2.85	3.70	3.80	3.75
Maize+blackgram	1.82	1.89	1.85	4.37	4.52	4.44	4.61	4.86	4.73
Maize+greengram	1.86	1.93	1.89	4.27	4.36	4.31	4.52	4.77	4.64
Maize+cowpea	1.96	2.05	2.00	4.57	4.67	4.62	6.19	6.47	6.33
Maize+soybean	2.06	2.16	2.11	4.66	4.83	4.74	6.48	6.74	6.61
S.Em. ±	0.03	0.03	-	0.09	0.09	-	0.12	0.13	-
C.D. (P = 0.05)	0.11	0.11	-	0.28	0.28	-	0.38	0.42	-
Weed control									
Weedy check	1.54	1.64	1.59	3.15	3.26	3.20	3.57	3.92	3.74
H.W. 30 DAS	1.54	1.64	1.59	4.44	4.54	4.49	5.68	5.85	5.76
Pendimethalin 1 kg ha^{-1}	1.95	2.01	1.98	4.27	4.38	4.32	5.27	5.45	5.36
Alachlor 2 kg ha^{-1}	1.94	1.99	1.96	4.36	4.48	4.42	5.38	5.62	5.50
Metolachlor 1 kg ha^{-1}	1.98	2.05	2.01	4.45	4.63	4.54	5.60	5.79	5.69
S.Em. ±	0.03	0.03	-	0.06	0.06	-	0.12	0.12	-
C.D. (P = 0.05)	0.10	0.10	-	0.18	0.17	-	0.34	0.35	-

Table 4.23 Effect of intercropping systems and weed control on total biological yield, N, P and K uptake of maize and intercrops

Treatments	Biological yield (q ha^{-1})			Nitrogen uptake (kg ha^{-1})			Phosphorus uptake (kg ha^{-1})			Potassium uptake (kg ha^{-1})		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems												
Sole maize	140.72	144.95	142.83	134.04	139.54	136.79	33.51	36.27	34.89	169.91	175.85	172.88
Maize+blackgram	152.16	157.10	154.63	157.00	163.38	160.19	36.84	39.84	38.34	183.35	190.23	186.79
Maize+greengram	152.10	156.56	154.33	159.33	164.87	162.10	36.92	40.20	38.56	183.17	188.29	185.73
Maize+cowpea	155.21	159.21	157.21	164.02	169.93	166.97	37.75	40.61	39.18	187.29	192.80	190.04
Maize+soybean	154.92	159.12	157.02	184.35	191.78	188.06	38.07	40.97	39.52	186.56	192.45	189.50
S.Em. ±	3.26	3.30	-	3.48	3.60	-	0.69	0.91	-	4.96	5.47	-
C.D. (P = 0.05)	10.05	10.17	-	10.73	11.10	-	2.13	2.81	-	NS	NS	-
Weed control												
Weedy check	108.69	113.52	111.10	102.22	109.26	105.74	24.24	26.20	25.22	119.11	125.69	122.40
H.W. 30 DAS	168.20	172.19	170.19	182.53	186.74	184.63	41.59	44.92	43.25	206.75	212.57	209.66
Pendimethalin 1 kg ha^{-1}	149.78	154.13	151.95	159.33	165.44	162.38	36.37	39.17	37.37	182.37	188.06	185.21
Alachlor 2 kg ha^{-1}	162.34	167.06	164.70	174.42	181.05	177.73	39.80	43.18	41.49	198.86	204.40	201.63
Metolachlor 1 kg ha^{-1}	166.09	170.05	168.07	180.24	187.01	183.62	41.08	44.40	42.74	203.19	208.89	206.04
S.Em. ±	2.49	2.61	-	2.54	2.55	-	0.56	0.66	-	3.62	4.11	-
C.D. (P = 0.05)	7.04	7.38	-	7.19	7.21	-	1.59	1.87	-	10.25	11.63	-

Table 4.24 Effect of intercropping systems and weed control on maize equivalent grain yield, maize equivalent stover yield, net returns and B:C ratio

Treatments	Maize equivalent grain yield (q ha^{-1})			Maize equivalent stover yield (q ha^{-1})			Net returns (Rs ha^{-1})			B:C ratio		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Intercropping systems												
Sole maize	44.14	45.57	44.85	96.57	99.37	97.97	20892	28973	24932	2.29	2.97	2.63
Maize+blackgram	54.10	56.63	55.36	105.39	108.51	106.95	24833	35172	30002	2.39	3.18	2.78
Maize+greengram	55.52	59.02	57.27	104.58	107.25	105.91	25404	36467	30935	2.47	3.33	2.90
Maize+cowpea	56.40	61.08	58.74	107.22	109.75	108.48	26084	37964	320224	2.54	3.47	3.00
Maize+soybean	54.17	57.62	55.89	106.86	109.49	108.17	24556	35383	29969	2.26	3.07	2.66
S.Em. ±	1.36	1.59	-	2.90	2.62	-	687	103	-	0.06	0.09	-
C.D. (P = 0.05)	4.21	4.90	-	8.94	8.09	-	2117	3198	-	NS	0.30	-
Weed control												
Weedy check	34.15	36.72	35.43	78.15	81.76	79.95	14537	21657	18097	1.61	2.23	1.92
H.W. 30 DAS	59.61	62.62	61.11	115.19	117.74	116.46	28047	39546	33796	2.67	3.53	3.10
Pendimethalin 1 kg ha^{-1}	53.35	56.54	54.94	102.71	105.15	103.93	23910	34390	29150	2.26	3.04	2.65
Alachlor 2 kg ha^{-1}	57.46	61.15	59.30	111.37	114.01	112.70	26996	38517	32756	2.64	3.52	3.08
Metolachlor 1 kg ha^{-1}	59.76	62.89	61.32	113.21	115.70	114.45	28278	39849	34063	2.79	3.69	3.24
S.Em. ±	1.21	1.25	-	2.28	2.37	-	566	778	-	0.05	0.07	-
C.D. (P = 0.05)	3.43	3.54	-	6.45	6.70	-	1602	2201	-	0.15	0.20	-

Appendix-Ia : **Meteorological observations : A weekly average during the experimental period (June to November, 2001)**

Standard Week no.	Dates	Temperature (C)		R.H.(%)		Sun-shine (hours)	Evaporation (in mm)	Mean wind velocity km hr^{-1}
		Maxi.	Mini.	Max.	Min.			
26	25 June to 1 July	32.8	25.3	75	56	7.6	7.5	9.2
27	2 July to 8 July	28.9	23.3	94	79	2.9	3.4	4.3
28	9 July to 15 July	28.7	23.4	93	83	2.5	4.3	5.4
29	16 July to 22 July	27.8	23.8	93	86	1.5	3.0	6.1
30	23 July to 29 July	29.0	23.7	91	82	2.8	3.6	4.9
31	30 July to 5 Aug.	29.5	23.2	88	74	5.1	4.2	4.4
32	6 Aug. to 12 Aug.	31.0	23.1	95	83	5.3	4.1	2.1
33	13 Aug. to 19 Aug.	29.2	23.3	90	80	3.1	3.4	4.0
34	20 Aug. to 26 Aug.	30.0	22.0	89	70	6.3	3.3	2.9
35	27 Aug. to 2 Sept.	29.6	22.3	82	67	7.6	4.7	6.4
36	3 Sept. to 9 Sept.	31.2	21.8	86	61	9.4	5.2	4.3
37	10 Sept. to 16 Sept.	32.7	20.9	87	61	9.7	4.6	3.6
38	17 Sept. to 23 Sept.	34.7	21.3	81	45	8.7	4.9	2.6
39	24 Sept. to 30 Sept.	36.6	18.4	70	35	10.1	5.5	2.0
40	1 Oct. to 7 Oct.	34.3	21.4	87	49	7.9	5.0	2.5
41	8 Oct. to 14 Oct.	33.4	22.5	89	50	6.7	3.9	2.6
42	15 Oct. to 21 Oct.	33.8	15.3	78	27	10.0	4.4	1.7
43	22 Oct. to 28 Oct.	34.8	14.9	69	26	10.3	4.5	1.8
44	29 Oct. to 4 Nov.	34.5	15.6	69	39	10.1	4.6	2.3

Appendix-I b : Meteorological observations : A weekly average during the experimental period (June to November, 2002)

Standard Week no.	Dates	Temperature (C)		R.H.(%)		Sun-shine (hours)	Evaporation (in mm)	Mean wind velocity km hr-1
		Maxi.	Mini.	Max.	Min.			
26	25 June to 1 July	32.8	24.5	82	63	4.1	5.0	6.1
27	2 July to 8 July	31.9	25.3	72	55	6.6	7.4	9.8
28	9 July to 15 July	32.9	25.0	72	47	9.7	8.0	9.4
29	16 July to 22 July	32.0	24.9	72	56	5.7	6.3	8.4
30	23 July to 29 July	30.7	24.5	73	56	5.3	6.8	9.5
31	30 July to 5 Aug.	32.6	23.7	83	61	5.1	6.5	5.0
32	6 Aug. to 12 Aug.	28.3	23.3	91	83	1.5	3.1	4.0
33	13 Aug. to 19 Aug.	28.1	23.1	83	71	1.6	3.7	5.6
34	20 Aug. to 26 Aug.	30.5	23.0	88	70	7.4	4.5	4.6
35	27 Aug. to 2 Sept.	28.8	22.3	86	69	5.3	3.3	4.7
36	3 Sept. to 9 Sept.	31.3	21.8	88	61	7.9	4.6	3.5
37	10 Sept. to 16 Sept.	31.8	20.1	74	44	10.6	5.0	4.9
38	17 Sept. to 23 Sept.	30.8	20.1	79	55	8.8	4.7	3.4
39	24 Sept. to 30 Sept.	33.5	20.5	72	44	9.1	5.4	3.1
40	1 Oct. to 7 Oct.	36.3	17.3	62	23	10.5	5.9	1.8
41	8 Oct. to 14 Oct.	36.4	19.0	71	32	9.8	5.5	1.4
42	15 Oct. to 21 Oct.	34.5	17.0	64	21	9.6	5.8	2.3
43	22 Oct. to 28 Oct.	33.3	14.4	55	16	10.0	5.4	1.9
44	29 Oct. to 4 Nov.	33.2	13.5	61	15	9.8	4.6	1.3

Appendix XXII Cost of cultivation and prices used to compute economics

Particulars		Unit cost (Rs.)		Cost ha^{-1} (Rs.)	
		2001	2002	2001	2002
A. Common Cost of Cultivation					
1.	Land preparation by tractors (8 hrs)	200 hr^{-1}	225 hr^{-1}	1600	1800
2.	Layout and bunding (3 mandays)	60 $mandays^{-1}$	60 $mandays^{-1}$	180	180
3.	Maize seed (20 kg ha^{-1})	20 kg^{-1}	20 kg^{-1}	400	400
4.	Fertilizer 86.95 kg DAP	9.34 kg^{-1}	9.50 kg^{-1}	812	826
-183.36 kg Urea		4.80 kg^{-1}	4.90 kg^{-1}	880	898
5.	Charge of fertilizer dressing and sowing (20 mandays)	60 $mandays^{-1}$	60 $mandays^{-1}$	1200	1200
6.	Irrigation (1 in 2001 and 2 in 2002)	250 $irrig^{-1}$	270 $irrig^{-1}$	250	540
7.	Charges of fertilizer dressing (2 mandays)	60 $mandays^{-1}$	60 $mandays^{-1}$	120	120
8.	Harvesting (23 mandays)	60 $mandays^{-1}$	60 $mandays^{-1}$	1380	1380
9.	Shelling and winnowing	-	-	850	930
10.	Miscellaneous	-	-	280	300
TOTAL				7952	8574
B.	**Cost of treatments**				
1.	Pendimethalin 1.0 kg ha^{-1}	1420 kg^{-1}	1470 kg^{-1}	1420	1470
2.	Alachlor 2 kg ha^{-1}	540 kg^{-1}	550 kg^{-1}	1080	1100
3.	Metolachlor 1 kg ha^{-1}	975 kg^{-1}	980 kg^{-1}	975	980
4.	Handweeding 25 mandays	60 $manday^{-1}$	60 $mandays^{-1}$	1500	1500
5.	Herbicide spray (2 man days)	60 $manday^{-1}$	60 $mandays^{-1}$	120	120
6.	Intercrops seeds				
(i)	Blackgram (8 kg ha^{-1})	40 kg^{-1}	40 kg^{-1}	320	320
(ii)	Greengram (8 kg ha^{-1})	30 kg^{-1}	30 kg^{-1}	240	240
(iii)	Cowpea	30 kg^{-1}	30 kg^{-1}	240	240
(iv)	Soybean (40 kg ha^{-1})	20 kg^{-1}	20 kg^{-1}	800	800
7.	Sowing of intercrops (8 mandays)	60 $mandays^{-1}$	60 $mandays^{-1}$	480	480
Threshing & Winnowing		-	-	450	500
C.	**Price of produce**				
1.	Maize grain	415 q^{-1}	575 q^{-1}		
2.	Maize stover	20 q^{-1}	125 q^{-1}		
3.	Blackgram seed	1300 q^{-1}	1800 q^{-1}		
4.	Greengram seed	1200 q^{-1}	1750 q^{-1}		
5.	Cowpea seed	1100 q-1	1800 q^{-1}		
6.	Soybean seed	850 q^{-1}	1300 q^{-1}		
7.	Stover of intercrops	120 q^{-1}	125 q^{-1}		