Effect of Herbicides on the Nodulation and Yield of Legume crops

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By

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Dedicated

To

My mom

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CERTIFICATE

This is to certify that the work recorded in the thesis entitled **"Effect of herbicides on the nodulation and yield of legume crops"** submitted by **Mr. Subhajit Mallick**, in partial fulfillment of the requirement for the award of the Degree of doctor of Philosophy in Agriculture (Agronomy) of the Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal is a faithful and bonafied research work carried out under my supervision and guidance.

The results and investigation reported in the thesis have not so far been submitted for any other degree or diploma. The assistance and help received during the course of investigation have been duly acknowledged.

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LIST OF ABBREVIATIONS AND SYMBOLS

@	:	At the rate of	^oC	:	Degree Celsius
%	:	Percentage	^oE	:	Degree east
BCKV	:	Bidhan Chandra Krishi Viswavidyalaya	^oN	:	Degree north
CD	:	Critical difference	P	:	Phosphorus
CGR	:	Crop growth rate	pH	:	Concentration of active hydrogen ions
cm	:	Centimeter	ppb	:	Parts per bilion
CV	:	Cultivar	ppm	:	Parts per milion
DAS	:	Days after sowing	S.Em	:	Standard error mean
e.g.	:	exempli gratia	SL	:	Soluble Liquid
EC	:	Emulsifiable concentration	sp.	:	Species
etc.	:	Etcetera	SSP	:	Single Super Phosphate
Fig.	:	Figure	t	:	Tone
g	:	Gram (s)	T	:	Treatment
ha	:	Hectare	*viz.*	:	Videlicet (namely)
i.e.	:	That is	Vs.	:	Versus
kg	:	Kilogram	WB	:	West Bengal
l	:	Liter	wt.	:	Weight
LAI	:	Leaf Area Index	HW	:	Hand weeding
m^2	:	Square meter	PE	:	Pre-emergence
mg	:	Milligram (s)	POE	:	Post-emergence
ml	:	Milliliter (s)	WCE	:	Weed control efficiency
mm	:	Millimeter (s)	l	:	Liter
MOP	:	Muriate of Potash	$g\ m^{-2}\ day^{-1}$	:	Gram per square meter per day
N	:	Nitrogen	$g\ m^{-2}$	:	Gram per square meter
No.	:	Number (s)	$t\ ha^{-1}$	:	Tonne per hectare
NS	:	Non significant	WM	:	Weed management

Abstract

The nitrogen fixing bacterium *Bradyrhizobium* sp. forms a specific symbiosis with legumes and is commonly applied to the seed or soil as microbial inoculants to ensure functional symbiosis in legumes. Further, during the production of legume crops, dicot and monocot weeds that appear in the crop field, are adversely affect the crop productivity. The management of these weed flora is therefore, required and in present situation considering the net return, chemicals are preferred to control weeds in order to augment the productivity. Chemicals when applied have variable effects on legume production and when applied frequently, are accumulated in to the soil and at elevated levels impair the metabolic activities resulting in reduced growth of *rhizobia*. For instance, several chemical herbicides affects the *Rhizobium* sp. (Rafia *et al.* 2007), and the legume – *Rhizobium* symbiosis (Martensson, 1992), nodulation (Anikwe *et al.* 2003), leghemoglobin (Mohd. *et al.*, 2004). Among the chemicals, botanicals considering its' lesser ill effect on environment are also considered for weed management in legume crops (Ghosh Subrata, 2006).

Field experiment conducted at Instructional Farm (Jaguli), Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia during pre-*kharif* 2009 and 2010 on groundnut (*Arachis hypogaea* L.), soybean (*Glycine max*), green gram (*Vigna radiata*) and black gram (*Vigna mungo*) with the objectives to study the effect of both synthetic herbicides and natural botanicals on nodulation, yield and bio-efficacy & phytotoxicity on both weeds and crops and also their effect on soil micro flora. Four separate experiments were carried out with Oilseed legumes (groundnut & soybean), Pulse legumes (green gram and black gram) in Randomized Block Design with three replications and seven treatments *viz.* POE application of herbicides Imazethapyr 10 SL @100 g ha^{-1} (T_1), Quizalofop-ethyl 5 EC @ 50 g ha^{-1} (T_2) and Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1} (T_3); PE application of Oxyfluorfen 23.5 EC @ 200 g ha^{-1} (T_4) and tank mixture of botanicals *Calotropis* & *Parthenium* raw leaf extract 5% v/v (T_5) besides Hand Weeding at 20 DAS (T_6) and control (T_7).

The results (Pooled data) revealed that the nodulation of all four crops in terms of number nodules content $plant^{-1}$ has reduced by 5.45 % in groundnut, 7.34 % in soybean, 6.27 % in green gram and 4.93 % in black gram as against application of three POE chemicals at flowering stage. The corresponding figures were 2.47 % decreased & 6.96 % increased; 2.63 % decreased & 8.65 % increased; 3.46 % decreased & 7.52 % increased and 2.18 % decreased & 5.70 % increased for PE chemicals and botanicals,

respectively. The dry weight of nodules were also followed the same trend of variations. The leghemoglobin contents were also recorded with similar variations *i.e.* 3.45 % in groundnut, 3.67 % in soybean, 7.46 % in green gram, 10.11 % in black gram as against application of three POE chemicals. The corresponding figures were 1.19 % decreased & 3.78 % increased; 1.00 % decreased & 3.89 % increased; 1.88 % decreased & 7.90 % increased and 3.65 % decreased & 10.22 % increased for PE chemicals and botanicals, respectively. All the chemical herbicides applied on legumes showed an adverse affect on the *rhizobium* population, as a result, symbiotic association of root nodule-*rhizobium* were also reduced. When the herbicides were degraded they allowed the multiplication of *rhizobium* bacteria as a result due to symbiotic association of *rhizobium* with newly emerged root produced higher nodule number at later stage. With increment of the nodule-*rhizobium* symbiotic association in legumes as the progress of the crop age, leghemoglobin content was also increased. This may be due to the reason that nodules are generally formed when a single bacterium infects a root hair and subsequently bacterial infection can only occur if both the bacteria and root hairs are present. Therefore, at later stage of the crop when chemicals were degraded, in the newly appeared fresh roots root hairs were formed that enabled nodule-*rhizobium* symbiotic association. The observations on microflora population of the soil showed almost similar to that of nodulation – an initial decrease followed by increase at harvest. Botanicals and hand weeding did not show any adverse effect either on nodulation or on microflora population of the experimental soil.

Among all the treatments hand weeding as recorded lowest weed dry matter in all stages excepting in first observation at 15 DAS, offered lesser crop weed competition which ultimately reflected on the growth and yield of all legume crops followed by Imazethapyr 10 SL. The yield was increased (pooled data) in HW treated plot by 26.92 % in groundnut, 31.09 % in soybean, 25.14 % in green gram and 26.00 % in black gram) as against average. The corresponding figures for the treatment Imazethapyr 10 SL and Oxyflourfen were 22.31 % & 6.15 %; 25.91 % & 16.58 %; 20.83 % & 12.64 % and 17.63 % & 6.50 % respectively.

From this experiment, for increasing the productivity by managing weed flora in legume oilseed and pulse crops the safer chemicals or botanicals with proper doses and application time is the best alternative of the traditional hand weeding as highest net return was obtained from it and also chemicals had no such detrimental effect on nodulation of legumes in this inceptisol.

Contents

Chapter		Title	Page No.
1		**Introduction**	1-3
2		**Review of literature**	**4-34**
	2.1	Weed management through herbicides	4-13
	2.2	Effect of botanicals on weeds	13-15
	2.3	Effect of herbicides on nodulation	15-17
	2.4	Weed management through herbicides and their effect on crop growth	17-22
	2.5	Weed management through herbicides and their effect on yield attributing characters and yield	22-30
	2.6	Economics of weed management	30-34
	2.7	Effect of herbicides on the *rhizosphere* micro flora	34
3		**Materials & Methods**	**35-61**
	3.1	Experimental site	35
	3.2	Climate and weather condition	35
	3.3	Status of the experimental soil	37
	3.4	Cropping history of the experimental plot	38
	3.5	Experimental details	38
	3.6	Chemical nature of the herbicide used	39
	3.6.1	Imazethapyr	39
	3.6.2	Quizalofop-ethyl	41
	3.6.3	Fenoxaprop-p-ethyl	42
	3.6.4	Oxyfluorfen	43
	3.6.5	*Calotropis* extract	46
	3.6.6	*Parthenium* extract	47
	3.7	Spraying schedule	48
	3.8	Details of the crop grown	48
	3.8.1	Description of the green gram variety used in the experiment	48
	3.8.2	Description of the black gram variety used in the experiment	48

Chapter	Title	Page No.
3.8.3	Description of the soybean variety used in the experiment	49
3.8.4	Description of the groundnut variety used in the experiment	49
3.8.5	Description of the rice variety used in the experiment	49
3.9	Layout of the Experimental Plot	50
3.10	Fertilizer application	50
3.10.1	Application of fertilizer for *pre-kharif* legume crop	50
3.10.2	Application of fertilizer for followup *kharif* direct seeded rice	50
3.11	Formulae adopted for calculation of different chemicals required in the experiment	53
3.11.1	Herbicide application	53
3.11.2	Fertilizer application	53
3.11.3	Insecticide application	53
3.12	Methods of recording different biometrical observations	53
3.12.1	Method for calculating growth attributes	53
3.12.1.1	Plant height	53
3.12.1.2	Dry matter accumulation	54
3.12.1.3	Crop growth rate (CGR)	54
3.12.1.4	Leaf area index (LAI)	54
3.12.1.5	Volume of Root	55
3.12.2	Methods for recording yield attribute	55
3.12.2.1	Number of branches plant^{-1}	55
3.12.2.2	Number of pods plant^{-1}	55
3.12.2.3	Number of seeds pod^{-1}	55
3.12.2.4	Test weight (1000 seeds)	55
3.12.2.4	Shelling percentage of groundnut	55
3.12.3	Methods for recording nodulation data	55

Chapter	Title	Page No.
3.12.3.1	Number of nodule plant^{-1}	55
3.12.3.2	Dry matter of nodule plant^{-1}	56
3.12.3.3	Leghemoglobin content of nodules	56
3.12.4	Methods for recording yield	56
3.12.4.1	Seed yield	56
3.12.4.2	Stalk yield	56
3.12.4.3	Pod yield of groundnut	56
3.12.4.4	Kernel yield of groundnut	56
3.12.5	Observation during follow up rice crop	57
3.12.6	Biometrical observation on weeds	57
3.12.6.1	Weed population	57
3.12.6.2	Dry weight of weeds	57
3.12.6.3	Weed Control Efficiency (WCE)	57
3.12.7	Observation on phytotoxicity effect on crops	58
3.12.8	Soil analysis	58
3.12.8.1	Mechanical analysis of soil	58
3.12.8.2	Chemical analysis of soil	58
3.12.8.2.1	Soil pH	58
3.12.8.2.2	Organic carbon content of the soil	59
3.12.8.2.3	Total Nitrogen content of the soil	59
3.12.8.2.4	Available phosphate (P_2O_5) content of the soil	59
3.12.8.2.5	Available potash (K_2O) in soil	59
3.12.8.3	Methods of analysis for study on the soil micro flora	59
3.12.8.3.1	Total bacteria	59
3.12.8.3.2	Actinomycetes	60
3.12.8.3.3	Fungi	60
3.12.9	Method of statistical analysis	61

Chapter		Title	Page No.
4		**Results**	62-148
	4.1	Study on weed flora	62
	4.1.1	Severity of different weeds in experimental plots	62
	4.1.2	Population of weeds	63
	4.1.2.1	Effect of weed management treatments on population of weeds at 15 DAS	63
	4.1.2.2	Effect of weed management treatments on population of weeds at 30 DAS	65
	4.1.2.3	Effect of weed management treatments on population of weeds at 45 DAS	75
	4.1.3	Dry weight of weeds	79
	4.1.3.1	Effect of weed management treatments on dry weight of weeds at 15 DAS	79
	4.1.3.2	Effect of weed management treatments on dry weight of weeds at 30 DAS	84
	4.1.3.3	Effect of weed management treatments on dry weight of weeds at 45 DAS	85
	4.2	Studies on nodulation	93
	4.2.1	Effect of weed management methods on number of nodule $plant^{-1}$	93
	4.2.2	Effect of weed management methods on dry weight of nodule $plant^{-1}$	94
	4.2.3	Effect of weed management methods on Leg hemoglobin content (mg g^{-1}) nodule	100
	4.3	Studies on growth characters of legumes	103
	4.3.1	Effect of weed management methods on plant height	103
	4.3.2	Effect of weed management methods on LAI	108
	4.3.3	Effect of weed management methods on dry matter production of crop	112
	4.3.4	Effect of weed management methods on Crop growth rate (CGR)	116
	4.3.5	Effect of weed management methods on root volume of crop	119

Chapter		Title	Page No.
	4.3.6	Effect of weed management methods on phytotoxicity of legume crops	123
	4.4	Studies on yield	123
	4.4.1	Effect of weed management methods on yield attributing characters of crop	123
	4.4.1.1	Number of branches plant^{-1}	123
	4.4.1.2	Pods plant^{-1}	123
	4.4.1.3	Kernels/Seeds pod^{-1}	130
	4.4.1.4	Test weight	130
	4.4.2	Effect of weed management methods on yield of crop	130
	4.5	Studies on soil micro flora	133
	4.5.1	Effect of weed management methods on total bacteria (CFU x 10^6 g^{-1} of soil)	133
	4.5.2	Effect of weed management methods on Fungi (CFU x 10^4 g^{-1} of soil)	136
	4.5.3	Effect of weed management methods on Actinomycetes (CFU x 10^5 g^{-1})	137
	4.6	Studies on residual effect in succeeding direct seeded rice crop	143
	4.7	Studies on economics	143
5		**Discussions**	**149-170**
	5.1	Effect of weed management methods on population and dry weight of dominant weeds	149
	5.2	Effect of weed management methods on nodulation of legume crops	155
	5.2.1	Nodule number and dry weight	155
	5.2.2	Leghemoglobin content of nodule	161
	5.3	Effect of weed management methods on crop growth	166
	5.4	Effect of weed management methods on yield attributing characters and yield	167
	5.5	Effect of weed management methods on soil micro flora	168

Chapter		Title	Page No.
	5.6	Effect of weed management methods on follow up crop	170
	5.7	Economics of weed management	170
6		**Summary and conclusion**	**171-173**
7		**Future scope of research**	**174**
		Bibliography	***i-xxii***
		Appendices	***i***

List of Tables

Table No.	Title	Page No.
3.1	Meteorological observations during the experimental period	36
3.2	Physico-chemical properties of the experimental soil	38
3.3	Previous crop history	38
3.4	Details of the treatments	39
3.5	Spraying schedule	48
3.6	Calendar of Farm Work	51
3.7	Quantitative description of phytotoxic effects on crops	58
4.1	Details of the dominant weed species found in the experimental field	62
4.2	List of the minor weed flora of the experimental field	63
4.3	Effect of WM treatments on population of monocot weeds (m^{-2}) at 15 DAS of groundnut	67
4.4	Effect of WM treatments on population of dicot weeds (m^{-2}) at 15 DAS of groundnut	67
4.5	Effect of WM treatments on population of monocot weeds (m^{-2}) at 15 DAS of soybean	68
4.6	Effect of WM treatments on population of dicot weeds (m^{-2}) at 15 DAS of soybean	68
4.7	Effect of WM treatments on population of monocot weeds (m^{-2}) at 15 DAS of green gram	69
4.8	Effect of WM treatments on population of dicot weeds (m^{-2}) at 15 DAS of green gram	69
4.9	Effect of WM treatments on population of monocot weeds (m^{-2}) at 15 DAS of black gram	70
4.10	Effect of WM treatments on population of dicot weeds (m^{-2}) at 15 DAS of black gram	70
4.11	Effect of WM treatments on population of monocot weeds (m^{-2}) at 30 DAS of groundnut	71
4.12	Effect of WM treatments on population of dicot weeds (m^{-2}) at 30 DAS of groundnut	71

Table No.	Title	Page No.
4.13	Effect of WM treatments on population of monocot weeds (m^{-2}) at 30 DAS of soybean	72
4.14	Effect of WM treatments on population of dicot weeds (m^{-2}) at 30 DAS of soybean	72
4.15	Effect of WM treatments on population of monocot weeds (m^{-2}) at 30 DAS of green gram	73
4.16	Effect of WM treatments on population of dicot weeds (m^{-2}) at 30 DAS of green gram	73
4.17	Effect of WM treatments on population of monocot weeds (m^{-2}) at 30 DAS of black gram	74
4.18	Effect of WM treatments on population of dicot weeds (m^{-2}) at 30 DAS of black gram	74
4.19	Effect of WM treatments on population of monocot weeds (m^{-2}) at 45 DAS of groundnut	76
4.20	Effect of WM treatments on population of dicot weeds (m^{-2}) at 45 DAS of groundnut	76
4.21	Effect of WM treatments on Population of monocot weeds (m^{-2}) at 45 DAS of soybean	77
4.22	Effect of WM treatments on population of dicot weeds (m^{-2}) at 45 DAS of soybean	77
4.23	Effect of WM treatments on population of monocot weeds (m^{-2}) at 45 DAS of black gram	78
4.24	Effect of WM treatments on population of dicot weeds (m^{-2}) at 45 DAS of blackgram	78
4.25	Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 15 DAS of groundnut	80
4.26	Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 15 DAS of groundnut	80
4.27	Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 15 DAS of soybean	81
4.28	Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 15 DAS of soybean	81
4.29	Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 15 DAS of green gram	82

Table No.	Title	Page No.
4.30	Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 15 DAS of green gram	82
4.31	Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 15 DAS of black gram	83
4.32	Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 15 DAS of black gram	83
4.33	Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 30 DAS of groundnut	86
4.34	Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 30 DAS of groundnut	86
4.35	Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 30 DAS of soybean	87
4.36	Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 30 DAS of soybean	87
4.37	Effect of WM treatments on dry weight of monocot weeds m^{-2} at 30 DAS of green gram	88
4.38	Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 30 DAS of green gram	88
4.39	Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 30 DAS of black gram	89
4.40	Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 30 DAS of black gram	89
4.41	Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 45 DAS of groundnut	90
4.42	Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 45 DAS of groundnut	90
4.43	Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 45 DAS of soybean	91
4.44	Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 45 DAS of soybean	91
4.45	Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 45 DAS of black gram	92
4.46	Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 45 DAS of black gram	92

Table No.	Title	Page No.
4.47	Effect of WM treatments on nodule number of groundnut	95
4.48	Effect of WM treatments on nodule number of soybean	95
4.49	Effect of WM treatments on nodule number of green gram	96
4.50	Effect of WM treatments on nodule number of black gram	96
4.51	Effect of WM treatments on dry weight of groundnut nodule	98
4.52	Effect of WM treatments on dry weight of soybean nodule	98
4.53	Effect of WM treatments on dry weight of green gram nodule	99
4.54	Effect of WM treatments on dry weight of black gram nodule	99
4.55	Effect of WM treatments on leghemoglobin content of groundnut nodule	101
4.56	Effect of WM treatments on leghemoglobin content of soybean nodule	101
4.57	Effect of WM treatments on leghemoglobin content of green gram nodule	102
4.58	Effect of WM treatments on leghemoglobin content of black gram nodule	102
4.59	Effect of WM treatments on plant height of groundnut	105
4.60	Effect of WM treatments on plant height of soybean	105
4.61	Effect of WM treatments on plant height of green gram	107
4.62	Effect of WM treatments on plant height of black gram	107
4.63	Effect of WM treatments on LAI of groundnut	110
4.64	Effect of WM treatments on LAI of soybean	110

Table No.	Title	Page No.
4.65	Effect of WM treatments on LAI of green gram	111
4.66	Effect of WM treatments on LAI of black gram	111
4.67	Effect of WM treatments on dry matter production of groundnut	113
4.68	Effect of WM treatments on dry matter production of soybean	113
4.69	Effect of WM treatments on dry matter production of green gram	115
4.70	Effect of WM treatments on dry matter production of black gram	115
4.71	Effect of WM treatments on CGR of groundnut	117
4.72	Effect of WM treatments on CGR of soybean	117
4.73	Effect of WM treatments on CGR of Green gram	118
4.74	Effect of WM treatments on CGR of black gram	118
4.75	Effect of WM treatments on root volume of groundnut	121
4.76	Effect of WM treatments on root volume of soybean	121
4.77	Effect of WM treatments on root volume of green gram	122
4.78	Effect of WM treatments on root volume of black gram	122
4.79	Phytotoxicity in groundnut crops	124
4.80	Phytotoxicity in soybean crops	125
4.81	Phytotoxicity in green gram crops	126
4.82	Phytotoxicity in black gram crops	127
4.83	Effect of WM treatments on yield attributing characters of groundnut	128
4.84	Effect of WM treatments on yield attributing characters of soybean	128
4.85	Effect of WM treatments on yield attributing characters of green gram	129
4.86	Effect of WM treatments on yield attributing characters of black gram	129
4.87	Effect of WM treatments on yield of groundnut and WCE	131

Table No.	Title	Page No.
4.88	Effect of WM treatments on yield of soybean and WCE	131
4.89	Effect of WM treatments on yield of green gram and WCE	132
4.90	Effect of WM treatments on yield of black gram and WCE	132
4.91	Influence of WM treatments on total bacteria (CFU x 10^6 g^{-1} of soil) in groundnut	134
4.92	Influence of WM treatments on total bacteria (CFU x 10^6 g^{-1} of soil) in soybean	134
4.93	Influence of WM treatments on total bacteria (CFU x 10^6 g^{-1} of soil) in green gram	135
4.94	Influence of WM treatments on total bacteria (CFU x 10^6 g^{-1} of soil) in black gram	135
4.95	Influence of WM treatments on Fungi (CFU x 10^4 g^{-1} of soil) in groundnut	139
4.96	Influence of WM treatments on Fungi (CFU x 10^4 g^{-1} of soil) in soybean	139
4.97	Influence of WM treatments on Fungi (CFU x 10^4 g^{-1} of soil) in green gram	140
4.98	Influence of WM treatments on Fungi (CFU x 10^4 g^{-1} of soil) in black gram	140
4.99	Influence of WM treatments on Actinomycetes (CFU x 10^5 g^{-1} of soil) in groundnut	141
4.100	Influence of WM treatments on Actinomycetes (CFU x 10^5 g^{-1} of soil) in soybean	141
4.101	Influence of WM treatments on Actinomycetes (CFU x 10^5 g^{-1} of soil) in green gram	142
4.102	Influence of WM treatments on Actinomycetes (CFU x 10^5 g^{-1} of soil) in black gram	142
4.103	Population and yield of follow up DS Rice in groundnut experiment	144
4.104	Population and yield of follow up DS Rice in soybean experiment	144

Table No.	Title	Page No.
4.105	Population and yield of follow up DS Rice in green gram experiment	145
4.106	Population and yield of follow up DS Rice in black gram experiment	145
4.107	Economics of weed management in groundnut	146
4.108	Economics of weed management in soybean	146
4.109	Economics of weed management in green gram	147
4.110	Economics of weed management in black gram	147
5.1	Correlations matrix among dry matter accumulation, root volume, nodule plant^{-1}, dry weight of nodule, leghemoglobin content of nodule, no. of pod plant^{-1}, no. of seed pod^{-1}, soil micro flora, weed dry mass and pod yield of groundnut	151
5.2	Correlations matrix among dry matter accumulation, root volume, nodule plant^{-1}, dry weight of nodule, leghemoglobin content of nodule, no. of pod plant^{-1}, no. of seed pod^{-1}, soil micro flora, weed dry mass and seed yield of soybean	152
5.3	Correlations matrix among dry matter accumulation, root volume, nodule plant^{-1}, dry weight of nodule, leghemoglobin content of nodule, No. of pod plant^{-1}, no. of seed pod^{-1}, soil micro flora, weed dry mass and seed yield of green gram	153
5.4	Correlations matrix among dry matter accumulation, root volume, nodule plant^{-1}, dry weight of nodule, leghemoglobin content of nodule, no. of pod plant^{-1}, no. of seed pod^{-1}, soil micro flora, weed dry mass and seed yield of black gram	154

List of Figure

Figure No.	Title	Page No.
3.1	Layout of the experimental plot	50
5.1	No. of nodule plant $^{-1}$ in groundnut	157
5.2	Percentage (%) increase or decrease over average nodule number plant^{-1} in groundnut	157
5.3	No. of nodule plant $^{-1}$ in soybean	158
5.4	Percentage (%) increase or decrease over average nodule number plant^{-1} in soybean	158
5.5	No. of nodule plant $^{-1}$ in green gram	159
5.6	Percentage (%) increase or decrease over average nodule number plant^{-1} in green gram	159
5.7	No. of nodule plant $^{-1}$ in black gram	160
5.8	Percentage (%) increase or decrease over average nodule number plant^{-1} in black gram	160
5.9	Leghemoglobin content (mg g^{-1}) in groundnut nodule	162
5.10	Percentage (%) increase or decrease over average Leghemoglobin content in groundnut	162
5.11	Leghemoglobin content (mg g^{-1}) in soybean nodule	163
5.12	Percentage (%) increase or decrease over average Leghemoglobin content in soybean	163
5.13	Leghemoglobin content (mg g^{-1}) in green gram nodule	164
5.14	Percentage (%) increase or decrease over average Leghemoglobin content in green gram	164
5.15	Leghemoglobin content (mg g^{-1}) in black gram nodule	165
5.16	Percentage (%) increase or decrease over average Leghemoglobin content in black gram	165
5.17	Influence of treatments on population (mean) of total bacteria (CFU x 10^6 g^{-1} of soil)	169
5.18	Influence of treatments on population (mean) of Fungi CFU x 10^4 g^{-1} of soil)	169
5.19	Influence of treatments on population (mean) of Actinomycetes (CFU x 10^5 $g^{-1}$of soil)	169

List of Plate

Figure No.	Title	Page No.
4.1	Weed flora of experimental plot	64
4.2	Nodule of different legume crops	97
4.3	Analysis of soil micro flora	138

Chapter-1

Introduction

INTRODUCTION

The two plant families of greatest importance in world agriculture are the Poaceae (cereals and grasses) and the Leguminosae. The legume family contains about 730 genera and 19400 species. In terms of production volume, the cereals are the most important as they furnish the carbohydrates that constitute the major portion of human and animal diets. On the other hand, in terms of sheer numbers of genera and species used by humans, the legumes are by far the most utilized plant family are used for chemicals, esthetic value, timber, as cooking fuel, browse trees and shrubs, forage crops, pasture crops, cover crops, green manures, for feed and food. Legumes form a major component of the human diet. They are easily stored and transported. Several grain legumes play major roles in world commerce. Not only do the legumes provide variety to the human diet but they also supply dietary protein for many populations lacking animal or fish protein. In general, the legumes are rich in lysine but poor in methionine content, thereby complementing the reverse amino acid pattern found in cereals. Additionally, virtually all of the grain legumes fix their own nitrogen, thereby reducing, in many situations, the cost of nitrogen inputs by farmers. The grain legumes, especially soybean and groundnut are excellent sources of vegetable oils used in the production of cooking oil, margarine, mayonnaise and salad dressings.

Traditionally in India the system was using legumes as normal diet. India is the largest producer of legumes in the world with 25 % share in global production. Most pulse crops, some oil seed crops and many fodder crops are under this legumes cultivating in India. Chickpea (*Cicer arietinum*), pigeon pea (*Cajanus cajan*), green gram (*Vigna radiata*), black gram (*Vigna mungo*), lentil (*Lens culinaris*), and fieldpea (*Pisum sativum*) are important pulse crop contributing 39, 21, 11, 10, 7 and 5 % to the total production of pulses in the country. The total production was estimated 14.56 m t and an area of 23.63 m ha with average productivity 616 kg ha^{-1} (MOSPI, 2008-09). Groundnut is the major oilseed of India accounts for around 25% of the total oilseed production of the country. Annual production of Indian groundnut (*Arachis hypogaea* L.) and Indian groundnuts oil are around 5 – 8 m & 1.5 m t respectively (Crop Report, 2010). In case of soybean (*Glycine max*) India annually produce 8 - 10 m t sharing 4 % global production. In recent years, price of legumes has been increasing drastically forcing small scale farmers to take up the crop at least for home consumption. These plants have the advantage of fixing atmospheric nitrogen for their own needs and for soil enrichment, thereby reducing the cost of fertilizer inputs in crop farming.

Further, during the production of legume crops, dicot and monocot weeds that appear in the crop field, are adversely affect the crop productivity. In addition to yield losses weeds can also affect quality of produce, increase the incidence of disease and insect problems, cause premature stand loss and create harvesting problems. The importance of weed control in legumes should not be overlooked, especially when consider the high investment. Weed management strategies in legumes should focus first on cultural practices and then on chemical weed control practices. At present situation considering the NPV, chemicals are preferred to control weeds in order to augment the productivity.

Biological nitrogen fixation is the major source of nitrogen input in agricultural systems. *Rhizobia* is co-symbiotic bacteria that elicit on the roots of specific legume hosts the formation of new organs *i.e.* nodule, within which the bacteria proliferates, differentiate into bacteroids and subsequently the atmospheric nitrogen into ammonia. The nitrogen fixing bacterium *Bradyrhizobium* sp. forms a specific symbiosis with legumes and is commonly applied to the seed or soil as microbial inoculants. The aim of inoculation is to provide sufficient numbers of viable *rhizobia* to induce rapid colonization of the *rhizosphere* whereby nodulation takes place as soon as possible after germination and produce optimal nodules. High protein legume crops have high nitrogen requirements that typically are met through inoculation with effective nitrogen fixing *rhizobia*. The amount of nitrogen (N) supplied by fixation depends not only on the ability of the inoculants *rhizobia* to fix nitrogen, but also on the ability of the plant to provide energy to the *rhizobia* in the nodules. Thus, any factor or factors that influence either the *rhizobia* directly or the ability of the plant to send energy to the nodules, may have a negative impact on nitrogen fixation. Herbicide application, both in crop and soil applied, is known to affect plant growth and microbial activity and thus it is possible that some herbicides having more toxicity may influence nitrogen fixation. Chemicals when applied have variable effects on legume production and when applied frequently, are accumulated in to the soil and at elevated levels impair the metabolic activities resulting in reduced growth of *rhizobia*. For instance, several chemical herbicides affects the *Rhizobium* sp. (Rafia *et al.* 2007), and the legume – *Rhizobium* symbiosis (Martensson, 1992), nodulation (Anikwe *et al.* 2003), leghemoglobin (Mohd. *et al.*, 2004). Unfortunately, current understanding of the nature and the magnitude of these effects is incomplete and in some instances research results are contradictory. The uncertainty regarding herbicide-inoculant interactions largely is due to the seemingly inexhaustible combinations of herbicides, crops, crop varieties, *Rhizobium* species & strains, soil types and environment – and the interactions that occur between all of these factors.

In this experiment, an attempts has been made to find out the effect of both synthetic herbicides and natural botanicals on four legume crops (groundnut and soybean two legume oil seeds and green gram and black gram two legume pulses) during summer season of 2009 and 2010 in the gangetic alluvial soil with following objectives,

- To study the bio-efficacy of the herbicides on the weed flora present in four legume crops.
- To study the phytotoxicity of the herbicides on both weeds and crops.
- To study the effect of chemical herbicides on the density and biomass of nodules in four summer growing legume crops.
- To study the effect of treatments on the growth and yield attributing characters of these legume crops.
- To study the effect of chemical herbicides and botanicals on micro-flora population in soil.

Chapter-2

Review of Literature

REVIEW OF LITERATURE

Several research works were conducted on herbicide effect on legume crops for managing different weed flora and their relation on growth and yield of crops by a number of scientists in India and abroad that have formed the basis of the experiment. A brief review was made on the following points *i.e.* weed management through herbicides, weed management through botanicals, effect of herbicides on legumes, effect of weed management on growth, yield and economics of legume crops and on soil microbial population.

2.1 Weed management through herbicides

Groundnut

Rafey and Prasad (1995) reported from field trials in sandy loam soil at Ranchi during *kharif* on weed control with Pendimethalin @ 1.0 & 1.5 kg ha^{-1}, Oxyfluorfen @ 1.0 kg ha^{-1}, Butachlor @ 1.5 kg ha^{-1}, 1.5 kg ha^{-1} Thiobencarb applied as PE, HW once 25 DAS and HW twice 15 & 25 DAS on groundnut cv. AK 12-24. PE applications of Pendimethalin (1.5 kg ha^{-1}), Butachlor and Oxyfluorfen were found to be comparable with HW twice in reducing weed density and dry weight, as well as in increasing pod yield $plant^{-1}$. Among the chemical weed control methods, PE applications of Oxyfluorfen had the lowest WI (9.7%), followed by Pendimethalin @ 1.5 kg ha^{-1} (11.6%).

Bhagat *et al.* (2002) conducted experiment with Pendimethalin, Oxyfluorfen, oxadiazon, Metolachlor integrated with hoeing and HW in groundnut cv. TAG-24 reported that all the herbicide treatments decreased weed population compared to the unweeded control.

Quizalofop applied early POE and Fenoxaprop applied sequentially provided common Bermuda grass control equivalent to fluazifop-P (Grichar, 1995).

Grey *et al.* (1995) reported that Imazethapyr applied alone early POE, with no further treatment, provided optimum *Cyperus esculentus* control.

Successful control of *Commelina benghalensis* and of other weeds achieved through the PE and POE applications of Imazethapyr (0.1 to 0.12 kg ha^{-1}) and the PE application of a mixture of Imazethapyr with Alachlor (Vouzounis, 2006).

Kavalappa *et al.* (1988) conducted field study in Bangalore using groundnuts cv. BH 8-18 with fertilizer and weed control treatments *i.e.* Dinitramine @ 1.0 kg ha^{-1} and HW followed by hoeing (20 and 40 DAS). Herbicide treatments and HW + hoeing reduced weed growth and also reduced the loss of nutrients.

Singh *et al.* (1996) conducted field experiment at Barapani on groundnuts cv. JL 24 with combinations of HW, herbicides (Pendimethalin and Butachlor) and mechanical weeding, found that Two HW and 1 kg Pendimethalin ha^{-1} with 1 HW at 40 DAS were equally effective at reducing weed population and dry weight as compared with unweeded controls.

Sujith *et al.* (2000) reported that Alachlor @ 2 kg ha^{-1} applied in irrigation water resulted in a significantly lower weed population in groundnut. The interaction effect between irrigation schedules and methods of herbicide application was significant.

Jhala *et al.* (2005) conducted experiment with sole application of Fluchloralin, Pendimethalin, Butachlor and Metolachlor, respectively each applied @ 1.0 kg ha^{-1}; next four treatments comprising application of same herbicides at the same dose with one HW at 30 DAS; one weed free treatment (HW at 15, 30, 45 DAS); and one unweeded control in groundnut, found that Pendimethalin @ 1.0 kg ha^{-1} + HW at 30 DAS gave minimum weed dry matter accumulation (70 kg ha^{-1}) with higher WCE (90.70%). This treatment was comparable to Fluchloralin applied @ 1.0 kg ha^{-1} combined with HW at 30 DAS.

Bailey and Wilcut (2002) reported that pre plant incorporation of Ethalfluralin + Diclosulam @ 17 or 26 g ha^{-1} followed by POE Acifluorfen plus Bentazon, Paraquat plus Bentazon or Imazapic controlled common *Chenopodium album, Ipomoea hederacea ,I. lacunose, Amaranthus hybridus, Anoda cristata and Cyperus esculentus.*

Acetochlor applied @ 900ml ha^{-1} gave control of 97.6% for monocot and 83.8% for dicot weeds (Liu-Jian *et al.*, 2000).

Grichar (2002) conducted experiments with POE Imazapic @ 0.05 and 0.07 kg ha^{-1}, Imazethapyr @ 0.07 kg ha^{-1}, and pre plant incorporation Metolachlor @ 1.7

kg ha^{-1} on groundnut (cv. GK-7) found that all herbicides controlled *Cyperus* sp 75% after 3 years.

Soybean

Singh (2005) after conducting experiment reported that Pendimethalin and Alachlor were very effective against most of the weeds and Quizalofop-ethyl was not effective against dicot weeds, but was effective against monocot weeds.

Kushwah and Vyas (2005) conducted experiment during 2001 and 2002 on soybean and reported that application of Imazethapyr 10 SL @ 75 g ha^{-1} was the most effective in reducing weed biomass and gave the highest weed control efficiency over other pre and POE herbicides. Quizalofop ethyl 5 EC @ 50 g ha^{-1} was also found effective particularly controlled the monocot weeds effectively.

Pandey *et al.* (2007) conducted experiment and reported that total density and dry matter of weeds was minimum at 30 DAS under PE application of Metolachlor (750 ml ha^{-1}) but at 60 DAS, the POE application of Imazamox + Imazethapyr (800 ml ha^{-1}) was found more effective. Among the POE herbicides, quizalofop-ethyl and quizalofop-p-tefuril significantly reduced the growth of monocots while Imazamox and Imazamox + Imazethapyr paralyzed the dicot weeds.

Application of Imazamox + Imazethapyr was found most effective in reducing weed count and biomass and resulted in higher weed control efficiency over other PE and POE herbicides (Pandey *et al.*, 2007).

Angiras and Rana (1995) conducted experiment during *kharif* 1990 and 1991 with Imazethapyr @ 50, 100, 150 and 200 g ha^{-1} in soybean revealed that lower dry matter and weed counts of all the weed species, except *Aeschynomene indica* were obtained with PE application of Imazethapyr @ 200 g ha^{-1} and HW twice and PE Imazethapyr @ 150 g ha^{-1}.

Bhattacharya *et al.* (1994) conducted experiment with Chlorimuron @ 3-24 g ha^{-1}, Metsulfuron @ 4 g ha^{-1}, Chlorimuron + Metsulfuron @ 2 + 2-4 g ha^{-1}, Oxyfluorfen @ 100 g ha^{-1} and Pendimethalin @ 750 g ha^{-1} analyzed that Chlorimuron @ 24 g ha^{-1} has greatest weed control ability at 60 and 80 DAS of soybean.

Ellis *et al.* (1998) conducted experiment and showed that Glufosinate @ 0.84, 1.1 and 1.4 kg ha^{-1} desiccated all weeds in soybean field by 90%. The addition of 3.4 or 6.7 kg ha^{-1} sodium chlorate to 0.28 kg ha^{-1} Paraquat, 1.1 and 2.2 kg ha^{-1} Glyphosate or 0.28 and 0.56 kg ha^{-1} Oxyfluorfen increased desiccation of most weeds.

Patra (1999) found that PE application of Oxyfluorfen had 49% weed control efficiency in soybean field.

Bhattacharya *et al.* (1998) observed during experiment in soybean *rabi* 1997-98 Imazethapyr @ 0.15 kg ha^{-1} and Pendimethalin @ 1.0 kg ha^{-1} as PE applications gave an effective level of weed control. No phytotoxicity was observed. Imazethapyr @ 0.15 kg ha^{-1} gave the most effective level of control across different weed categories.

Sarpe *et al.* (1999) viewed that application of Quizalofop-p-tefuryl @ 40 g $litre^{-1}$ provided 96-100% control of *Sorghum halepense* in soybean field.

Mandloi *et al.* (2000) conducted experiment on soybean weed control revealed that lowest weed dry matter was recorded HW treatment at 30 and 45 DAS followed by Fenoxaprop-p-ethyl @ 70 g ha^{-1} as POE.

The PE application of Oxyfluorfen or Metolachlor with Pendimethalin significantly reduced weed density and dry weight at the early stages in soybean field (Reddy *et al.*, 2003).

Idapuganti *et al.* (2005) reported that Quizalofop-ethyl was the most effective against *Echinochloa colona* and *Cyperus rotundus* among Alachlor (2.0 kg ha^{-1}), quizalofop-ethyl @ 0.05 kg ha^{-1}, Fluchloralin @ 1.0 kg ha^{-1}, Pendimethalin @ 1.0 kg ha^{-1}.

Girothia and Thakur (2006) conducted experiment during the *kharif* of 2000 and 2001 to find out the efficacy of pre plant incorporation of Trifluralin 48 EC @ 1.2 kg ha^{-1}, PE application of Pendimethalin 30 EC @ 1.00 kg ha^{-1} and POE application of Imazethapyr 10 SL @ 75 or 100 g ha^{-1}, Imazamox 12 EC @ 30 or 40 g ha^{-1} and Imazamox (2.5%) + Imazethapyr (2.5%) @ 800 or 1000 ml ha^{-1} on soybean field observed from pooled results Imazamox + Imazethapyr @ 800 and 1000 ml ha^{-1}, and Imazethapyr 10 SL @ 75 and 100 g ha^{-1} were equally effective as the weed free treatment up to 60 DAS.

Billore *et al.* (2006) studied on PE and pre planting application of Oxyfluorfen @ 0.25, 0.50, 0.75 or 1.00 kg ha^{-1} on soybean concluded that PE application of Oxyfluorfen @ 0.75 and 1.00 kg ha^{-1} recorded the highest monocot weed control efficacy (90.40 and 74.58%) at 30 and 60 DAS and @ 0.50, 0.75 and 1.00 kg ha^{-1} showed 70.82, 75.35 and 79.44% dicot weed control efficacy at 30 DAS, whereas the highest dicot weed control efficiency (74.67%) at 60 DAS was recorded from Oxyfluorfen @ 0.75 kg ha^{-1}. The highest total weed control efficiency at 30 and 60 DAS (83.12 and 74.18%) was registered for PE application Oxyfluorfen 0.75 kg ha^{-1}.

Shete *et al.* (2007) observed that the soybean yield attributing characters were significantly higher under mechanical weed control which was at par with application of Imazethapyr @ 87.5 g ha^{-1}. Weed control efficiency, dry matter of weed were observed significantly highest in the application of Imazethapyr @ 87.5 g followed by @ 75 g ha^{-1} at harvest.

Experiment on weed control with POE application of Imazethapyr 70% @ 52.5, 75 and 87.5 g ha^{-1}, Chlorimuron-ethyl 25 WP @ 9.37 g ha^{-1} , Fenoxoprop-p-ethyl 9% @ 67.5 , one hoeing (20 DAS)+2 HW (30 and 60 DAS) , weedy control on soybean cv. DS-228 conducted by Shete *et al.* (2008) found that Imazethapyr 70% @ 87.5 g ha^{-1} gave highest WCE (85.77%) and higher yield among all herbicides.

Dhane *et al.* (2009) viewed that the application of Imazethapyr @ 100 g ha^{-1}+one HW at 30 DAS was found to be superior vis-a-vis other integrated weed control methods.

Skrzypczak and Blecharczyk (1994) observed better weed control efficacy from Imazethapyr was applied after sowing compared to POE application in leguminous crops.

Kalpana and Velayutham (2004) reported from experiment conducted on soybean among the POE herbicides, Imazethapyr performed better control of all types of weed.

Halvankar *et al.* (2005) from an experiment with PE application of Alachlor 50 EC at 2 kg ha^{-1} and S-Metolachlor 96 EC @ 500 and 750 g ha^{-1}; POE application of quizalofop-ethyl EC @ 37.5 and 50 g ha^{-1}, quizalofop-p-tefuryl 4 EC @ 50 g ha^{-1}, Imazamox 12 SL @ 40 g ha^{-1} and Imazamox + Imazethapyr 5 SL @ 75 g ha^{-1}; 2 HW at 30 and 45 DAS found that all the weed control treatments reduced weed biomass at 30, 60 DAS and at harvest of the crop.

Tiwari and Mathew (2002) conducted experiment during the *kharif* 1999 and reported Fenoxaprop-p-ethyl @ 70 g, Sethoxydim @ 250 g, and Propaquizafop @ 50 g ha^{-1} were effective against monocot weeds. Imazethapyr @ 75 g ha^{-1} found effective against dicot weeds. The seed yield under all herbicidal treatments was significantly superior compared with the control.

Aslam *et al.* (1991) conducted field trials with PE Pendimethalin (1.5 kg ha^{-1}) and Oxadiazon (2.3 kg), and of POE Isoproturon (1.0 kg ha^{-1}), Fomesafen (0.2 kg ha^{-1}) + surfactant (Agral 90) and Fluazifop-butyl (0.5 kg ha^{-1}) + surfactant in rainfed soybeans cv. Williams-82. Fomesafen resulted in the greatest control of dicot weeds, reducing weed density from unweeded control values of 16-32 to 0-1 weeds msu script $^{-1}$. Fluazifop resulted in the greatest control of monocot weeds and sedges, reducing weed density from 39-76 and 25-50 weeds, in control plots to 0-4 and 3-28 weeds. The HW treatment resulted in the greatest reduction in weed growth compared with all herbicide treatments. Pendimethalin was the only herbicide treatment which resulted in effective monocot weed control as well as effective dicot weed control.

Sinzar and Stankovic (1995) reported that Trifluralin + Imazaquin and Acetochlor + Linuron gave best result in weed control of soybean. Average control was obtained from Metolachlor + Linuron and Metolachlor + Prometryn applied plots.

Qian (1996) reported that PE application of Linuron @ 50 or 100 g mu^{-1} gave better control than the same rates of Prometryn. PE application of Dibutalin at 96-144 g mu^{-1} in early June gave complete control and also gave high levels of control when applied in July. Effective control was also given by some rates of Glyphosate and by 107.5 g Alachlor mu^{-1}. (1 mu = 0.067 ha.).

Pandey *et al.* (1996) found form an experiment on soybean that weed dry weight was lowest with Chlorimuron-ethyl @ 4 g ha^{-1} applied 15 DAS and highest with Chlorimuron-ethyl @ 12 g ha^{-1} applied on the same date. Pendimethalin and Fluchloralin decreased populations of both types of weeds.

Dubey *et al.* (2000) reported that Chlorimuron-ethyl @ 9 & 12 g ha^{-1} as PE reduced the population of monocotes in soybean plot. Metolachlor application @ 2.0 kg ha^{-1} as PE suppressed *C. rotundus* significantly compared with weedy control plot. Metolachlor was superior to Chlorimuron-ethyl in reducing total dry weed biomass production at harvest but it was inferior to two HW at 20 & 35 DAS.

Esbenshade *et al.* (2001) found that Chlorimuron @ 13 g ha^{-1}, Chlorimuron + Thifensulfuron, Glyphosate, Glyphosate + Chlorimuron, and Glyphosate + CGA-277476 provided 87% or greater control of burcucumber 12 weeks after planting. These herbicides reduced burcucumber density and biomass by more than 56% in 1997 and 96% in 1998.

Maity and Ghosh (2001) conducted experiment during summer 1996 and 1997 with Trifluralin (0.48 kg ha^{-1} at 2 DBS), Metolachlor (0.75 kg ha^{-1} at 2 DAS) or cycloxydim (0.20 kg ha^{-1} at 5 DAS) at single doses or followed by HW at 30 DAS; or HW at 15 and 30 DAS in soybean reported that seed yield was higher in Trifluralin treatments followed by weeding.

Yadav *et al.* (1999) conducted experiment with weed control treatments weedy control, PE application of Metolachlor @ 2 kg ha^{-1}, Alachlor @ 2 kg ha^{-1} or HW 20 and 40 DAS on soybean cv. JS 71-05 and reported that HW and Metolachlor application were equally effective in reducing the weed population and weed dry matter.

Reynolds *et al.* (1995) reported that Chlorimuron applied as POE following Trifluralin applied pre plant incorporation and Metribuzin applied PE or Trifluralin + Flumetsulam applied pre-plant incorporation improved weed control and soybean yield compared with soil applied herbicides alone. Excellent *Echinochloa crusgalli* control was obtained with all herbicide treatments.

Ozair *et al.* (1993) conclude from a two year experiment POE application of Fluazifop-butyl alone or with surfactant gave 90-100% monocot control in both the seasons. Similarly, Fomesafen alone or with other mixtures, gave 100% dicot control.

Kurmvanshi *et al.* (1995) reported from an experiment on weed control of soybean that weed biomass was lowest in the weed free treatment followed by the 1.0 Fluchloralin @ kg ha^{-1} treatment.

Joshi *et al.* (1996) declared that Alachlor and Clomazone were the most efficient herbicides for controlling weeds in soybean.

Kurmvanshi *et al.* (1996) reported that application of Fluchloralin @ 1.00 kg ha^{-1} as preplanting and by soil incorporation, Metolachlor @ 1.50-3.0 kg ha^{-1} and Clomazone at 1.0-1.5 kg ha^{-1} as PE and Fluazifop-P-butyl @ 0.3-0.5 kg ha^{-1} as POE effectively controlled *E. crusgalli* without phytotoxic effects on soybeans. The control efficacy of these herbicides was comparable with three HW at 20, 40 and 60 DAS.

Application of Fluchloralin, Lactofen, Clomazone and Metribuzin significantly reduced the weed population compared with the weedy control (Balusamy *et al.*, 1996).

Kumar *et al.* (1999) reported that PE application of Alachlor @ 1.0 kg ha^{-1} resulting in 95.4% WCE in soybean field *Kharif* 1996. Lesser WCE was observed under Chlorimuron ethyl application even at a dose of 1.5 kg ha^{-1}.

Experiment conducted during *kharif* 1995 and 1996 by Chauhan *et al.* (2002) reported that the application of Alachlor @ 1.5 kg ha^{-1} and Pendimethalin @ 1.5 kg ha^{-1} as PE and two HW (20 and 35 DAS) in soybean crop drastically reduced weed density and weed biomass.

Combination of Fomesafen, Haloxyfop-methyl and Chlorimuron-ethyl provided 85-95% control of dicot weeds and 70-90% of monocot (Balyan and Malik, 2003).

Singh *et al.* (2003) viewed that drastic reduction in the density of *Echinochloa colona* and density and dry weight of total weeds when Acetochlor was applied @ 0.50-2.00 kg ha^{-1}.

Multiple applications of POE herbicide combinations of Oxasulfuron + Imazamox (92%), Clethodim + Fomesafen (93%) and Oxasulfuron + Imazamox + Thifensulfuron methyl (94%) at reduced rates, provided better weed control compared to a single application of Oxasulfuron (91%) and Imazamox (89%) at recommended rates (Knezevic *et al.*, 2008).

Baviskar *et al.* (2008) reported that spraying of Haloxyfop 10 EC @ 100 g ha^{-1} at 21 DAS gave highest (84.02%) WCE which was at par with treatment of

Haloxyfop 10 EC @ 100 g ha^{-1} at 14 DAS gave (83.32%) in soybean during *kharif* season.

Shete *et al.* (2009) studied on soybean weed control through POE application of Haloxyfop @ 25 g, 50 g, 75 g & 100 g ha^{-1} at 14 & 21 DAS, pre plant incorporation of Trifluralin @ 1200 g ha^{-1} found that treatment spraying of Haloxyfop 10 EC @ 100 g ha^{-1} at 21 DAS gave highest WCE (84.02%).

Field experiment carried out with oxyflourfen, Pendimethalin, Bentazon, Metribuzine, Ethalfloralin, Trifluralin and Acyflourfen+Bentazon compared with HW and weedy check results indicated that Oxyflourfen @ 0.48 kg ha^{-1} as PE significantly reduced the number and dry weight of the weed plants (Nejad *et al.*, 2010).

Green gram

Bera and Patra (1995) conducted experiment with Fluchloralin @ 1.0 kg ha^{-1} (2 DBS and 1 DAS or 10 DAS) and Pendimethalin @ 1.0 kg ha^{-1} (1 DAS or 10 DAS) in black gram and green gram found that Fluchloralin at 2 DBS or 1 DAS and Pendimethalin at 1 DAS were more effective than other treatments in reducing the weed population.

Black gram

Ramamoorthy *et al.* (1994) declared that after application of Sethoxydim @ 0.5, 1.0 or 1.5 kg ha^{-1} at 10, 15 or 20 DAS total weed counts and weed dry weight at 30 DAS increased with decreasing herbicide rate and as herbicide application was delayed in black gram crop.

Yadav *et al.* (1997) found lowest weed population with Oxyfluorfen @ 0.20 kg ha^{-1} + HW in a field trial for weed control in black gram.

Application of Pendimethalin (1.0 kg ha^{-1}) PE followed by fluazifop-p-butyl (0.375 kg ha^{-1}) POE caused 100% mortality of *Trianthema monogyna* a major dominating dicot weed and *Sorghum halepense* a perennial monocot in black gram field (Kumar and Tewari, 2004).

Pendimethalin @ 1.25 kg ha^{-1} + HW and Fluchloralin @ 1.25 kg ha^{-1} + HW gave lowest weed population which were equivalent to weed free control in black gram plot (Kumar and Gupta, 2005).

Among Imazethapyr @ 0.005-0.075 kg ha^{-1}, Fluchloralin @ 1.0-1.5 kg ha^{-1} and Fenoxaprop-p-ethyl @ 0.12-0.18 kg ha^{-1} used in black gram weed control, POE Fenoxaprop-ethyl resulted in a significant reduction in monocot weeds but was ineffective against dicot weeds. The best overall weed control was obtained with Fluchloralin, while grain and pod yields were greatest with Imazethapyr (Chin and Pandey, 1991).

2.2 Effect of botanicals on weeds

Oudhia *et al.* (1997) conducted experiment with stem and leaf extracts of *Calotropis gigantea* were allowed to decay for 120, 168, 216 and 264 hours in normal water in the ratio of 1:10 *w/v* of plant material reported that at 5, 7, 9 and 11 DAS, stem extract of 216 hours suppressed the germination of chickpea. Stem extract of 264 hours and leaf extract of 216 hours stimulated the root elongation of chickpea.

Oudhia and Tripathi (1998) reported that 264 hours soaked stem extract (Root, stem, leaf and stem + leaf of *Calotropis* were allowed to decay for 120, 168, 216 or 264 hours in 1:10 weed : water) applied at 3 DAS on linseed gave maximum germination (90%). The extracts of vegetative parts of *Calotropis* generally produced positive allelopathic effects, with some specific extracts giving higher root elongation.

Oudhia (1999) conducted experiment with allelopathic effects of noxious weeds Parthenium *hysterophorus, Blumea lacera, Lantana camara, Calotropis gigantea, Ipomoea carnea, Datura stramonium* and *Cynodon dactylon* on germination and seedling vigour of *L. sativus* cv. BioL-212, were studied in a pot culture. The aqueous extracts of these weeds were prepared and *Lathyrus* seeds were soaked in these extracts for 24 hours. Seeds treated with the *Calotropis* and *Cynodon* leaf extracts, germination was 0%. At 13 and 15 DAS, lowest germination was recorded in seeds treated with *Ipomoea* leaf extracts (21.0% in both cases). All extracts exhibited lower germination than the controls at 7, 9, 11, 13 and 15 DAS except leaf extracts of *Datura* (at 7, 9 and 15 DAS) and *Cynodon* (at 7, 9, 11, 13 and 15 DAS). Inhibitory effects on shoot and root elongation were also noted. Lowest root and shoot elongation (4.8 cm $plant^{-1}$) were recorded from the *Ipomoea* leaf extract treatment.

Mandal *et al.* (2002) revealed the efficiency of chopped and macerated leaves of *Calotropis* in controlling weeds of rice evaluated in a field experiment conducted in West Bengal, India during 2000. *Calotropis* reduced the weed dry weight equivalent to that of Butachlor and recorded weed control efficiency above 80%.

Al-Taisan,(2010) conducted an experiment in Saudi Arabia with leaf aqueous extracts from *Calotropis procera* at 5, 10, 30, 50 and 100% concentrations were applied on seed germination and seedling growth, found that extracts brought about considerable inhibition in the seeds germination and growth of the radicle and plumule. The final germination percentage and rate of germination in the extract-treated seeds were decreased with the increase in the concentration and concluded that the *Calotropis procera* leaf aqueous extract containing water-soluble allelochemicals could inhibit the seeds germination and reduce radicle length of some range plant species.

Tefera (2002) reported that increasing concentrations of aqueous extracts of *Parthenium hysterophorus* from leaf and flower inhibited *Eragrostis tef* seed germination and complete failure was recorded when the extract concentration from the leaf part was 10%. Aqueous extracts from stem and root had no effect on seed germination. Roots appeared more sensitive to allelopathic effect than shoots. Extracts from flower, root and stem had a stimulatory effect on shoot length at all concentration levels, as against an inhibitory effect of leaf extracts. Root extracts at low concentration (1%) greatly promoted root length but aqueous extracts from leaf and flower inhibited root length.

Increasing concentration of *Parthenium hysterophorus* on the germination percentage, seedling length and seedling weight of *Triticum aestivum* , *Avena fatua* , *Lepidium sp.* were significantly decreased. Different concentration of *Parthenium hysterophorus* extract had significant effect on the weed density at 50 DAS in POE as well as PE. This might be due to delayed germination of weeds due to allelochemicals (Marwat *et al.*, 2008).

A laboratory experiment was conducted to study the effect of *Parthenium* (*Parthenium hysterophorus*) leaf and stem aqueous extracts. Data were recorded for seed germination, seedling vigour index, as well as radicle and plumule length. All extracts significantly reduced all parameters in comparison with the control, with leaf extracts exhibiting more adverse effects than the stem extracts. Higher concentrations of the extracts and boiling the extracts prior to preparation resulted in more detrimental effects (Sajjan and Pawar, 2005).

2.3 Effect of herbicides on nodulation

Anderson *et al.* (2004) reported that Sulfonylurea residues inhibit the growth of some legume crops and pastures. The presence of Chlorsulfuron in the soil reduced the nodulation and nitrogen fixation of the chickpea plants. Pre-exposing *rhizobia* to Chlorsulfuron before inoculating them with germinating chickpea seeds reduced the number of nodules. Chlorsulfuron can adversely affect the formation and activity of symbiotic nitrogen-fixing nodules in chick pea.

The effects of herbicide on yield and nitrogen fixation of *Trifolium subterraneum* investigated in a field study with application of Simazine + Paraquat @ 0.9 + 0.3 kg ha^{-1} was used at different times on it. Fixed nitrogen in the root system was reduced in the by early application of the recommended rate of simazine + Paraquat (Fajri *et al.*, 1996).

Reddy and Zablotowicz (2003) found from a field study with ITD, and ADT salt formulations of Glyphosate on weed control, nodulation, and grain yield in soybean. Glyphosate levels in nodules from treated plants ranged from 39 to 147 and leghemoglobin content was reduced by as much as 10%. Control of five predominant weed species 14 DAA was >83% with one application and >96% with two applications regardless of the Glyphosate salts used.

Malavia and Patel (1989) reported from experiment conducted herbicides Fluchloralin @ 0.675 kg ha^{-1}, Nitrofen @ 1.875 kg ha^{-1} and oxadiazon @ 1 kg ha^{-1} adversely affected nodulation in groundnut.

Akhtar *et al.* (1990) reported that pendimethalin @ 3.75 l ha^{-1} as post emergence and Fluazifop-butyl @ 4 l ha^{-1} gave approx. 95% control of weeds. Pendimethalin was more effective against broadleaved weeds while Fluazifop-butyl was more effective against grasses. The highest seed yields were obtained with HW (1235 kg ha^{-1}), although these did not differ significantly from yields obtained with Fluazifop-butyl (1196 kg ha^{-1}). Root nodulation was decreased by both herbicides.

Yueh and Hensley (1993) conducted experiment with 12 pesticides (3 fungicides, 5 insecticides and 4 herbicides) on nodulation of soybean cv. Williams 82.

Soybean nodule counts were significantly decreased by application of 3-fold concentration of Methomyl and Trifluralin. Trifluralin also depressed soybean nodulation at the recommended label concentration. Methomyl was innocuous to soyabean nodulation at the recommended label concentration. Both methomyl and trifluralin were non-toxic to *Bradyrhizobium* and *Rhizobium* spp

Shveta and Dhingra (2003) found that application of pendimethalin @ 1.0 kg ha^{-1} + one HW in place of 2 HW recorded significant decline in nodule number (24.5%) and nodule dry weight (14.8%). Pendimethalin application did not show any effect on seed yield, harvest index and oil yield.

Anikwe *et al.* (2003) reported that both POE and a combination of PE and POE herbicide treatments applied at 3 weeks after planting reduced the nodulation, shoot dry weight, N accumulation in the biomass and seed yield of soybean. PE herbicide application reduced weed density and sparingly affected nodule dry weight, N accumulation and seed yield. So selection and timing of herbicide application in soybean plots affect weed competition, nodulation, N accumulation and overall performance of the crop in the field.

Deshmukh *et al.* (2004) conducted experiment during *kharif* 2001-02 with Alachlor, Pendimethalin, Fluchloralin, Chlorimuron-ethyl and Trifluralin on soybean revealed that treatment with herbicides showed minimum and maximum nodule number, nodule dry weight, shoot length, shoot dry weight at 20, 40 and 60 DAS.

Rafia *et al.* (2007) conducted experiment with Atrazine herbicicide green gram reported that a low number of microorganisms were isolated from the roots of the plants. *Rhizobium* species, a nitrogen fixing bacteria, was not observed thus nodulation hamper in the roots.

Atrazine, Isoproturon and Metribuzin significantly reduced the nodulation (nodule number and dry mass) of green gram (Khan *et al.* 2006).

Martensson (1992) decleared from an experiment that symbiotic interactions were adversely affected by several agrochemicals. Necessary bacterial induced root hair deformation for nodulation decreased in the presence of Benomyl, Bentazone, Chlorsulfuron, Fenpropimorph, Mancozeb and Monochlorophenoxyacetic acid.

Sandhu *et al.* (1991) found from a field trials at Ludhiana with lentil that average number of nodules plant $^{-1}$, nodule dry weight plant $^{-1}$ and nitrogenase activity g^{-1} nodule were highest in hand hoeing treatment as compared with Terbutryn, Oxyfluorfen, Linuron, Metribuzin, Methabenzthiazuron and Oxadiazon applied plot.

Sprout *et al.* (1992) found that Metribuzin had a significant negative effect on number of nodules, taproot growth and acetylene reduction activity. Spraying at 5 to 10 DAS the plants began to recover from the inhibitory effects. When spraying was delayed to 13 days after planting Metribuzin had little effect.

Madhavi *et al.* (1993) reported from a green house experiment herbicides had the strongest effects on dry weight and total nitrogen content, followed by fungicides then insecticides.

Singh *et al.* (1994) reported that Methabenzthiazuron @ 1.31 kg ha^{-1}, Linuron @ 0.75 kg ha^{-1}, Pendimethalin @ 0.75 kg ha^{-1} reduced the number of nodules plant^{-1} and nitrogenase activity in a *rhizobium*-pea symbiosis.

Arias and Peretti (1993) reported that herbicide 2,4-D had a deleterious effect on *rhizobium* Growth.

Singh *et al.* (1995) conducted experiment in Punjab to study the effect of PE herbicides on the symbiotic parameters of soybean reported that soybean nodulation was adversely affected by Oxyfluorfen, Dimethazone, Sethoxydim, Pendimethalin and Oxadiazon.

Sawicka and Selwet (1998) stated from a field study in Poland with legumes, that Imazethapyr and Linuron caused a decrease of root-nodule bacteria nitrogenase activity.

2.4 Weed management through herbicides and their effect on crop growth

Groundnut

Velu *et al.* (1994) found from an experiment in Tamil Nadu, India with PE herbicides Pendimethalin @ 1.0 & 1.5 kg ha^{-1}, Metolachlor @ 10 & 1.5 kg ha^{-1}, Oxyfluorfen @ 0.1 & 0.15 kg ha^{-1} and Imazethapyr @ 0.15 & 0.2 kg ha^{-1} on the growth and yield of groundnut. In case of chemical weed control treatment increased plant growth in terms of leaf area and dry matter due to better weed control efficiency. The chemical treatments were compared with HW 15 and 40 DAS.

Widaryanto (1994) conducted field study at Lowokwaru, Malang (500 msl), to determine the rate of PE Oxyfluorfen and groundnut population density, growth and yield. The results showed that Oxyfluorfen @ 1-2 l ha^{-1} suppressed total weed dry weight over the study period (90 DAP) up to 56-63%, improved peanut growth (as revealed by number and area of leaves, plant dry weight, number of gynophores, number of seeded pods, and number of dry pods per plant) as compared with the control plot.

Richburg *et al.* (1993) found from field trials were conducted under weed infested conditions on sandy loam at Tifton in 1990-91, and under weed free conditions on sandy clay loam at Plains, Georgia, and on sandy loam at Tifton in 1990 and 1991 respectively pre-sowing incorporated applications of benfluralin @ 1.68 kg ha^{-1}. Nicosulfuron reduced the early season growth of groundnuts, but the crop recovered by mid August.

Kumar (1995) reported that drymatter accumulation and nutrient uptake by groundnuts was best with Fluchloralin + HW at 40 DAS which gave the best weed control in experiments with weed control through Fluchloralin with or without HW 40 DAS or HW at 20 and 40 DAS in groundnut cv. TMV-2 .

Pannu *et al.* (1989) found that Fluchloralin + HW gave best crop growth and yield, and best control of monocots, followed by 2 HW. Dicot weed control with Fluchloralin + HW was less successful and was equivalent to that achieved by 2 HW when conduct experiment with groundnuts cv. MH2 for weed control.

Mohanty *et al.* (1997) found that Fluchloralin and Pendimethalin were superior to HW in terms of most growth parameters from field studies at Bhubaneswar, Orissa, India.

Hassan and Metwally (2001) conducted two season pot experiments in a net greenhouse to investigate the effect of Paraquat and Fluazifop-butyl on groundnut cv. Giza-4 found that highest increase in plant height at 60, 80 and 120 DAS in both season was recorded with Fluazifop-butyl @ 0.125 kg + Paraquat @ 0.100 kg ha^{-1}. In both season, the highest increase in fresh weight of root per plant was obtained with fluazifop-butyl @ 0.125 kg ha^{-1} +Paraquat @ 0.100 kg ha^{-1}. The herbicide treatment had significant effect on fresh weight of foliage and fresh weight of plant 60, 90 and 120 DAS.

Somasundaram *et al.* (2010) conducted experiments during rabi-summer seasons of 2005-06, 2006-07 and 2007-08 reported that PE application of Fluchloralin @ 0.9 kg ha^{-1} along with one HW at 45 DAS recorded the least weed dry matter, highest pod number, shelling percentage, pod and haulm yield during all the three years of study. However, it was comparable with PE application of Pendimethalin @ 1.0 kg ha^{-1} along with one HW on 45 DAS.

Soybean

Oxyfluorfen @ 0.2 kg ha^{-1} controlled 67.6% weed in soybean field found economical than HW. PE herbicides used in soybeans did not show phytotoxic effects on succeeding crops (Tiwari and Kurchania, 2007).

Jain *et al.* (1996) found that All growth parameters of sybean gave higher values up to the age of 50 days when the treated with herbicides Fluchloralin and Metribuzin, whereas growth parameters in plots treated with Oxadiazon increased up to the 75th day. CGR was positively correlated with seed yield (r = 0.4568) and crop biomass (r = 0.4597) and was described by the regression equation (Y = 1281.04 + 48.761X). Oxadiazon, Oxyfluorfen and Metribuzin also effectively controlled weeds and increased crop yield.

Mishra and Bhan (1996) conducted experiment with six herbicides (Metolachlor (2.0 kg ha^{-1}), oxadiazon (1.0 kg ha^{-1}), Alachlor (1.0 kg ha^{-1}), Pendimethalin (1.0 kg ha^{-1}), Oxyfluorfen (0.15 kg ha^{-1}) and Bentazone (1.5 kg ha^{-1}) in soybean cv. JS 75-46 and reported that application of herbicides significantly reduced weed growth rate and increased crop growth rate. The greatest crop growth rate (other than in the weed-free plot) occurred as a result of Bentazone treatment. Crop growth rate increased with time, while weed growth rate decreased. The relative growth rate of both crop and weeds declined from 60 days onwards.

Hassanein *et al.* (2000) reported that chemical herbicides like Pendimethalin, Oxyfluorfen, Butralin/Linuron, Imazaquin either used in combination with Bentazone were effective and comparable to hand hoeing from point of weed control and yield and also there was no significant effect for soybean cultivars on weed growth.

Gurjar *et al.* (2001) conducted experiment on soybean and reported that Fluchloralin (1.0 & 1.5 kg ha^{-1}), Pendimethalin (1.0 & 1.5 kg ha^{-1}), Oxyfluorfen (0.15 & 0.20 kg ha^{-1}) and Alachlor (1.0 & 1.5 kg ha^{-1}) had no effect on soybean growth and Alachlor @ 1.5 kg ha^{-1} recorded the highest values for plant height, number of branches, number of leaves, pods per plant, seeds per pod, 100 seed weight, weight of pods per plant and number of grains per plant.

Early pre-sowing Imazethapyr application gave 88% control of weeds for the entire growing season. No soybean injury from Imazethapyr was observed and differences in soybean yield appeared to be due to differences in weed control. No significant carryover of Imazethapyr was detected in the field (Buhler and Proost, 1992).

Deore *et al.* (2008) found when conducted experiment on weed control of soybean Imazethapyr @ 200 g ha^{-1} resulted in the greatest plant spread, number of branches per plant, number of functional leaves per plant, mean leaf area, dry matter per plant and seed yield, and lowest dry weight of weed.

Tjitrosemito and Suwinarno (1988) reported that Imazapyr @ 2 kg ha^{-1} and Glyphosate @ 2.5 kg ha^{-1} provided the best growth (plant height, LAI and leaf number) and the highest yields (750 kg ha^{-1}) of soybean causing no phytoxicity.

Tiwari *et al.* (1997) found that application of fluazifop-p-butyl @ 0.25 & 0.5 kg ha^{-1} POE 20 DAS on soybean effectively controlled the monocot weeds and did not affect growth rate cause no phytotoxicity.

Kurchania *et al.* (2000) conducted experiment during *kharif* 1996 and 1997 with Acetachlor and Alachlor at different rates for weed control in soybean revealed that Acetachlor @ 0.9, 1.35, 1.8 and 3.6 kg ha^{-1} and Alachlor @ 2.0, 2.5 and 5.0 kg ha^{-1} were effective to control *Echinochloa crusgalli* and the efficacy increased with the increase in the rates of application. The Acetachlor and Alachlor did not show adverse effects on germination and plant growth.

Higher levels (1.5 kg ha^{-1}) of Fluchloralin, Pendimethalin and Alachlor were equal to HW twice in weed control efficiency and in increasing the weight and number of pods without affecting growth of soybean (Jain *et al.*, 2000)

Application of Metolachlor spray @ 1 kg ha^{-1} with one HW at 30 DAS was effective in controlling monocots, sedges and broad leaved weeds and also improved the growth and yield characters of soybean (Ganesaraja and Kanchanarani, 2003)

Ahmed *et al.* (2001) reported from experiment conducted the highest efficiency in decreasing dry weight of total weeds was recorded when Bentazone + Fluazifop-p-butyl was applied, followed by 2 hand hoeing and Metribuzin + Fluazifop-p-butyl treatments. All the weed control treatments markedly increased the growth, yield and yield components as well as chemical composition of soybean seeds in both seasons. The maximum values were obtained from Bentazone + Fluazifop-p-butyl followed by hand hoeing twice.

Treating soybean with combination of herbicides (Ethalfloralin, Therifloralin and Metribuzin) plus weeding showed 30% increase in number of lateral branches, 11.5% for number of pod per plant compared with untreated check (Kordasiabi *et al.* 2010).

Singh *et al.* (2004) found that Chlorimuron-ethyl at various doses (6, 9 and 18 g ha^{-1}) was effective on non-monocot weeds in soybeans without causing any crop phytotoxicity.

Green gram

Panwar *et al.* (1999) reported from experiment conducted summer 1995-96 and 1996-97 on green gram, plant height, number of branches, pods per plant, and seed yield were highest with Fluchloralin @ 0.75 kg ha^{-1} application. Weed population and dry matter of weeds were lowest with Fluchloralin 0.75 kg ha^{-1} resulting in the highest mean WCE (92.39%).

Black gram

Rao (2008) conducted experiment during rabi 2002-03 and 2004-05 with to study the optimum time and dose of POE herbicides for *Echinochloa* spp. control in black gram relay crop found that POE herbicides like Fenoxaprop-p-ethyl, Clodinafop-propargyl and Cyhalofop-butyl significantly reduced *Echinochloa colona* growth and increased black gram growth over weedy check without any crop injury. Among different herbicides Fenoxaprop @ 68 g ha^{-1} recorded the highest seed yield (1332 kg ha^{-1}).

2.4 Weed management through herbicides and their effect on yield attributing characters and yield

Groundnut

Bhattacharya *et al.* (1996) experiments conducted indicated that Imazethapyr applied @ 0.15 kg ha^{-1} was the most effective herbicide for weed control in groundnut. This treatment resulted in the highest pod yields as compared to the other treatments namely Oxyfluorfen and Pendimethalin.

Hiremath *et al.* (1997) found that Pendimethalin @ 1.5 kg ha^{-1} and Oxyfluorfen @ 0.5 kg ha^{-1} have higher WCE and lower WI values and gave higher pod yields from a experiment with five herbicides (Alachlor, Fluchloralin, Pendimethalin, Oxyfluorfen and Glyphosate) on three groundnut varieties *viz.* Kadiri-3, JL-24 and Gangapuri at Rajendranagar, Hyderabad. During the crop growth period *Cyperus rotundus, Dactyloctenium aegyptium, Digitaria sanguinalis* and *Cynodon dactylon Ocimum canum*, *Lagasca mollus* and *Parthenium hysterophorus* were predominant. The loss in pod yield due to weed competition was 71.9 to 74.4%.

Kumar (1993) conducted experiment with Alachlor @ 1.5 & 2.0 kg ha^{-1}, Fluchloralin @ 1.0 & 1.5 kg, Oxyfluorfen @ 0.25 & 0.50 kg, Ametryn + 2, 4-D @ 0.75 & 1.25 kg, Propyzamide @ 1.0 & 1.5 kg, Metribuzin @ 0.75 & 1.25 kg and Fluazifop + Bentazone @ 0.25 + 1.0 & 0.25 + 1.5 kg ha^{-1} on groundnuts cv. Kadiri-3 found that Oxyfluorfen at 0.5 kg resulted in the greatest weed control efficiency and groundnut yields.

Sasikala *et al.* (2007) conducted field experiment with Pendimethalin, Imazethapyr and Fluchloralin on groundnut reported that the pre-plant incorporation of Fluchloralin 1.5 kg ha^{-1} followed by Imazethapyr 75 g ha^{-1} at 20 DAS and Pendimethalin 1.5 kg ha^{-1} as PE followed by Imazethapyr 75 g ha^{-1} as POE at 20 DAS was an effective weed management practice and on par with HW at 20 & 40 DAS, and gave equally high pod yield in irrigated groundnut.

Kori *et al.* (1998) conducted field experiment on groundnut at Karnataka, India with weed free control. Trifluralin @ 1.5 kg ha^{-1} + inter-cultivation at 30 and 45 DAS resulted in significantly higher dry matter accumulation at harvest (29.71 and 27.11 g $plant^{-1}$ respectively) and higher pod yields (26.55 and 23.63 q ha^{-1}) than the unweeded control (15.31 g $plant^{-1}$ dry matter production and 9.91 q ha^{-1} pod yield). Trifluralin @ 1.5 kg ha^{-1} + inter-cultivation at 30 DAS and Alachlor @ 3 kg ha^{-1} + HW at 30 DAS + inter-cultivation at 45 DAS resulted in groundnut yields of 2.20 and 2.28 t ha^{-1} respectively.

Jana *et al.* (1989) reported that HW or application of 1.5 l ha^{-1} Bentazone in groundnut increase growth parameters, yield attributes and yields compared with the unweeded control. The significant interaction between irrigation and weed control measures indicated that 2 irrigations with either 2 HW or POE herbicide application were most effective in increasing yields.

Thorat (2004) found from a experiment with groundnut in Dapoli, Maharashtra, India, that the herbicide application significantly increased the protein and dry pod yields of groundnut, and reduced the dry matter of weeds, with Oxadiargyl resulting in the highest mean protein and dry pod yields, and WCE (80.6%).

Chandrika (2004) conducted study on groundnut weed management at Tirupati, Andhra Pradesh, India in rabi and reported that PE application of Pendimethalin @ 0.75 kg ha^{-1} followed by one HW at 30 DAS was very effective in increasing pod yield (36% over unweeded check) and reducing WI. In all years of experimentation HW at 20 and 40 DAS was at par with that of PE application of Pendimethalin @ 0.75 kg ha^{-1} + HW at 30 DAS with identical increase in pod yields.

Reddy and Reddy (2005) conducted an experiment during the *kharif* 1999 and 2000 and reported that yield attributes, seed yields of groundnut was higher with Metolachlor @ 1 kg ha^{-1} as PE +one HW at 35 DAS and Pendimethalin @ 0.75 kg ha^{-1} as PE + one HW at 35 DAS.

Bhondve *et al.* (2009) conducted field experiment during *kharif* 2006 on groundnut reported that growth, yield and quality parameters of groundnut were superior with PE application of Pendimethalin @ 0.75 kg ha^{-1} supplemented with hoeing at 25 DAS than rest of the weed control practices except weed free check and hoeing at 15 DAS with HW at 25 DAS.

Prasad *et al.* (2010) found that higher pod yield obtained from groundnut plots applied with Pendimethalin @ 1.0 kg ha^{-1} (2160 kg ha^{-1}) was similar to HW twice (2094 kg ha^{-1}). A saving of weeding cost to an extent of Rs. 3018 to 3910 ha^{-1} was observed in groundnut by using herbicides as compared to HW. None of the herbicides affected the establishment, growth and yield of succeeding.

Gill *et al.* (1990) with single or combined application of pre-plant incorporated Fluchloralin @ 750 g $ha^{-1}$and Fluazifop-butyl 125-250 g ha^{-1} on groundnut cv. M 13 revealed that lowest weed dry weight and highest crop yield obtained from Fluazifop-butyl 250 g ha^{-1} treated plot.

Sarpe *et al.* (1989) found most efficient control of annual dicot weeds with two POE applications of Fomesafen @ 0.25-0.5 kg ha^{-1} or three POE applications of Bentazone @ 0.9 kg ha^{-1}. Highest groundnut yield recorded with pre-plant incorporated applications of Trifluralin @ 0.9 kg ha^{-1} or Napropamide @ 3 kg ha^{-1} followed by POE applications of Bentazone or Fomesafen with Fluazifop or Haloxyfop.

Herbicide weed control treatment with Butachlor reduced weed dry weight from untreated control values of 544 kg to 145-450 kg ha^{-1}, and increased groundnut dry pod yields from 358 kg to 475-888 kg ha^{-1} (Mahadkar *et al.* 1993).

Soybean

Tjitrosemito (1990) found that POE application of Imazethapyr @ 100 g ha^{-1} or PE applications of Imazethapyr @ 50-150 g ha^{-1}, Pendimethalin @ 600-1320 g ha^{-1}, Pendimethalin + Imazethapyr @ 660 or 1320 + 50 g ha^{-1} or Alachlor @ 1440 g ha^{-1} increased soybean yield over control. HW 3 and 6 weeks after sowing gave highest yield (1.84 t ha^{-1}).

Avav *et al.* (1995) conducted during 1991 and 1992 with herbicide mixture in soybean and reported that POE application of Sethoxydim + Imazethapyr (0.37 + 0.10 kg ha^{-1}) as a tank mixture gave the highest grain yield (2.47 t ha^{-1}), followed by Fluazifop + Imazethapyr (0.25 + 0.10 kg ha^{-1}; 2.46 t ha^{-1}), PE application of imazaquin + Pendimethalin (0.72 + 1.25 kg ha^{-1}; 2.44 t ha^{-1}), Imazethapyr +

Pendimethalin (0.23 + 1.13 kg ha^{-1}; 2.20 t ha^{-1}) and metobromuron + Metolachlor (1.25 + 1.25 kg ha^{-1}; 2.12 t ha^{-1}). Increased grain yield of herbicide treated plots were comparable with 2 and 3 hoeing plots. Weed control efficiency was 60.7-77.2% for herbicides and 61.4-82.9% for hoeing. Uncontrolled growth of weeds in the unweeded control reduced the grain and stover yields by 51 and 66%.

Raskar and Bhoi (2002) found that the pre-plant incorporation of Imazethapyr + Pendimethalin @ 2.5 l ha^{-1} was most effective in the suppression of weed growth and in the improvement of soybean grain yield. HW at 15 and 30 DAS, Imazethapyr + Pendimethalin @ 2.5 & 3 l ha^{-1}, and Alachlor @ 2 kg ha^{-1} were equally effective in the enhancement soybean grain yield and in the reduction of weed density and dry matter.

Singh *et al.* (2002) conducted experiment to investigate the efficacy of Flumetsulam (50 & 70 g ha^{-1}), Cloransulam (35 & 45 g ha^{-1}) and Diclosulam (25 & 40 g ha^{-1}) in controlling weeds in soybean cv. PK 1162. Other herbicide treatments were Chlorimuron ethyl @ 6 g ha^{-1}; Imazethapyr @ 75 g ha^{-1} and Clomazone @ 750 g ha^{-1}. Grain yields obtained in the treatments with Flumetsulam, Cloransulam and Diclosulam were lower than those obtained with Imazethapyr and the weed free control.

Soybean grain yield due to two HW at 15 and 30 DAS was similar to that of Imazethapyr+Pendimethalin @ 800 & 960 g ha^{-1} and Alachlor @ 2000g ha^{-1}. Crop phytotoxicity symptoms were not observed on soybean due to application of Imazethapyr+Pendimethalin (Raskar and Bhoi, 2002).

Thakare *et al.* (1998) from an experiment with PE applications of herbicides (Metolachlor, Oxyfluorfen, Metribuzin, Oxadiazon or Pendimethalin) on soybean concluded that Oxyfluorfen (0.1 kg ha^{-1}) was best herbicide treatment which resulted in a soybean seed yield of 688 kg ha^{-1}.

Chandel and Saxena (2001) found highest seed yield and seed production efficiency by 2 HW treatment, with Anilofos @ 1.75 kg ha^{-1}, propaquizafop @ 75 g ha^{-1} and Imazethapyr @ 100 g ha^{-1}.

Singh *et al.* (2003) conducted experiment with Oxyfluorfen @ 60, 120, 180 and 240 g ha^{-1}, Alachlor 2500 g ha^{-1}, Fluchloralin @ 1000 g ha^{-1} on soybean (cv. PK

564) reported that Oxyfluorfen @ 180 & 240 g ha^{-1} produced grain yields (1370 & 1480 kg ha^{-1} respectively) at par with those of weed free (1495 kg ha^{-1}).

Rani *et al.* (2004) from a field experiment on soybean weed control conclude that POE application of Imazethapyr @ 75 g ha^{-1} and Lectofen @ 90 g ha^{-1} was promising alternatives to HW practices and each recorded 23% higher yield over the weedy control.

Singh *et al.* (2004) stated from a field experiment Imazethapyr had a wide weed control spectrum and very high weed control efficiency. Imazethapyr alone recorded the highest yields among the herbicide treatments applied in soybean.

Kothawade *et al.* (2007) found that Imazamox + Imazethapyr @ 0.8 & 1.0 l ha^{-1} have greatest WCE (75.77 & 76.15%) and WI (2.33 and 1.82%) resulted greatest soybean seed yield (30.11 & 30.26 q ha^{-1}) when conducted weed control experiment on soybean (cv. JS-335).

Sharma *et al.* (2008) reported from experiment conducted grain yield and weed control efficiency were highest with Quizalofop-ethyl at 50 g ha^{-1} + Chlorimuron at 9 g ha^{-1} as POE application in soybean weed control.

Yadav *et al.* (2009) conducted experiment on integrated weed management of soybean observed that application of Imazethapyr @ 0.075 kg ha-1 with hoeing at 30 DAS was superior with respect to seed yield.

Nimje (1996) conducted experiment during *kharif* 1992-93 and reported that Fluchloralin + cultivation gave the best weed control and highest soybean seed yield.

Singh *et al.* (2001) conducted a field experiment with Clomazone (0.5, 1.0 and 1.5 kg ha^{-1}), Metribuzin (0.350, 0.525 & 0.700 kg ha^{-1}) and Alachlor @ 2.5 kg ha^{-1} as PE on soybean and found that all the major weed species of the experimental field were effectively controlled by Metribuzin at all rates. All treatments significantly increased grain yield, with Metribuzin treated plants recording the highest grain yield in both years.

Chamate *et al.* (2002) conducted experiment with Pendimethalin and Fluchloralin @ 1.0 kg ha^{-1} with and without cultural practices on growth, quality and yield of soybean. Found that per-emergence of application of Pendimethalin or

Fluchloralin @ 1 kg ha^{-1} with one hoeing at 40 DAS recorded significantly higher grain and straw yields. The higher yield attributed to maximum plant height, no. of branches and no. of leaves plant^{-1}. The quality parameter like test weight, oil and protein content in seed were significantly increased due to these treatments.

The PE application of Alachlor 10 G @ 2.0 kg ha^{-1}, pre-plant incorporation of Fluchloralin 45 EC @ 1.0 kg ha^{-1}, and pre-plant incorporation and POE application of Anilofos 5 G or 30 EC @ 1.5 ha^{-1} were equally effective in increasing grain yield in soybean (Chavan *et al.*, 2000).

Sankaranarayanan *et al.* (2002) from experiment conducted reported that HW twice at 15 and 30 DAS and Pendimethalin @ 0.75 kg ha^{-1} with one HW at 30 DAS was the most effective in the control of soybean field weeds. These treatments also reduced weed dry matter production, with increased growth characters, yield attributes and yield of soybean. The highest yield and net return were observed in Pendimethalin @ 0.75 kg ha^{-1} with HW 30 DAS (1436 kg ha^{-1}), which was followed by HW twice at 15 and 30 DAS (1415 kg ha^{-1}).

Pre-plant incorporation of squadron (formulated product of 3.4% imazaquin + 22% Pendimethalin) @ 3 l ha^{-1} and Pendimethalin @ 1 kg ha^{-1} were the most effective for weed control, recording the lowest weed densities and highest pods per plant, seeds per pod and seed yields (Gaikwad and Pawar, 2001).

Kumar *et al.* (2005) conducted experiment and reported that Trifluralin incorporation combined with one HW at 40 DAS significantly improved plant dry matter accumulation, number of branches per plant, number of pod per plant, test weight, and seed and stover yields.

Prabha *et al.* (2006) found from an experiment Clomazone + Pendimethalin @ 2.0 l ha^{-1} gave 67% higher seed yield the control and the highest pod number plant^{-1} (58 pods plant^{-1}) was also obtained under this treatment. Clomazone + Pendimethalin at 6.0 l ha^{-1} produced the lowest weed dry matter production at 20, 40 and 60 DAS.

Billore *et al.* (2007) reported that application of Flumioxazin @ 45 g ha^{-1} as PE in soybean effectively contained the weed load, promoted growth of soybean leading to enhanced yield. Flumioxazin as PE @ 36.19 g ha^{-1} gave maximum yield and weed control. The dicot weed control efficiency of Flumioxazin was found to be higher than Trifluralin at all the stages of observations.

Shah *et al.* (2006) conducted experiment reported that Paraquat + Pendimethalin gave significantly higher yield of soybean followed by the Pendimethalin alone. HW resulted in significantly higher yield than weedy check but lower than herbicide treated plots. Pendimethalin was observed effective in weeds control but in combination with Paraquat showed excellent performance.

Nagaraju *et al.* (2009) reported from an experiment PE application of Pendimethalin @ 1.0 kg ha^{-1} or Alachlor @ 1.0 kg ha^{-1} with one HW at 50 DAS was found to be superior to suppress the weeds in pigeonpea + soybean intercropping system. Weed density and weed dry matter were significantly lower with the two HW at 25 and 50 DAS. Combination of one herbicide with one HW provided better growth and yield attributes resulted in higher grain yields.

Singh *et al.* (1991) conducted experiments with Alachlor @ 1.0-1.5 kg ha^{-1}, Metribuzin @ 0.25-0.5 kg, Oxadiazon @ 0.5 kg, Pendimethalin @ 1.0 kg, Metolachlor @ 1.0 kg and Thiobencarb @ 2.0 kg ha^{-1} on soybean found that Metribuzin @ 0.5 kg ha^{-1} greatest weed control (73%) and greatest grain yields (1953 kg).

The PE application of herbicides Metolachlor @ 1.0 kg ha^{-1}, Chlorimuron ethyl @ 0.009 kg ha^{-1} and Chlorimuron ethyl @ 0.009 kg ha^{-1} + Metolachlor @ 1.0 kg ha^{-1} were equally effective with HW at 30 DAS in controlling the weeds and increasing the yield of soybean (Behera *et al.* 2005).

Singh and Bajpai (1994) showed that HW and Fluchloralin application gave significantly higher seed yield and reduced weed density over the weedy control.

Upadhyay *et al.* (1993) found that pre-planting application of Fluchloralin @ 2.5 l ha^{-1} caused lower density and biomass of all the weeds, as well as greater weed control and higher seed yield of soybean.

Shylaja *et al.* (1997) conclude from an experiment pre plant incorporation and PE application of Alachlor @ 2 kg ha^{-1} gave best WCE (90%) and greatest soybean yield among pre plant incorporation of Alachlor @ 2 kg ha^{-1} and Anilophos @ 1.5 kg and four PE application of Alachlor @ 2 kg ha^{-1}, Fluchloralin @ 1 kg ha^{-1}, Clomazone @ 1 kg ha^{-1} and Metribuzin @ 0.25 kg ha^{-1}.

Basavaraju and Nanjappa (1996) conclude from an experiment pre-plant incorporation of Alachlor granules @ 2.0 kg ha^{-1} gave an excellent level of control of weeds and resulted in a high seed yield (3400 kg ha^{-1}) compared with the untreated control and PE application of Clomazone @ 1.0 kg ha^{-1} also gave a high seed yield (3315 kg ha^{-1}).

Gowri *et al.* (2009) conducted experiment and reported that Alachlor @ 1.0 kg ha^{-1} + one HW at 35 DAS was found to be the best treatment followed by Pendimethalin @ 1.0 kg ha^{-1} + one HW at 35 DAS and two HW at 20 and 35 DAS treatments. The quality parameters of soybean seeds were not affected by weed control practices.

Green gram

Velu and Sankaran (1997) conducted experiment with Fluchloralin (0.90 kg ha^{-1}), thiobencarb (1.25 kg ha^{-1}) and Metolachlor (1.00 kg ha^{-1}) on green gram reported that Metolachlor followed by Fluchloralin and Thiobencarb was most effective at reducing density and dry weight of weeds. The PE application of Metolachlor followed by pre-sowing incorporation recorded the greatest weed control efficiency and higher grain yield was on a par with HW.

Kumar *et al.* (1999) observed that yield of both green gram and black gram increased with application of Fluchloralin (1.0 kg ha^{-1}) by more than HW at 25 days after sowing.

Parasuraman (2000) declared that application of Pendimethalin (1.5 or 2.0 l ha^{-1}) or Fluchloralin (1.0 or 1.5 l ha^{-1}) at 3 DAS + HW at 30 DAS resulted in significant reduction in weed population and weed dry matter, and significant increased in crop yield in rainfed green gram.

Black gram

Singh and Singh (1990) conducted field trial on black gram weed control through PE herbicides Alachlor @ 1.0 or 1.5 kg ha^{-1} or Pendimethalin @ 0.75 kg ha^{-1} found that herbicides reduced weed dry weight and also gave high yields.

Ramanathan and Chandrashekharan (1998) conducted field study on weed management systems for black gram observed that PE application of Pendimethalin @ 1.5 kg ha^{-1} followed by a HW at 30 DAS gave the highest weed control efficiency, maximum number of pods $plant^{-1}$, seed yield and net return in 3 years.

Shaikh *et al.* (2002) carried out experiment during *kharif* 1996-99 to evaluate different weed control treatments on black gram and their economics observed that PE application of Oxyfluorfen @ 0.1 g ha^{-1} or Pendimethalin @ 0.75 g ha^{-1}; or pre-plant incorporation of Fluchloralin @ 0.9 g ha^{-1} was found effective in controlling the weeds and increasing the seed yield and relative monetary returns of black gram.

Rao and Rao (2003) conducted experiment during 2001-02 with Clodinafop-propargyl (at 37.5, 45.0, 52.5, 60.0 and 75.0 g ha^{-1} at 20 DAS), Imazethapyr @ 62.5 g ha^{-1} at 15 DAS, Thiobencarb @ 2000 g ha^{-1} at 8 DAS on black gram reported that Clodinafop-propargyl @ 75 g ha^{-1} was more effective in minimizing weed population and dry weight, but was at par with (52.5 and 60.5 g ha^{-1}). Clodinafop-propargyl at 52.5 g ha^{-1} recorded the highest seed yield (740 kg ha^{-1}) and yield attributes, but was at par with its other rates except 37.5 g ha^{-1}. Among all treatments, HW recorded the highest seed yield (760 kg ha^{-1}).

Veeraputhiran *et al.* (2008) found that application of Imazethapyr @ 90 g ha^{-1} recorded lowest weed density and weed dry weight and on par with 75 g ha^{-1}. Higher growth and yield attributes and highest grain yield of black gram were associated with imazethpyr application on 21 DAS at 90 g ha^{-1}. The favorable economic benefits in terms of higher gross income, net income and benefit-cost ratio were also observed by the application of Imazethpayr @ 90 g ha^{-1} on 21 DAS.

2.5 Economics of weed management

Groundnut

Sasikala *et al.* (2004) reported that preplant incorporation of Fluchloralin and Imazethapyr was found most economical, giving highest net profit followed by HW twice and PE application of Pendimethalin and Imazethapyr has higher weed control efficiency in groundnut.

Gnanamurthy and Balasubramaniyan (1998) found from a experiment at Vriddhachalam with weed control treatments *viz.* Fluchloralin (1.0 kg ha^{-1}), Pendimethalin (1.0 kg ha^{-1}), Thiobencarb (0.75 kg ha^{-1}), Butachlor (0.75 kg ha^{-1}) and Metolachlor (1.0 kg ha^{-1}), with and without HW at 30 DAS, HW twice at 15 and 30 DAS and a control on groundnut. Weed dry weight was reduced and WCE increased due to adoption of Metolachlor + HW at 30 DAS. This combination resulted in the highest groundnut yields (2.35 t ha^{-1} averaged over 3 years), the greatest pod yield increase compared with unweeded controls (45.3%) and the highest net returns.

Singh *et al.* (1994) found best weed control, pod yields and highest net return from Pendimethalin + Butachlor @ 0.75 l ha^{-1} + 0.5 l ha^{-1} followed by the Pendimethalin @ 0.75 l ha^{-1}treatment. The highest marginal benefit:cost (3.88) was achieved with the 0.5 l ha^{-1} Butachlor treatment.

Soybean

Deore *et al.* (2007) suggested that Imazethapyr @ 100 g ha^{-1} was the most economical viable treatment in soybean as found that weed intensity and weed dry weight were significantly reduced due to early post application of Imazethapyr @ 200 g ha^{-1} and was at par with Imazethapyr @ 100 g ha^{-1}. Imazethapyr @ 200 g ha^{-1} (89.26%) gave maximum weed control efficiency followed by Imazethapyr @ 100 g ha^{-1} (83.65%). Same trend was also found in case of soybean seed yield. The B:C ratio was maximum in Imazethapyr 100 g ha^{-1} (1.98) followed by Fenoxyprop ethyl 67.5 g ha^{-1} (1.97), Chlorimuron ethyl 9.37 g ha^{-1} (1.84) and Imazethapyr 200 g ha^{-1} (1.79).

Kurmvanshi *et al.* (1995) conducted experiment in *kharif* and reported soybean cv. Gaurav (JS72-44) growth was equally good in the weed free, Fluchloralin and Clomazone treatments. Grain yield was highest (1.72 t ha^{-1}) in the weed free control followed by the Fluchloralin treatment (1.5 t ha^{-1}). The highest gross economic returns were obtained with the weed free control and Fluchloralin treatments (Rs 13 736 & 12 112 ha^{-1} respectively) with the later giving the highest cost:benefit ratio (2.06). Gross returns of Rs 10 000 to 11 000 were obtained using 1.5-3.0 kg ha^{-1} Metolachlor, Clomazone @ 1.0-1.5 kg and fluazifop-P-butyl @ 0.5 kg ha^{-1}.

Kushwah and Kushwaha (2001) found that Pendimethalin @ 1.0 kg ha^{-1} (PE) + HW resulted in significantly higher growth, yield attributing characters and seed yield than the rest of the methods including the control. This treatment also recorded the highest weed control efficiency. The highest benefit: cost was obtained with the use of Pendimethalin alone.

Metribuzin @ 0.5 kg ha^{-1}, being at par with Chlorimuron-ethy @ 10.01 kg ha^{-1} gave the highest seed yield and additional returns owing to higher yield attributes. But the highest benefit:cost (11.37) was recorded with Chlorimuron @ 0.01 kg ha^{-1} due to its lower cost (Singh *et al.* 2006).

Tomar *et al.* (1994) viewed from an experiment conducted Fluchloralin @ 1 l ha^{-1} + HW resulted in the greatest weed control, crop yields and net income.

Herbicidal weed control appeared more economical than HW (Dubey *et al.* 1996).

Chandel *et al.* (1995) conducted experiment on soybean with Fluchloralin @ 1.0 kg ha^{-1} pre-plant soil incorporated, PE Metolachlor @ 1.0 kg ha^{-1} , PE Alachlor @ 2.0 kg ha^{-1} and Pendimethalin @ 0.5 kg ha^{-1} with and without HW at 30 DAS revealed that Alachlor + 1 HW greatest decrease in weed dry matter. Alachlor also gave the highest seed yield, which was 36.4% more than that in the weedy control plot and resulted in the highest net return.

Avav and Ugese (2000) analyzed that application of Fluazifopbutyl @ 0.125, 0.25, 0.375 and 0.50 kg ha^{-1} at 2 weeks after planting reduced 67-90% weed density and biomass and also gave higher grain yield of soybean than those weeded with hoe. The highest benefit:cost ratio was obtained with 0.375 kg ha^{-1} by the herbicide.

Shivaprasad *et al.* (2000) studied on application of Alachlor, Chlorimuron ethyl, Metolachlor and Pendimethalin alone and in combinations on soybean and found that Alachlor @ 2 kg ha^{-1} gave the highest seed yield, stalk yield, weed control efficiency, gross return, net return and marginal return, and the lowest weed dry weight and yield loss.

Saha and Aktar (2008) conducted experiment during 2006 with Oryzalin, application of Oryzalin @ 3 Kg ha^{-1} along with HW at 30 DAS or application of oryzalin @ 4.5 Kg ha^{-1} along with HW at 30 DAS or HW at 15 DAS and 30 DAS in soybean reported that maximum profitability (benefit: cost ratio) was obtained in the treatment where Oryzalin @ 3 Kg ha^{-1} is applied along with HW at 30 DAS. It was observed that with the increasing dose of Oryzalin, persistence of Oryzalin in soil also increased.

Green gram

HW and application of 0.05 kg Imazethapyr + 0.5 kg Pendimethalin ha^{-1} significantly decreased weed populations, weed dry weight and increased yields and yield components of pigeonpea + green gram intercropping. Net returns and benefit:cost were also higher in these treatments (Patil and Pandey, 1996).

Singh *et al.* (2008) found from an experiment with summer green gram two HW (20 and 40 DAS) was best in terms of growth, yield attributes and yield but the treatment Alachlor @ 1.5 kg ha^{-1} + HW at 20 DAS was best in terms of B: C.

Black gram

Rao *et al.* (2010) observed that PE sand mix application of Pendimethalin @1000 g ha^{-1} followed by Imazethapyr @ 50 g ha^{-1} at 20 DAS significantly reduced weed growth and recorded the highest black gram seed yield (1113 kg ha^{-1}), net monetary returns (Rs. 2255 ha^{-1}) and B:C (1.33) and was at par with other sequential treatment Oxyfluorfen @ 120 g ha^{-1} followed by Imazethapyr @ 50 g ha^{-1} and also with HW at 15 and 30 DAS.

Sharma and Rajkhowa (1988) stated that Fluchloralin @ 1.5 kg ha^{-1} resulted in the best yield and net return after conducting experiment in *kharif* black gram.

Rathi *et al.* (2004) conducted experiment during 2001 and 2002 to develop an eco friendly integrated weed management technology for *kharif* black gram stated that Pendimethalin @ 0.5 kg ha^{-1} followed by one HW control of all the associated weeds resulting in 67.81% WCE, enhanced grain yield and fetched net monetary return.

Bhandari *et al.* (2004) found with increasing doses of the herbicides decreasing the weed density and dry weight and increasing seed and straw yields of black gram compared with the weedy control. Fluchloralin @ 1.5 kg ha^{-1} and Pendimethalin @ 2.0 kg ha^{-1} recorded the highest seed yields, which were at par with that obtained in the weed-free treatment. However, Fluchloralin @ 0.5 kg ha^{-1} alone or supplemented with one hoeing was the most cost effective treatment, with the highest benefit:cost ratio.

Velayudham (2007) reported that PE application of Pendimethalin @ 0.75 kg ha^{-1} +HW on 40 DAS with normal seed rate recorded higher grain yield of 753 kg ha^{-1} and highest benefit cost ratio in black gram.

2.6 Effect of herbicides on the *rhizosphere* micro flora

Singh *et al.* (1994) found that Methabenzthiazuron @ 1.31 kg ha^{-1}, Linuron @ 0.75 kg ha^{-1}, Pendimethalin @ 0.75 kg ha^{-1} and HW twice 3 and 4 weeks after sowing in pea, all herbicide treatments reduced the number of soil bacteria and fungi. However, only Linuron reduced the number of soil fungi. All herbicide treatments reduced the number of nodules $plant^{-1}$ and nitrogenase activity of pea. All weed control treatments increased grain yields from untreated control, Pendimethalin resulting in the greatest yields. All weed control treatments resulted in 79.6-85.1% control of weeds.

Choudhari *et al.* (2009) declared that all the POE herbicides were effective against weed control and also had less effect on soil microbial population.

Yousef *et al.* (1987) found from a field experiments, populations of fungi, bacteria and actinomycetes were significantly higher in the *rhizosphere* of cotton treated with herbicides.

Khanmova *et al.* (1990) declared that herbicides reduced numbers of bacteria and actinomycetes to a lesser extent.

Banerjee and Dey (1992) conducted experiment with 3 pesticides (fluchloralin, mancozeb and Bengard), separately or in combination on jute rhizosphere microflora found that all the pesticides hindered microbial growth in the early stages but at later stages were not affected rhizosphere microflora.

Mukherjee *et al.* (1999) conducted experiment with fluchloralin @ 1.5 kg ha^{-1} on biological activity alluvial, lateritic and saline soils declared that application of herbicide significantly enhanced the micro flora population in alluvial soil.

Chapter-3

Materials & Methods

MATERIALS & METHODS

3.1 Experimental site

The present field experiment was conducted at Instructional Farm, Jaguli, Nadia to study the effect of both synthetic herbicides and natural botanicals on nodulation, yield and bio-efficacy & phytotoxicity on both weeds and crops and also their effect on soil micro flora during *pre-kharif* (summer) season of 2009 and 2010 with groundnut (*Arachis hypogaea* L.) & soybean (*Glycine max*) two legume oil seeds and green gram (*Vigna radiata*) & black gram (*Vigna mungo*) two legume pulses. The Farm is situated at $22^0 95'$ N latitude, $80^0 50'$ E longitude with an altitude of 9.75 m above MSL.

3.2 Climate and weather condition

The place has a subtropical humid climate. The average rainfall is 1457 mm, mostly precipitates during June – September and the mean temperature ranges from 10^o C to 37^oC. Broadly; the seasons are classified as –

i) Cool season (November - February)
ii) Dry season (March - May) and
iii) Wet season (June - October)

The data on different weather parameters during crop growth period were recorded from the Agro-meteorology Research Station, Research Complex, Directorate of Research, BCKV, Kalyani during the experimental period.

Climate - Warm and humid

- Average maximum temperature – May – June
- Average minimum temperature – December – January
- Mean monthly rainfall –

  Maximum in July – August

  Minimum in December – February

  Average rainfall – 1700mm/annum

  70% rainfall – July – October
- Lowest RH – December
- Highest RH – August

Table 3.1 Meteorological observations during the experimental period

2009

Month	Fortnight	Temperature (^oC)		Relative Humidity (%)		Rainfall (cm)
		Max.	Min.	Max.	Min.	
January	First	25.67	12.96	97.27	87.46	0.00
	Second	27.06	12.05	98.87	84.68	0.00
February	First	28.63	12.86	·99.07	75.42	0.00
	Second	30.29	15.70	97.17	34.42	0.00
March	First	32.90	18.01	101.26	35.33	0.00
	Second	32.80	18.95	95.50	49.62	4.45
April	First	35.02	23.44	96.13	50.67	0.00
	Second	38.22	25.82	87.40	41.67	0.00
May	First	38.35	25.32	93.60	60.60	3.69
	Second	33.69	24.43	93.81	71.00	8.94
June	First	35.22	26.23	93.86	68.26	3.24
	Second	37.84	27.00	94.86	70.20	1.98
July	First	32.45	26.19	90.67	79.60	16.21
	Second	33.29	26.32	94.93	77.68	6.43
August	First	33.12	26.18	97.40	78.80	12.61
	Second	32.15	24.04	97.95	81.75	14.95
September	First	32.59	27.60	98.66	84.33	9.98
	Second	33.32	25.87	97.26	78.86	15.86
October	First	32.15	24.21	98.26	73.80	4.26
	Second	31.63	19.99	95.50	53.50	0.00
November	First	31.97	20.74	97.13	55.13	0.00
	Second	27.42	15.34	96.93	52.53	0.93
December	First	26.84	12.78	98.96	48.46	0.00
	Second	25.25	10.48	97.50	42.43	0.00

Source: *Department of Agricultural Meteorology and Physics, Faculty of Agriculture, BCKV*

Cont..

2010

Month	Fortnight	Temperature (°C)		Relative Humidity (%)		Rainfall (cm)
		Max.	Min.	Max.	Min.	
January	First	22.78	15.28	96.20	55.47	0.00
	Second	24.48	8.73	96.00	50.56	0.00
February	First	27.89	12.58	95.64	39.42	0.00
	Second	30.52	16.62	97.14	48.28	0.54
March	First	34.55	19.97	95.33	35.67	0.00
	Second	36.09	23.51	94.56	47.56	0.00
April	First	37.39	26.08	95.80	46.00	0.00
	Second	37.03	25.64	92.87	55.87	1.99
May	First	35.43	24.69	93.47	64.53	7.87
	Second	34.19	25.82	97.69	65.12	2.95
June	First	34.99	26.29	95.47	76.00	12.91
	Second	33.07	25.06	97.60	80.80	7.04
July	First	32.83	26.36	95.47	77.13	4.65
	Second	33.16	26.31	98.06	75.5	3.63
August	First	32.80	26.08	98.06	76.06	7.70
	Second	33.21	26.23	99.00	77.00	3.13
September	First	32.80	25.89	98.66	76.46	4.10
	Second	32.60	24.96	99.6	76.6	4.45
October	First	31.96	24.02	99.0	73.73	4.54
	Second	32.30	22.72	99.43	73.18	0.37
November	First	30.62	18.95	95.86	63.66	0.06
	Second	29.93	17.29	97.26	56.53	0.00
December	First	25.32	14.27	97.53	86.06	1.16
	Second	25.14	8.76	95.5	48.0	0.00

Source: *Department of Agricultural Meteorology and Physics, Faculty of Agriculture, BCKV*

3.3 Status of the experimental soil

The experiment was conducted in soil, which has medium fertility status with low water holding capacity. The soil was typical Gangetic Alluvial (*i.e.,* Inceptisol) with sandy loam in texture. Composite soil samples from 0-15 cm depth of experimental field were collected and physico-chemical properties of the soil have been analyzed which are summarized in the table 3.2

Table 3.2 Physico-chemical properties of the experimental soil

Particulars	**Content**				**Method Followed**
Textural Class	***Pre kharif 2009***	***Kharif 2009***	***Pre kharif 2010***	***Kharif 2010***	
Sand(%)	51.3	52.1	52.7	52.6	International Pipette Method (Piper, 1966)
Silt(%)	25.2	24.6	24.9	25.3	
Clay(%)	22.1	22.7	22.3	22.8	
Organic Carbon (%)	0.5867	0.5874	0.5939	0.5995	Rapid titration method as described by Walkely and Black Method (1934)
Total Nitrogen (%)	0.0543	0.0548	0.0559	0.0561	Modified Macrokjeldahl Method (Jackson, 1973)
Available Phosphorus (Kg/ha)	18.97	18.42	19.64	18.54	Bray Method No. 1 (Bray and Kurtz, 1945) followed by Jackson (1973).
Available Potassium (Kg ha^{-1})	126.37	124.38	128.92	123.67	Flame Photometric Method (Muhr *et al.*, 1965)
pH	6.69	6.63	6.71	6.74	Beckmen's pH meter using soil water suspension (1:2.5) following the method of Jackson (1973).

3.4 Cropping history of the experimental plot

The information of the previous crops grown in the experimental plot have been summarized in table 3.3

Table 3.3 Previous crop history

Year	***Pre-kharif***	***Kharif***	***Rabi***
2006-2007	Fallow	Paddy	Wheat
2007-2008	Moong	Paddy	Potato
2008-2009	Sesame	Paddy	Mustard

3.5 Experimental details

The main objective of the experiment was to study the effect of chemical herbicides on the nodulation and yield of different legume crops and also bio-efficacy and phytotoxicity of the herbicides on both weeds and crops. There were 7 treatments, which were allocated randomized in different plots under Randomized Block Design (RBD) with three replication.

Design of the experiment - Randomized Block Design (RBD)

Treatment No. – 7

Replication - 3

No. of the plots – 21

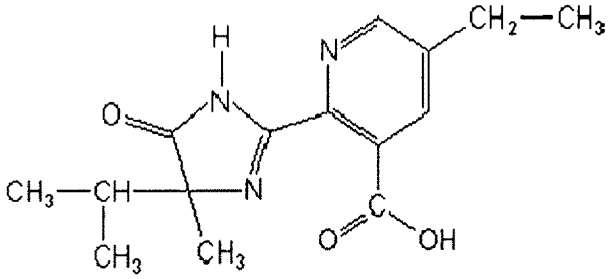
Size of the plot – 5m x 5m

Table 3.4 Details of the treatments

Treatments		Treatment Details		Time of application
T_1	:	Imazethapyr 10SL @ 100 g a.i. /ha	-	Post emergence
T_2	:	Quizalofop-ethyl 5 EC @ 50 g a.i. /ha	-	Post emergence
T_3	:	Fenoxaprop-p-ethyl 9 EC @ 50 g a.i. /ha	-	Post emergence
T_4	:	Oxyfluorfen 23.5 EC @ 200 g a.i. /ha	-	Pre emergence
T_5	:	Tank mix of *Calotropis* raw leaf extract 5% *v/v* + *Parthenium* raw leaf extract 5% *v/v*	-	Pre emergence
T_6	:	Hand Weeding	-	20 DAS
T_7	:	Control		

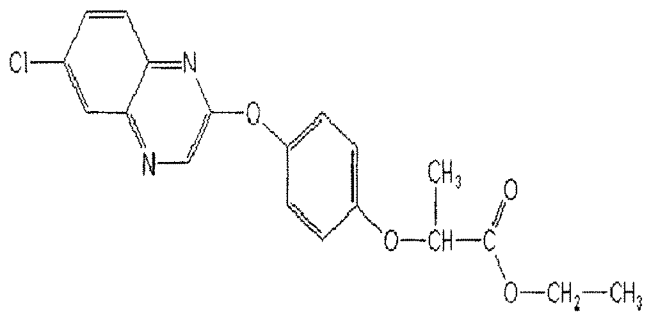
3.6 Chemical nature of the herbicide used

3.6.1 Imazethapyr

1	Technical Name	:	Imazethapyr
2	IUPAC Name	:	*5-ethyl-2-[(RS)-4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl]nicotinic acid*
3	Chemical Abstracts name	:	(-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid
			$C_{15}H_{19}N_3O_3$
4	Structural Formula	:	
5	Formulation	:	10% SL
6	Herbicide Family	:	Imidazolinone
7	Type of the herbicide	:	Post emergence for control of broadleaf weeds and grasses

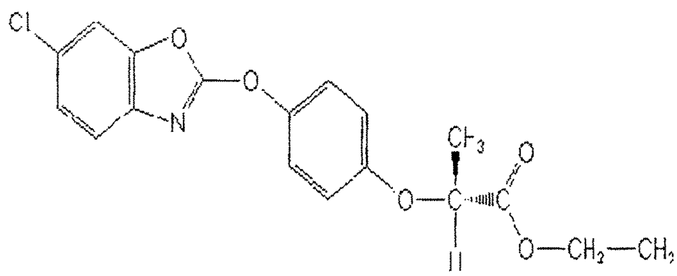
8	Dose of Application	:	100 g a.i. /ha
9	Time of application	:	Can be applied as an early pre-plant, pre-plant incorporated, pre-emergent or post-emergent treatment.
10	Method of Application	:	Application by spray in addition to water by knapsack sprayer fitted with flat fan deflector nozzle.
11	Solubility	:	In water 1.4 g/l (25 °C). In acetone 48.2, methanol 105, toluene 5, dichloromethane 185, dimethyl sulfoxide 422, isopropanol 17, heptane 0.9 (all in g/l, 25 °C)
12	Toxicity class	:	Toxicity Class "III" by WHO (a.i) & EPA (formulation)
13	Mode of action	:	Systemic herbicide, absorbed by the roots and foliage, with translocation in the xylem and phloem, and accumulation in the meristematic regions. The compound controls weeds by reducing the levels of three branched-chain aliphatic amino acids, isoleucine, leucine and valine, through the inhibition of aceto-hydroxyacid synthase, an enzyme common to the biosynthetic pathway for these amino acids. This inhibition causes a disruption in protein synthesis which, in turn, leads to an interference in DNA synthesis and cell growth.
14	Residue information	:	The formulated product does not leach through the soil. It is weakly to moderately adsorbed and is not lost from the soil through volatilization. Soil microorganisms do not appear to play a significant role in the degradation of the formulated product. The formulated product is readily absorbed through the roots and foliage. It is translocated in both xylem and phloem tissues and accumulates in growing points.

3.6.2 Quizalofop-ethyl

1	Technical Name	:	Quizalofop- ethyl
2	IUPAC Name	:	ethyl (2*RS*)-2-[4-(6-chloroquinoxalin-2-yloxy)phenoxy]propionate
3	Chemical Abstracts name	:	ethyl 2-[4-[(6-chloro-2-quinoxalinyl)oxy]phenoxy]propanoate
4	Structural Formula	:	$C_{19}H_{17}ClN_2O_4$ 
5	Formulation	:	5% EC
6	Herbicide Family	:	Aryloxyphenoxypropionic acid
7	Type of the herbicide	:	Selective post emergence grass killer herbicide
8	Dose of Application	:	50 g a.i. ha^{-1}
9	Time of application	:	Post-emergence at 15-20 days after emergence (DAE). Applied on 3-6 leaf stage of annual grass weeds and on 10-15 cm height of perennial grass weeds. Application should be made well before the crop covers the weeds.
10	Method of Application	:	Application by spraying in addition to water (with WFN 040 Floodjet nozzle))
11	Solubility	:	Soluble in water
12	Toxicity class	:	WHO (a.i.) III, EPA (formulation) III
13	Mode of action	:	It is an acetyl Co-A carboxylase inhibitor and also inhibitor of fatty acid biosynthesis. It is quickly absorbed by the foliage and during translocation in plant, it moves both through xylem and phloem, accumulates in the nodes and underground rhizomes and destroys meristematic tissues. In addition to top killing activity, it also effectively

			controls re-growth of perennial grasses. After folier application of this herbicides, the growth of weeds is retarded and young leaves turn yellowish or purple within 4-5 days after application (DAA) and all the leaves of the weeds become necrotic at 5-7 DAA. Subsequently, necrotic death of whole weed plant occurs within 10 DAA.
14	Residue information	:	In soil it degrades rapidly to quizalofop; DT < ld

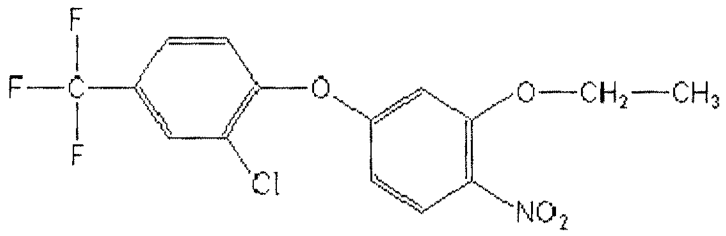
3.6.3 Fenoxaprop-p-ethyl

1	Technical Name	:	Fenoxaprop-p-ethyl
2	IUPAC Name	:	ethyl (*R*)-2-[4-(6-chloro-1,3-benzoxazol-2-yloxy) phenoxy] propionate or ethyl (*R*)-2-[4-(6-chlorobenzoxazol-2-yloxy)phenoxy]propionate
3	Chemical Abstracts name	:	ethyl (R)-2-[4-[(6-chloro-2-benzoxazolyl)oxy]phenoxy]propanoate
4	Structural Formula	:	$C_{18}H_{16}ClNO_5$ 
5	Formulation	:	9 % EC
6	Herbicide Family	:	Aryloxyphenoxypropionic acid
7	Type of the herbicide	:	Selective control of annual and perennial grass weeds
8	Dose of Application	:	50 g ha^{-1}
9	Time of application	:	Post-emergence
10	Method of Application	:	Application by spray in addition to water by

11	Solubility	:	knapsack sprayer fitted with flat fan deflector nozzle. Water: 0.0007 Methanol: 43.1 2-Propanol: 14.2 Acetone: > 400 Ethylacetate: > 380 Toluene: > 480 n-Hexane: 7 Dichloromethane: > 400 Dimethylsulfoxide: > 500 Polyethylene glycol (PEG): 18.2 (in $g\ l^{-1}$ at 20°C)
12	Toxicity class	:	WHO Classification - U Definition - Product unlikely to present acute hazard in normal use color code - Green
13	Mode of action	:	Mode of action Fenoxaprop-P-ethyl is a selective herbicide with contact and systemic action, absorbed principally by the leaves, with translocation both acropetally and basipetally to the roots or rhizomes.
14	Residue information	:	Fenoxaprop-ethyl is metabolised via fenoxaprop to 6-chloro-2,3-dihydrobenzoxazol-2-one in plant. In soil and Environment fenoxaprop-ethyl is rapidly hydrolysed to fenoxaprop (A. E. Smith, J. Agric. Food Chem., 1985, 33, 483); DT50 1-10 d.

3.6.4 Oxyfluorfen

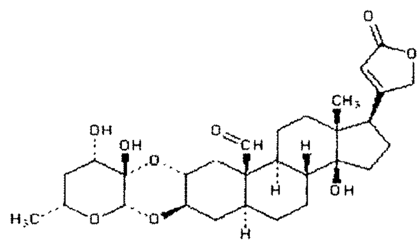
1	Technical Name	:	Oxyfluorfen
2	IUPAC Name	:	2-chloro-α,α,α-trifluoro-*p*-tolyl 3-ethoxy-4-nitrophenyl ether
3	Chemical Abstracts name	:	2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene

4	Structural Formula	:	$C_{15}H_{11}ClF_3NO_4$ 
5	Formulation	:	23.5 % EC
6	Herbicide Family	:	Nitrophenyl ether herbicides
7	Type of the herbicide	:	Contact herbicide used for pre- or post-emergence control of monocotyledenous and broad-leaved weeds.
8	Dose of Application	:	200 g ha^{-1}
9	Time of application	:	preemergence
10	Method of Application	:	Application by spray in addition to water by knapsack sprayer fitted with flat fan deflector nozzle.
11	Solubility	:	0.1 mg l^{-1} in water readily soluble in most organic solvents (e.g acetone, cyclohexanone, isophorone)
12	Toxicity class	:	EPA toxicity class III
13	Mode of action	:	Oxyfluorfen targets a specific enzyme, protoporphyrinogen oxidase, in the chlorophyll biosynthetic pathway. Inhibiting protoporphyringen oxidase in plants leads to an accumulation of phototoxic chlorophyll precursors which, in the presence of light, produce activated oxygen species which rapidly disrupt cell membrane integrity. Oxyfluorfen must contact plant foliage to cause effects. Plants that are actively growing are most susceptible to oxyfluorfen. By forming a chemical barrier on the soil surface, oxyfluorfen affects plants at emergence. This barrier is formed with adequate spray coverage or irrigation following granule application (to partially dissolve granules and promote dispersion of oxyfluorfen over the soil surface). Because of the length of oxyfluorfen soil half-life, this barrier may last up to three months. All plants attempting to emerge through the soil surface will be affected through contact. Oxyfluorfen also affects plants

			through direct contact of spray or granules to exposed tissues.
14	Residue information	:	Breakdown of Chemical in Soil and Groundwater Oxyfluorfen has a strong tendency to adsorb to soil particles and is nearly insoluble in water. Once oxyfluorfen is adsorbed to soil particles, it is not readily removed. It is therefore unlikely to leach downward or to contaminate groundwater. In aged sandy loam, 82% of applied oxyfluorfen remained in the top 2 inches of soil. Oxyfluorfen did not leach below 4 inches in any soil except sand. In soils, oxyfluorfen is not subject to microbial degradation, and is not subject to hydrolysis at pH 5, 7 or 9. It is therefore highly resistant to degradation in the soil environment. Decomposition by light occurs slowly, with 15% of the oxyfluorfen applied to a soil surface degrading within 28 days. In laboratory studies, its soil half-life was 6 months. Its soil half-life in field studies is 30 to 70 days, with much of the loss probably due to volatilization. Breakdown of Chemical in Surface Water In water, oxyfluorfen is rapidly decomposed by light. Because oxyfluorfen is nearly insoluble in water and has a tendency to adsorb to soil, it is unlikely to remain in water. It will instead adsorb to suspended particles or sediments. Breakdown of Chemical in Vegetation There is very little movement of oxyfluorfen within treated plants. It is not readily metabolized by plants, but since it is not readily taken up by roots, residues in plants are very low. In crop rotation studies, residues of oxyfluorfen were found in small grains, but not in root or vegetable crops grown on previously treated fields. When carrots, lettuce, oats and cotton were planted in plots treated with 0.25 to 0.5 pounds per acre of radio-labeled oxyfluorfen on year prior to planting, low levels of residues were found in carrots and oats, but not in cotton or lettuce.

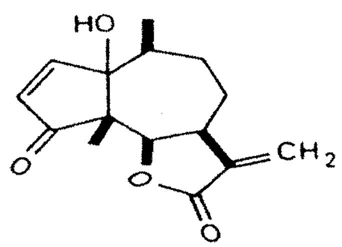
3.6.5 *Calotropis* extract

The raw leaf extract done by green and fresh part of the plant, at first collected plant wash with tap water, after wash the plant material crushed by mixer grinder, than the raw extract strained by sieve , add 50 ml. of extract mix with one liter volume of water to make 5 % solution.

1	*Calotropis procera*	:	Calotropin
2	Chemical Abstracts name	:	[2a(2*S*,3*S*,4*S*,6*R*),3b,5a]-14-Hydroxy-19-oxo-3,2-[(tetrahydro-3,4-dihydroxy-6-methyl-2*H*-pyran-2,3-diyl)bis(oxy)]card-20(22)-enolide
3	Structural Formula	:	$C_{29}H_{40}O_9$ 
4	Molecular Weight	:	532.62
5	Percent Composition	:	C 65.40%, H 7.57%, O 27.04%
6	Properties	:	Rectangular platelets from alcohol or ethyl acetate, mp 223° (dec). [a]D18 +66.8° (in methanol). Sol in water, alc. Practically insol in ether. uv max: 217, 310 nm (log e 4.21, 1.49). MLD i.v. in cats: 0.12 mg kg^{-1} (Brüschweiler)
7	Melting point	:	mp 223° (dec)
8	Optical Rotation	:	[a]D18 +66.8° (in methanol)
9	Absorption maximum	:	uv max: 217, 310 nm (log e 4.21, 1.49)
10	Toxicity data	:	MLD i.v. in cats: 0.12 mg kg^{-1} (Brüschweiler)

3.6.6 *Parthenium* extract

The raw leaf extract done by green and fresh part of the plant, at first collected plant wash with tap water, after wash the plant material crushed by mixer grinder, than the raw extract strained by sieve , add 50 ml. of extract mix with one liter volume of water to make 5 % solution.

1	*Parthenium hysterophorus*	:	Parthenin
2	Chemical Abstracts name	:	[3aS-(3aa,6b,6aa,9ab,9ba)]-3,3a,4,5,6,6a,9a,9b-Octahydro-6a-hydroxy-6,9a-dimethyl-3-methyleneazuleno[4,5-*b*]furan-2,9-dione
3	Structural Formula	:	$C_{15}H_{18}O_4$ 
4	Molecular Weight	:	262.30
5	Percent Composition	:	C 68.68%, H 6.92%, O 24.40%
6	Properties	:	Crystals from water, mp 163-166°. [a]D25 +7.02° (c = 2.71 in chloroform). uv max: 215, 340 nm (e 15,100; 22). Practically insol in water. Sol in alcohol, chloroform, ether, ethyl acetate.
7	Melting point	:	mp 163-166°
8	Optical Rotation	:	[a]D25 +7.02° (c = 2.71 in chloroform)
9	Absorption maximum	:	uv max: 215, 340 nm (e 15,100; 22)

3.7 Spraying schedule

All the herbicides were sprayed by using 500 litres of water ha^{-1} with knapsack sprayer fitted with flat fan deflector nozzle.

Table 3.5 Spraying schedule

No.		Treatment Details	Spraying time
T_1	:	Imazethapyr 10SL @ 100 g a.i. /ha	20 DAS
T_2	:	Quizalofop- ethyl 5 EC @ 50 g a.i. /ha	20 DAS
T_3	:	Fenoxaprop-p-ethyl 9 EC @ 50 g a.i. /ha	20 DAS
T_4	:	Oxyfluorfen 23.5 EC @ 200 g a.i. /ha	1 DAS
T_5	:	Tank mix of *Calotropis* raw leaf extract 5% *v/v* + *Parthenium* raw leaf extract 5% *v/v*	1 DAS
T_6	:	Hand Weeding at 20DAS	-
T_7	:	Control	

3.8 Details of the crop grown

Crop	Cultivar	Scientific name	Family
Green gram	WBM – 34-1-1 (Bireswar)	*Vigna radiata* L.	Leguminosae
Black gram	B-76 (Kalindi)	*Vigna mungo*. L	Leguminosae
Groundnut	JL 24 (Phule Pragati)	*Arachis hypogaea* L.	Leguminosae
Soybean	PK-327	*Glycine max* L.	Leguminosae
Follow up crop			
Rice	IET-4786 (Satabdi)	*Oryza sativa*	Poaceae

3.8.1 Description of the green gram variety used in the experiment

The variety Bireswar (WBM – 34-1-1) was taken for the experiment. It matures in 60-65 days. The colour of the seed is shining pale green and the seeds are bold in size. It can be sown both pre-*kharif* and *kharif* season. Yield potentiality of the variety is 10-12.5 q ha^{-1} . Test weight (i.e. 1000 seed weight) of seed is about 32g.

3.8.2 Description of the black gram variety used in the experiment

Black gram variety Kalindi (B-76) was used in this experiment, which was released in 1982. Plant height 30-35 cm, erect, stem and foliage dark green in colour, profusely pubescent. Leaves lanceolate. Pods are short profusely pubescent turns black on maturity. Seeds medium in size (4.2 g/100 seeds) and black in colour. It matures within 80-85 days. Yield potentiality of this variety is 10-12.5 quintal ha^{-1}.

3.8.3 Description of the soybean variety used in the experiment

The name of the soybean variety used in this experiment was PK-327, which was developed at GBPUAT, Pantnagar and released by Central Variety Release Committee. Duration of the variety is 105-110 days. Height of the plant is 50-70 cm. The flowering starts from the base of the plant to the top of the plant. It has light yellow colored seeds with black hilum. Its oil and protein content are 20 and 39-42%, respectively. Yield potentiality of this variety is 25-30 quintal ha^{-1}.

3.8.4 Description of the groundnut variety used in the experiment

The variety JL-24 (Phule Pragati) used in this experiment. It matures 100-110 days. Average yield is about 20-25 q ha^{-1}. Shelling percentage and oil content of this variety are 75% and 50.7 % respectively. The size of the seed is medium (45g per 1000 seeds).

3.8.5 Description of the rice variety used in the experiment

The name of the rice variety used in the experiment was IET 4786 (popularly known as Satabdi). It is a non-scented rice cultivar with super fine grains fetching very high market price. Some important characters of this variety are,

a) This is a semi dwarf, high yielding variety, developed at CRRI, Cuttack from crossing CR 10-114 x CR 115 in the year 1977 and is suitable for medium land situation.
b) The seed to seed duration of the variety ranges from 120 days (in *kharif* season) to 140 days (in *boro* season).
c) It has good cooking and milling quality and grains are of long slender (LS) type (average length 6.5-7.0 mm and Length: Breadth ratio around 3.3).
d) Average yield varies from 3.0 to 6.0 t ha^{-1}.

3.9 Layout of the Experimental Plot

The experimental field was divided into three blocks. Each block was divided into seven plots 1 meter irrigation channel were given first and second and second and third block, half-meter space were given between the plots. Plan of layout has been presented in Fig. 3.1

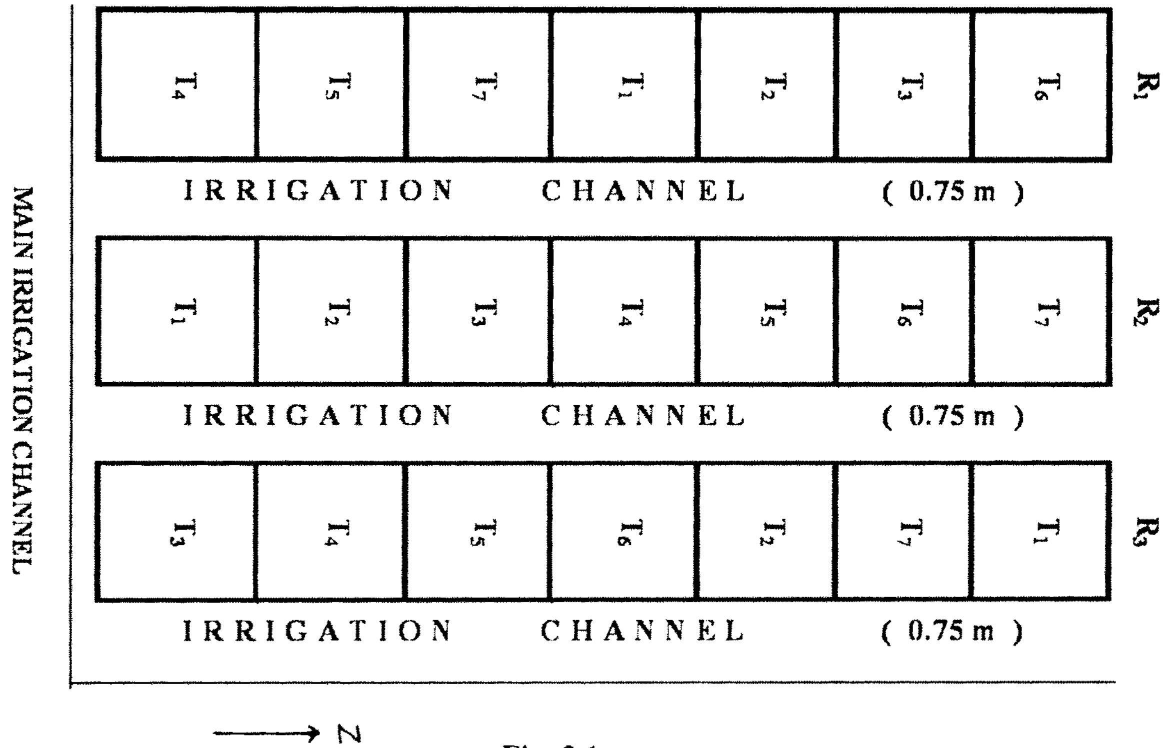


Fig. 3.1

3.10 Fertilizer application

3.10.1 Application of fertilizer for *pre-kharif* legume crop

One-fourth part (25 %) of the recommended dose 20 kg ha^{-1} of Nitrogen through Urea was applied as basal along with full amount of Phosphorus @ 40 kg ha^{-1} through Single Super Phosphate and Potassium @ 40 kg ha^{-1} through Muriate of Potash. The rest amount of Urea was applied in two splits; 50% at 20 days after sowing arfter hand weeding was done and another 25 % at 40 DAS.

3.10.2 Application of fertilizer for followup *kharif* direct seeded rice

Full doses of Phosphorus through Single Super Phosphate and Potash through Muriate of Potash each @ 30 kg ha^{-1} was applied at basal. Recommended dose of Nitrogen @ 60 kg ha^{-1} through Urea was applied in 4 splits at 5, 25, 45 and 65 DAT of the direct seeded *kharif* rice.

Table 3.6 Calendar of farm work

Type of the operation	YEAR				Details of the operation
	Soybean and Groundnut		Greengram and Blackgram		
	2009	2010	2009	2010	
A. *Pre-kharif*					
1. Land preparation	06.02.2009	08.02.2010	26.03.2009	27.03.2010	Two crosswise deep ploughing by tractor followed by two laddering were done to level the total field. Removal of the clods, stubbles and weeds also done.
2. Fertilizer application and Layout	11.02.2009	12.02.2010	01.04.2009	04.04.2010	The layout was done and basal dose of fertilizers were applied.
3. Seed treatment, *rhizobium* inoculation and sowing of seeds	12.02.2009	13.02.2010	02.04.2009	05.04.2010	The seeds were treated with Indofil-M-45 thoroughly @ 2.5 g kg-1 of seeds and before sowing in the line 30 cm x 10 cm spacing *rhizobium* inoculation was done.
4. Spraying of Herbicides	13.02.2009	14.02.2010	03.04.2009	06.04.2010	Spraying of *Parthenium* and *Calotropis* extract were done as per treatment.
5. Thinning	02.03.2009	02.03.2010	26.04.2009	28.04.2010	Thinning was done to keep the proper spacing between plants.
6. Spraying of Herbicides and weeding	04.03.2009	05.03.2010	22.04.2009	25.04.2010	Spraying of chemical herbicides, *Parthenium* and *Calotropis* extract and weeding were done as per treatment
7. Plant protection	19.03.2009	22.03.2010	10.05.2009	13.05.2010	Spraying of Confidor (Immidachlorprid) as insecticide @ 2.5 ml lt^{-1} water was done.
8. Harvesting	03.06.2009 08.06.2009	06.06.2010 11.06.2010	01.06.2009 22.06.2009	03.06.2010 23.06.2010	**Green gram and Black gram** – The pods were handpicked when the pods turned yellowish green in green gram and blackish green in black gram since over maturity may result in shattering. 3-4 times hand picking were carried out in both the crops from individual plots. The harvested pods were dried in the sun on threshing floor for few days and then

			threshed manually. **Groundnut** - Groundnut plants were dug with a spade and nuts were separated by hand. Nuts were dried in the sun and threshed with hands for estimating the shelling percentage and yield. **Soybean** – The crop is harvested when the leaves turn yellow and the pod dries out. Harvesting is done by hand, breaking the stalks on the ground level on with sickle. Threshing is done manually.
9. Post harvesting operation			The harvested plants were heaped and left in the field (plot wise) for 3 days for sun drying of pods.

B. Kharif* *follow up crop	**YEAR** 2009	2010	**Details of the operation**
1. Land preparation	28.06.2009	30.06.2010	Each plots were brought to a fine tilth and well pulverized condition with the help of spade without destroying the layout which was done at previous season.
2. Fertilizer application	29.06.2009	01.07.2010	Full doses of Phosphorus through Single Super Phosphate and Potash through Muriate of Potash each @ 30 kg ha^{-1} was applied at basal. Recommended dose of Nitrogen @ 60 kg ha^{-1} through Urea was applied in 4 splits at 5, 25, 45 and 65 DAT of the direct seeded *kharif* rice.
3. Sowing	29.06.2009	01.07.2010	Seeds were treated with *Trichoderma viride* @ 4 g kg^{-1} of seed and kept under shade for overnight. Sowing was done with a spacing of 20cm in line.
4. Hand weeding	19.07.2009	20.07.2010	Hand weeding was done to remove the weed and to keep the field weed free.
6. Plant protection	21.07.2009	22.07.2010	Spraying of Confidor (Immidachlorprid) as insecticide @ 2.5 ml lt-1 water was done.
9. Harvesting	18.10.2009	17.10.2010	The crop was harvested by cutting with the sickle at 5 cm above from the ground.
10. Threshing	28.11.2007	30.11.2010	It was done with paddy thresher. The grain and straw were separated, dried in sun and weighed plot wise.

3.11 Formulae adopted for calculation of different chemicals required in the experiment

3.11.1 Herbicide application

The amount of herbicides required for the experiment was calculated by using the following formula:

$$Q = \frac{R \times A}{C} \times 100$$

Where,

Q= Quantity of formulated product of the herbicide required in kg or litre ha^{-1}.

R= Rate of application in kg ha^{-1}.

A= Area in m^2

C= Concentration (active ingredient) of the chemical in percentage.

3.11.2 Fertilizer application

The amount of fertilizers required for the experiment was calculated by using the following formula:

$$\text{Amount (kg)} = \frac{\text{Amount of element desired (kg) x area (ha) x 100}}{\text{\% element in fertilizer}}$$

3.11.3 Insecticide application

The amount of insecticide required for the experiment was calculated by using the following formula:

$$\text{Amount (kg or l)} = \frac{\text{Rate desired (kg ai ha}^{-1}\text{) x area (ha) x 100}}{\text{Concentration of insecticide (\%)}}$$

3.12 Methods of recording different biometrical observations

For recording observations 1m x 1m area was marked in each plot from the total 5 m X 5 m area and the rest area was kept for yield and yield parameters assessment.

3.12.1 Method for calculating growth attributes

3.12.1.1 Plant height

In each plots 5 plants were randomly selected and tagged avoiding border row. Plant height was recorded from ground level up to the apical portion of the main shoot.

3.12.1.2 Dry matter accumulation (DM)

Destructive plant samples were taken at different stages of growth of the crops. The samples were taken from two fixed rows of each plot excluding border rows. The plants were cut from ground level and kept in labeled brown paper packet. Then they were kept in oven and dried at a temperature of 80-90^0 C till it attained constant dry weight. From this dry matter accumulation was calculated.

3.12.1.3 Crop growth rate (CGR)

Crop growth rate (CGR) is the dry weight gained by a unit area of crop in a unit time and is expressed as g m^{-2} day^{-1}. The following formula (Watson, 1958) was used for computing crop growth rate of the crop

$$CGR = \frac{W_2 - W_1}{t_2 - t_1}$$

Where, W_1 and W_2 are dry weights of plants and t_1 and t_2 are time of observations.

3.12.1.4 Leaf area index (LAI)

Leaf area index (LAI) is the ratio between the area of the surface of green leaves and ground area cover. LAI was determined by indirect method. 5 green leaves were selected from the plant samples. The middle portions of the leaves were punched with a puncher with a radius of 1 cm. Then the area of 5 punched leaves was calculated by multiplying the area of puncher with the number of leaves. Then the samples of each treatment were dried in an oven at 60 ^{0}C for about 8-10 hours till a constant weight was obtained and their weight was recorded separately. The weight of these 5 punched leaves was used to determine the leaf area indices. LAI is obtained through the ratio of the area corresponding to the dry weight of green leaves to area of the land surface. LAI was worked out with the concept proposed by Watson (1947).

The following formula was used for computing leaf area index.

$$LAI = \frac{\text{Total leaf area}}{\text{Area of land (m}^2\text{)}}$$

3.12.1.5 Volume of Root

Five plants were randomly selected and dug out carefully. Roots were then washed and dipped in a container completely full of water. The displaced water, made by root dipping, was measured in a measuring cylinder. The volume of displaced water was equal to the volume of root. Then the average value of volume of each plant root was recorded treatment wise.

3.12.2 Methods for recording yield attribute

3.12.2.1 Number of branches plant^{-1}

Numbers of branches at harvest was simply counted on the main stem from 5 labeled plants from each plot.

3.12.2.2 Number of pods plant^{-1}

Total number of pods from 5 plants randomly selected in each plot was counted and then converted into the number of pods plant^{-1}.

3.12.2.3 Number of seeds pod^{-1}

Ten capsules were randomly selected from each plot. Seeds were counted to determine the number of seeds pod^{-1}.

3.12.2.4 Test weight (1000 seeds)

One thousand seeds were counted from each plot separately after threshing and cleaning and their respective weights were recorded after drying in the sun.

3.12.2.5 Shelling percentage of groundnut

To determine shelling, 100 g sun-dried pods were taken and seeds were collected from it after shelling. The weight of collected seeds was recorded. Shelling percentage was determined by dividing the weight of seeds by 100g and then multiplied by 100. It is expressed in percentage.

3.12.3 Methods for recording nodulation data

3.12.3.1 Number of nodule plant^{-1}

Total number of nodules collected from 5 plants randomly selected in each plot was counted and then converted into the number of nodules plant^{-1}.

3.12.3.2 Dry matter of nodule plant^{-1}

Total nodules collected from 5 plants randomly selected in each plot were kept in oven and dried at a temperature of 80-90^{0} C till it attained constant dry weight. From this dry weight of nodules plant^{-1} was calculated.

3.12.3.3 Leghemoglobin content of nodules

One hundred mg fresh nodule was collected from each plot. Then the nodules were crushed in 4 ml of phosphate buffer solution. From the crushed solution 2 ml of solution was collected after distillation. It was mixed with 2 ml of buffer solution and 2 ml of colour developing reagent and shakened for 30 seconds in a glass tube. It was then placed in a spectrocolorimeter and density cut off readings were taken at 660 μm. A standard curve was made for density cut off and leghemoglobin content was recorded for each treatment. Colour developing reagent was prepared by mixing 100 mg benzenidine and 0.5 ml H_2O_2. Then the volume was made up to 50 ml by mixing absolute alcohol.

3.12.4 Methods for recording yield

3.12.4.1 Seed yield

The seeds after threshing from respective crops were cleaned and dried in the sun. After which yield data were calculated from the area and converted into tonne hectare^{-1}

3.12.4.2 Stalk yield

From each plot, plants were cut at ground level demarcated for yield assessment from the area. The plants were dried in the sun, threshed, weighed and then converted into tonne hectare^{-1}

3.12.4.3 Pod yield of groundnut

Plants were uprooted from demarked net plot with the help of spade and pods were collected from plants by stripping. The pods were dried under the sun and weighed plot wise.

3.12.4.4 Kernel yield of groundnut

The pod yields obtained from each plot in hectare basis were multiplied by their respective shelling percentage and kernel yield was recorded.

3.12.5 Observation during follow up rice crop

The plants from demarcated area (undisturbed 1 m^{-2} area) were cut and at the base in each plot. These plants were sun dried, threshed, then straw and grain yield were recorded for each plot separately. These readings then converted into t ha^{-1}.

3.12.6 Biometrical observation on weeds

The identification of different species of weeds, appeared in the experimental plots, was done throughout the crop growth period. The weed species were categorized into grasses (G), sedges (Sg) and broadleaf weeds (BLW).

3.12.6.1 Weed population

The population of different types of weeds (grass, sedge and broadleaf) was recorded at 15, 30, 45 DAA soybean, groundnut, green gram and black gram. A quadrate with a dimension of 0.5 m × 0.5m was placed randomly at three places in each plot and the weeds from that area were removed. These weeds were washed thoroughly and categorized into three groups viz., grass, sedge and broadleaf weeds. Each group of weeds was counted and expressed as number per square meter.

3.12.6.2 Dry weight of weeds

Weeds belonging to three categories obtained in population at 15, 30, 45 DAS and at harvest were labeled properly. The labeled samples were then kept in a drier at a temperature of 60^0C till constant weights of the samples were obtained. The dry weight of weeds was then taken and recorded separately.

3.12.6.3 Weed Control Efficiency (WCE)

Weed control efficiency is expressed as the percentage of control of weeds over unweeded control. It denotes the efficiency of the applied herbicide for comparison purpose. WCE of different treatments was computed on the basis of weed biomass by using the following formula,

$$\text{Weed Control Efficiency (\%)} = \frac{X-Y}{X} \times 100$$

Where, X= Weed dry weight in control (untreated or un-weeded) plot

Y= Weed dry weight of treated plot

3.12.7 Observation on phytotoxicity effect on crops

Visual assessment of crops was taken on 7, 15 and 30 DAA and data were recorded on the basis of rating scale (PRS) at percent basis injury as shown in Table 3.7. The parameters on phytotoxicity were taken as necrosis of leaf tips and margins, wilting, vein clearing, necrosis, epinasty and hyponasty. The herbicide toxicity was observed by visual scoring scale (1-10) with number of plants in respect of leaf injury on leaf tip and margin and also on the wilting of plant (CIB, 1989)

Table 3.7 Quantitative description of phytotoxic effects on crops

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

3.12.8 Soil analysis

Composite soil samples were collected from the experimental field at a depth of 0-15cm.

3.12.8.1 Mechanical analysis of soil

Mechanical analysis of soil particularly the contents of sand, silt and clay was done by International Pipette Method (Piper, 1966)

3.12.8.2 Chemical analysis of soil

3.12.8.2.1 Soil pH

The pH was determined by using electronic digital pH meter with glass electrode, caomel reference electrode and salt bridge at soil: water ratio of 1: 2.5, stirred till the reading (at 20^0C) was recorded (Jackson, 1973).

3.12.8.2.2 Organic carbon content of the soil

Organic carbon was determined in percentage, according to the Walkley and Black Method (1934), as stated by Jackson (1973), taking 2 g soil using diphenylamine as indicator.

3.12.8.2.3 Total Nitrogen content of the soil

Total Nitrogen content of the soil was determined in percentage, according to Modified Macro Kjeldahl Method (Jackson, 1973) as described by Jackson (1973).

3.12.8.2.4 Available phosphate (P_2O_5) content of the soil

Available phosphate content of the soil in kg ha^{-1} was determined by Bray and Kurtz (1945) method, as described by Jackson (1973).

3.12.8.2.5 Available potash (K_2O) in soil

Available potash (K_2O) in kg ha^{-1} was determined from 5 g of soil by Flame Photometric Method (Muhr *et al.*, 1965)

3.12.8.3 Methods of analysis for study on the soil micro flora

The enumeration of the microbial population was done on agar plates containing appropriate media following serial dilution technique and pour plate method (Pramer and Schmidt, 1965), plates were incubated at 30°C. The counts were taken at 3rd day of incubation. The results were recorded as number of cells per gram of soil. The media used are as follows –

3.12.8.3.1 Total bacteria

For counting total number of viable bacteria, Thornton's agar medium (Thornton, 1922) was used -

Thornton's agar medium

Dipotassium hydrogen phosphate	-	K_2HPO_4	-	1.0 g
Calcium chloride	-	$CaCl_2$	-	0.1 g
Magnesium sulphate	-	$MgSO_4$, 2 H_2O	-	0.2 g
Sodium chloride	-	NaCl	-	0.1 g
Ferric chloride	-	$FeCl_3$, $6H_2O$	-	0.002 g
Pottasium nitrate	-	KNO_3	-	0.5 g
Asparagine	-	$C_4H_8N_2O_3$	-	0.5 g
Mannitol	-	$C_6H_8(OH)_6$	-	1.0 g
Agar			-	15.0
Distilled water			-	1000 ml

pH of the medium was adjusted at 7.4 and sterilized at 15 lb pressure for 20 minutes.

3.12.8.3.2 Actinomycetes

Jensen's agar medium for actinomycetes (Jensen, 1930) was unused for counting the number of total actinomycetes.

Jensen's agar medium (for actinomycetes)

Dextroe	-	$C_6H_{12}O_6$	-	2.0 g
Casein [dissolved in 10 ml of 0.1 (N) NaOH]	-		-	0.2 g
Dipotassium hydrogen phosphate	-	K_2HPO_4	-	0.5 g
Magnesium sulphate	-	$MgSO_4, 7H_2O$	-	0.2 g
Ferric Chioride	-	$FeCl_3, 6H_2O$	-	Trace
Agar			-	15.0 g
Distilled water			-	1000 ml

3.12.8.3.3 Fungi

Martin's rose Bengal streptomycin agar medium (Martin, 1950) of the following composition was used for counting total fungi.

Martin's rose Bengal streptomycin agar medium

Potassium dihydrogen phosphate	-	KH_2PO_4	-	1.0 g
Magnesium sulphate	-	$MgSO_4, 7H_2O$	-	0.5 g
Dextrose	-	$C_6H_{12}O_6$	-	10.0 g
Peptone				5.0 g
Agar				10.0 g
Rose Bengal (1 : 300 aq)				10.0 g
Distilled water				1000 ml 30 î g ml
Streptomycin				30 î g ml

Sterile streptomycin was added to the medium just prior to plating. A stock solution was prepared by dissolving 10.0 mg of streptomycin in 2.0 ml distilled water. Approximately 0.1 ml of this stock solution was added to each plate containing about

15 ml of the medium. Medium containing all the ingredients except streptomycin was sterilized at 15 lb steam pressure for 20 minutes.

3.12.9 Method of statistical analysis

The data obtained were analyzed statistically by the analysis of variance method (Gomez and Gomez, 1984) and the significance of different sources of variation was tested by Error Mean Square by Fischer Snedecor's 'F' test, at probability level 0.05. The tables formulated by Fischer and Yates (1979) were consulted for the comparison of 'F' value and for the determination of critical differences (CD) at 5% probability level. The data in the parenthesis are original values of weed population which are subjected to square root transformation.

Chapter-4

Results

RESULTS

The experiment was performed during *pre-kharif* season with legume oil seeds groundnut & soybean and green gram & black gram pulse crops to study the effect of chemical herbicides on the nodulation and yield of crops and also bio-efficacy and phytotoxicity of the herbicides on weeds and crops respectively. Observations recorded on severity of different species of weeds, effect of different weed management methods on weed flora dynamics, growth and yield attributing characters of crops, soil microorganism and leghemoglobin content of these four legume crops during investigation were analyzed and have been presented in this chapter.

4.1 Study on weed flora

4.1.1 Severity of different weeds in experimental plots

Different weed species of different categories intercepted during different growth stages of crops. General investigation was made at regular interval on the weed flora up to 45 days after sowing (DAS) to note the different weed species present and their special characteristics features. The details on different dominant weed species present in the experimental field through the growing season are given in the Table 4.1

Table 4.1 Details of the dominant weed species found in the experimental field

A. Monocot Grass Weeds		**Special characteristics**
Botanical name - *Dactyloctenium aegyptium* **Family** - Poaceae **English name** - Star grass **Local name** – Makra ghash	:	Annual grass, propagated by seeds. Commonly found in summer and *kharif* season in upland situation.
Botanical name - *Digitaria sanguinalis* **Family** - Poaceae **English name** - Crab grass **Local name** – Kewai ghash	:	Annual grass, flowers and fruits through throughout the year, propagated by seeds. Commonly found in all upland crops.
Botanical name - *Echinochloa colona* **Family** - Poaceae **English name** - Jungle rice **Local name** - Bunodhan	:	Annual grass with fibrous root system.Commonly found in both on dry and moist soil,cultivated fields.Shorter than E. Crusgalli,used as green fodder. Panicle green or purplish in color.Propagation troughseed.
B. Monocot Sedge Weeds		
Botanical name - *Cyperus rotundus* **Family** - Cyperaceae **English name** - Nutsedge **Local name** - Mutha ghash	:	Perennial sedge. Persistent, erect, triangular stem, swollen at base, leaves smooth, groved on the upper surface, propagated by tubers. Essential oil can be extracted from tubers.

C. Dicot Weeds		
Botanical name - *Physalis minima* **Family** - Solanaceae **English name** - Wild cape gooseberry **Local name** – Thak Kali	:	Annual herb with forking branches. Found in aerobic ecosystem. Propageted by seed. Number of seeds plant^{-1} – 15,000. Fruit is covered with pappus.
Botanical name - *Digera arvensis* **Family** - Amaranthaceae **English name** - Carpet weed **Local name** – Luta mahawria	:	Annual Herb, Leaves alternate or opposite . Flowers small. Seeds lenticular , reniform , subglobose, or shortly cylindric , smooth or verruculose . Propogation through seeds.
Botanical name - *Trianthema portulecastrum* **Family** – Aizoaceae **English name** - Desert horsepurslane **Local name** – Punaranavi	:	Found in summer and *kharif* season. Grows in a wide variety of habitat types and can easily take hold in disturbed areas and cultivated land. It is an annual herb forming a prostrate mat or clump with stems up to a meter long. Propagated by seeds and by fragments of stem.
Botanical name - *Melilotus alba* **Family** - Leguminosae **English name** - White sweet clover **Local name** – Zerareca	:	Can grow up to 2 meters in height and can produce abundant amounts of seeds that readily float and disperse in water.

Apart from these some other weeds were also found in the experimental plots.

Table 4.2 List of the minor weed flora of the experimental field

Monocot	Dicot
Eleusine indica	*Euphorbia hirta* *Scoparia dulcis* *Commelina benghalensis*

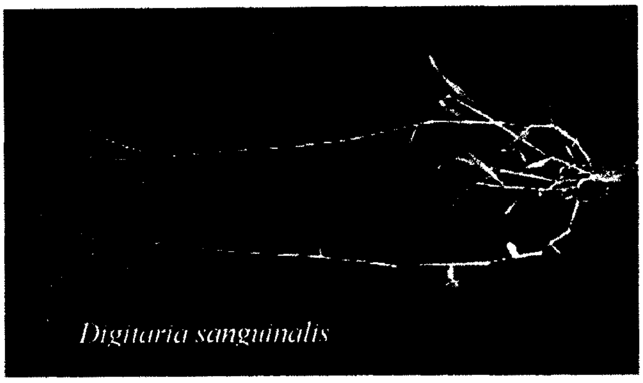
4.1.2 Population of weeds

Species wise population of monocot and dicot weeds were recorded at 15, 30 and 45 DAS of the all four crops during both the year of experimentation.

4.1.2.1 Effect of weed management treatments on population of weeds at 15 DAS

The population of monocot weeds m^{-2} at 15 DAS as presented in Table 4.3 (groundnut), Table 4.5 (soybean), Table 4.7 (green gram) and Table 4.9 (black gram) revealed that the treatments T_4 (Oxyflourfen) and T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) recorded significantly lower number of monocot weeds in comparison to all other treatments. The treatments T_1, T_2, T_3, T_6 and T_7 did not differ significantly among them in respect of the population of monocot weeds at 15 DAS in all the four crops and in both years as well as in pooled data. The minimum number of *Digitaria sanguinalis* population m^{-2} (pooled) was

Echinochloa colona

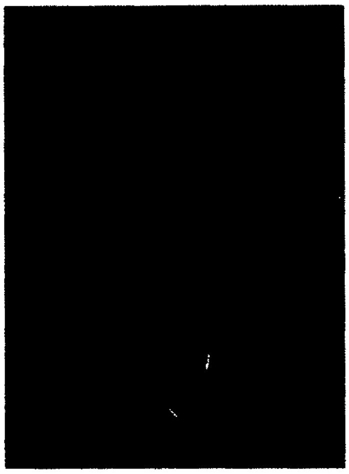


Digitaria sanguinalis

Eleusine indica

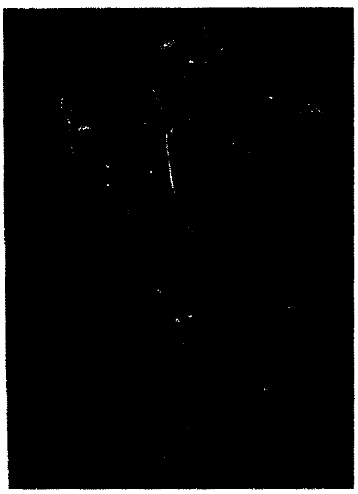
Plate 4.1 Weed flora of experimental plot

Dactyloctenium aegyptium

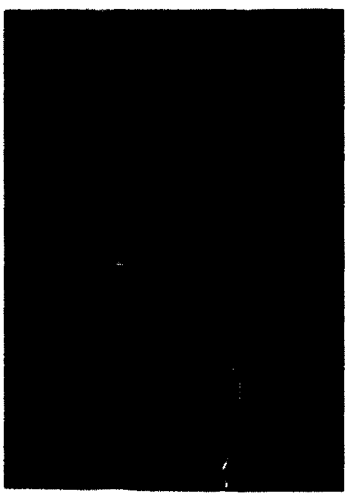


Cyperus rotundus

Digera arvensis



Physalis minima



Melilotus alba

Trianthema portulecastrum

observed in groundnut (2.61), soybean (1.11), green gram (2.83) and black gram (3.39) by treatment T_4 (Oxyflourfen 23.5 EC) during both years as well as in pooled followed by T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) the values were 2.84 (groundnut), 1.45 (soybean), 3.00 (green gram) and 3.67 (black gram). Similar kind of results was also found in case of *Echinochloa colona, Dactyloctanium aegyptium* and Other Monocots found in the experimental plot.

Among the different monocot weed species the grassy weed flora were controlled by both the chemical treatment (T_4) and botanical treatment (T_5) but the sedge weed flora *Cyperus rotundus* controlled only by the treatment T_4, and T_5 did not show any efficiency on this species. The minimum sedge weed flora m^{-2} (pooled data) was 5.34 (groundnut), 7.28 (soybean), 4.72 (green gram) and 7.06 (black gram) found against T_4. All the other treatments (T_1, T_2, T_3, T_5, T_6 and T_7) did not show any effect on monocot sedge weed flora.

The effect of treatments on dicot weed flora (Table 4.4 for groundnut, Table 4.6 for soybean, Table 4.8 for green gram and Table 4.10 for black gram) showed almost similar trend as that recorded in monocot weed flora excepting the treatment T_5, the botanicals extract applied as pre emergence. *Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v* (T_5) did not show any response on dicot weeds and also did not differ significantly with other treatments (T_1, T_2, T_3, T_6 and T_7) excepting T_4.

The minimum population m^{-2} (pooled) of dicot *Digera arvensis* were recorded from the PE chemical treatment Oxyfluorfen 23.5 EC @ 200 g ha^{-1} for 0.77 (groundnut), 2.28 (soybean), 1.44 (green gram) and 2.00 (black gram). The corresponding figures for *Physalis minima* 0.56 (groundnut), 0.72 (soybean), 1.50 (green gram) and 1.28 (black gram), for *Trianthema portulecastrum* 0.44 (groundnut), 0.94 (green gram) and 0.94 (black gram), for *Melilotus alba* 0.39 (soybean) and for other dicots 0.22 (groundnut), 0.72 (soybean), 0.78 (green gram) and 0.61 (black gram).

4.1.2.2 Effect of weed management treatments on population of weeds at 30 DAS

Weed management brought about a decrease in both monocot and dicot weed population significantly at this stage of crop growth during both the year has presented in Table 4.11 & 4.12 for groundnut, Table 4.13 & 4.14 for soybean, Table 4.15 & 4.16 for green gram and Table 4.17 & 4.18 for black gram. Regarding monocot weed flora HW at 20DAS (T_6) recorded significantly lower population m^{-2} over all other treatments. Treatments receiving Imazethapyr 10 SL @ 100 g ha^{-1} (T_1), Quizalofop-ethyl 5 EC @ 50 g ha^{-1} (T_2) and Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1} (T_3) also showed lower population of grassy weed produce at par result with treatment

T_6 *i.e.* HW at 20DAS. Among chemical herbicides Imazethapyr 10 SL @ 100 g ha^{-1} (T_1) recorded lowest population of monocot weeds in both years as well as in pooled data. The minimum population m^{-2} (pooled) of *Digitaria sanguinalis, Echinochloa colona, Dactyloctenium aegyptium* and other monocots by HW treatment (T_6) were 1.67, 1.00, 1.45 & 0.95 (groundnut), 0.50, 0.83, 1.06 & 1.89 (soybean), 1.56, 1.67 , 1.44 & 1.78 (green gram) and 0.84, 1.50, 1.56 & 0.56 (black gram) respectively. The corresponding figures for Imazethapyr 10 SL @ 100 g ha^{-1} (T_1) treatment were 3.16, 2.00, 2.84 & 1.72 (groundnut), 0.89, 1.67, 2.28 & 2.56 (soybean), 2.00, 2.11, 1.83 & 2.39 (green gram) and 1.95, 2.44, 2.94 & 1.22 (black gram) respectively. Application of *Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v* (T_5) recorded significantly lower monocot grassy weed population than control treatment (T_7). Oxyfluorfen 23.5 EC @ 200 g ha^{-1} (T_4) was also able to control the population of monocot weeds and statistically at par with T_5. Maximum monocot weed population was found from control treatment (T_7).

Minimum population (m^{-2}) of sedge weed *Cyperus rotundus* were recorded from hand weeded plot at 20DAS (T_6) followed by Imazethapyr 10 SL @ 100 g ha^{-1} (T_1) applied plot. Oxyfluorfen 23.5 EC found more effective in controlling sedge as compared with Quizalofop-ethyl 5 EC (T_2) and Fenoxaprop-p-ethyl 9 EC (T_3).

Oxyfluorfen 23.5 EC @ 200 g ha^{-1} (T_4) was failed to keep its superiority on minimizing the broadleaf weed population at this stage of observation. Regarding population of dicot weed flora also HW at 20DAS (T_6) gave the best result followed by T_1 & T_4 (Imazethapyr 10 SL @ 100 g ha^{-1} and Oxyfluorfen 23.5 EC @ 200 g ha^{-1} respectively). Quizalofop-ethyl 5 EC (T_2) and Fenoxaprop-p-ethyl 9 EC (T_2) had no effect on dicot weeds. The minimum population (m^{-2}) of *Digera arvensis, Physalis minima* and for other dicots were 1.95, 1.56 & 1.17 (groundnut), 1.67, 1.22 & 1.50 (soybean), 1.78, 1.11 & 1.06 (green gram) and 2.17, 1.89 & 0.78 (black gram) recorded by the HW at 20 DAS (T_6) treatment. The corresponding figures for Imazethapyr 10 SL @ 100 g ha^{-1} treatment were 2.50, 2.17 & 1.94 (groundnut), 2.39, 1.94 & 2.06 (soybean), 2.06, 1.94 & 1.39 (green gram) and 3.44, 2.61 & 1.06 (black gram). The minimum populations (m^{-2}) of *Trianthema portulecastrum* were 1.62 & 2.56 (groundnut), 1.78 & 2.28 (green gram) and 1.22 & 1.72 (black gram) recorded by HW at 20 DAS (T_6) and Imazethapyr 10 SL @ 100 g ha^{-1} treatment respectively. Botanicals remain ineffective to show any efficacy on reducing the population of dicot weed in all the experiment during both the year as well as in pooled data.

Imazethapyr 10 SL (T_1) showed better results in controlling all categories of weeds in comarison with other herbicides.

Table 4.3 Effect of WM treatments on population of monocot weeds (m^{-2}) at 15 DAS of groundnut

Tr.	Treatment Details	*Digitaria sanguinalis*			*Echinochloa colona*			*Dactyloctanium aegyptium*			*Cyperus rotundus*			*Other Monocots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha $^{-1}$	2.15 (4.78)	2.25 (5.11)	2.16 (4.94)	1.87 (3.22)	1.89 (3.33)	1.87 (3.28)	1.50 (2.11)	1.80 (3.22)	1.66 (2.67)	4.12 (17.22)	4.26 (18.67)	4.19 (17.94)	1.66 (2.33)	1.84 (3.22)	1.75 (2.78)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha $^{-1}$	2.13 (4.67)	2.22 (5.11)	2.15 (4.89)	1.93 (3.33)	1.91 (3.44)	1.90 (3.39)	1.52 (2.22)	1.83 (3.33)	1.69 (2.78)	4.20 (17.89)	4.33 (19.22)	4.26 (18.55)	1.67 (2.44)	1.82 (3.22)	1.74 (2.83)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha $^{-1}$	2.11 (4.56)	2.17 (5.00)	2.13 (4.78)	1.89 (3.22)	1.86 (3.22)	1.86 (3.22)	1.51 (2.11)	1.80 (3.22)	1.64 (2.67)	4.19 (17.67)	4.29 (18.89)	4.23 (18.27)	1.61 (2.22)	1.82 (3.11)	1.70 (2.67)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha $^{-1}$	1.67 (2.44)	1.77 (2.77)	1.63 (2.61)	0.75 (0.11)	0.75 (0.11)	0.75 (0.11)	1.15 (1.00)	1.51 (2.11)	1.34 (1.56)	2.20 (4.56)	2.53 (6.11)	2.37 (5.34)	1.14 (1.00)	1.40 (1.67)	1.28 (1.34)
T_5	*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*	1.72 (2.67)	1.85 (3.00)	1.77 (2.84)	1.26 (1.44)	1.31 (1.89)	1.21 (1.67)	1.28 (1.33)	1.69 (2.56)	1.50 (1.95)	4.01 (16.44)	4.17 (17.78)	4.08 (17.11)	1.28 (1.33)	1.44 (1.78)	1.36 (1.56)
T_6	Hand Weeding at 20 DAS	2.25 (4.78)	2.44 (5.67)	2.35 (5.23)	1.91 (3.33)	1.93 (3.44)	1.92 (3.39)	1.66 (2.44)	1.91 (3.33)	1.78 (2.89)	4.23 (17.56)	4.36 (18.67)	4.29 (18.12)	1.66 (2.44)	1.85 (3.11)	1.75 (2.78)
T_7	Control	2.14 (4.67)	2.24 (5.11)	2.11 (4.89)	1.92 (3.22)	1.87 (3.33)	1.89 (3.28)	1.49 (2.11)	1.81 (3.22)	1.67 (2.67)	4.16 (17.33)	4.28 (18.67)	4.20 (18.00)	1.64 (2.33)	1.85 (3.22)	1.73 (2.78)
	S.Em (±)	**0.078**	**0.070**	**0.065**	**0.174**	**0.192**	**0.167**	**0.079**	**0.087**	**0.078**	**0.219**	**0.231**	**0.206**	**0.070**	**0.100**	**0.068**
	C.D (P=0.05)	**0.241**	**0.217**	**0.189**	**0.536**	**0.591**	**0.487**	**0.243**	**0.267**	**0.229**	**0.675**	**0.713**	**0.601**	**0.216**	**0.307**	**0.198**

Table 4.4 Effect of WM treatments on population of dicot weeds (m^{-2}) at 15 DAS of groundnut

Tr.	Treatment Details	*Digera arvensis*			*Trianthema portulecastrum*			*Physalis minima*			*Other Dicots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha $^{-1}$	2.28 (5.56)	2.65 (7.67)	2.47 (6.61)	2.05 (3.89)	1.82 (3.00)	1.94 (3.44)	1.85 (3.33)	2.05 (4.33)	1.94 (3.83)	1.73 (2.56)	1.70 (2.56)	1.70 (2.55)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha $^{-1}$	2.35 (5.67)	2.68 (7.88)	2.50 (6.77)	2.01 (3.78)	1.81 (3.00)	1.93 (3.39)	1.83 (3.33)	2.07 (4.44)	1.95 (3.89)	1.71 (2.44)	1.64 (2.33)	1.65 (2.39)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha $^{-1}$	2.33 (5.67)	2.69 (7.89)	2.52 (6.77)	2.00 (3.78)	1.83 (3.00)	1.91 (3.39)	2.07 (4.44)	2.06 (4.44)	2.11 (4.44)	1.72 (2.56)	1.58 (2.11)	1.64 (2.33)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha $^{-1}$	1.01 (0.67)	1.09 (0.89)	1.04 (0.77)	0.88 (0.33)	0.99 (0.56)	0.94 (0.44)	0.73 (0.11)	1.14 (1.00)	0.96 (0.56)	0.83 (0.22)	0.83 (0.22)	0.83 (0.22)
T_5	*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*	2.19 (5.11)	2.57 (7.22)	2.39 (6.17)	1.92 (3.44)	1.97 (3.67)	1.96 (3.55)	2.00 (4.11)	2.00 (4.11)	2.00 (4.11)	1.64 (2.33)	1.67 (2.44)	1.66 (2.39)
T_6	Hand Weeding at 20 DAS	2.21 (5.11)	2.59 (7.22)	2.41 (6.17)	1.94 (3.56)	2.00 (3.78)	1.99 (3.66)	2.06 (4.11)	2.05 (4.33)	2.03 (4.22)	1.68 (2.33)	1.72 (2.56)	1.69 (2.44)
T_7	Control	2.31 (5.56)	2.66 (7.78)	2.48 (6.66)	2.02 (3.89)	1.84 (3.00)	1.95 (3.44)	2.09 (4.33)	2.08 (4.44)	2.07 (4.39)	1.69 (2.44)	1.69 (2.44)	1.67 (2.44)
	S.Em (±)	**0.175**	**0.201**	**0.173**	**0.160**	**0.173**	**0.151**	**0.138**	**0.172**	**0.143**	**0.137**	**0.158**	**0.137**
	C.D (P=0.05)	**0.538**	**0.618**	**0.505**	**0.492**	**0.534**	**0.442**	**0.426**	**0.531**	**0.417**	**0.421**	**0.486**	**0.399**

Table 4.5 Effect of WM treatments on population of monocot weeds (m^{-2}) at 15 DAS of soybean

Tr.	Treatment Details	*Dactyloctanium aegyptium*			*Digitaria sanguinalis*			*Echinochloa colona*			*Cyperus rotundus*			*Other Monocots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	2.50 (5.78)	2.55 (6.11)	2.52 (5.95)	1.50 (1.78)	1.55 (1.89)	1.52 (1.84)	1.91 (3.22)	2.07 (3.78)	1.98 (3.50)	4.58 (20.67)	4.82 (23.11)	4 69 (21.89)	2.57 (6.22)	2.83 (7.56)	2.69 (6.89)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	2.52 (5.89)	2.57 (6.22)	2.54 (6.06)	1.47 (1.67)	1.53 (1.89)	1.49 (1.78)	1.94 (3.33)	2.01 (3.56)	1.97 (3.45)	4.63 (21.11)	4.81 (23.00)	4.71 (22.06)	2.59 (6.33)	2.75 (7.11)	2.66 (6.72)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	2.45 (5.56)	2.53 (6.00)	2.48 (5.78)	1.48 (1.78)	1.57 (2.00)	1.53 (1.89)	1.97 (3.44)	2.04 (3.67)	2.00 (3.56)	4.62 (21.00)	4.85 (23.44)	4.73 (22.22)	2.62 (6.44)	2.77 (7.22)	2.70 (6.83)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	1.86 (3.00)	1.94 (3.33)	1.89 (3.17)	1.22 (1.00)	1.30 (1.22)	1.25 (1.11)	1.12 (0.78)	1.22 (1.00)	1.16 (0.89)	2.57 (6.33)	2.92 (8.22)	2.75 (7.28)	1.66 (2.44)	2.05 (3.89)	1.86 (3.17)
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	1.98 (3.44)	2.05 (3.78)	2.01 (3.61)	1.35 (1.33)	1.42 (1.56)	1.38 (1.45)	1.55 (2.11)	1.79 (2.89)	1.67 (2.50)	4.42 (19.22)	4.64 (21.33)	4.52 (20.28)	1.62 (2.33)	2.10 (4.11)	1.88 (3.22)
T_6	Hand Weeding at 20 DAS	2.44 (5.67)	2.68 (6.89)	2.57 (6.28)	1.48 (1.89)	1.44 (1.78)	1.46 (1.84)	2.02 (3.78)	1.91 (3.33)	1.96 (3.56)	4.48 (19.78)	4.84 (23.11)	4.66 (21.45)	2.62 (6.56)	2 80 (7.56)	2.71 (7.06)
T_7	Control	2.47 (5.67)	2.59 (6.33)	2.52 (6.00)	1.51 (1.78)	1.52 (1.89)	1.51 (1.84)	2.00 (3.56)	1.98 (3.44)	1.98 (3.50)	4.60 (20.78)	4.83 (23.22)	4.71 (22.00)	2.54 (6.11)	2.81 (7.44)	2.67 (6.78)
	S.Em (±)	**0.061**	**0.078**	**0.058**	**0.074**	**0.082**	**0.067**	**0.175**	**0.203**	**0.175**	**0.288**	**0.258**	**0.226**	**0.094**	**0.115**	**0.084**
	C.D (P=0.05)	**0.189**	**0.241**	**0.168**	**0.227**	**0.253**	**0.196**	**0.538**	**0.624**	**0.511**	**0.886**	**0.794**	**0.659**	**0.289**	**0.353**	**0.246**

Table 4.6 Effect of WM treatments on population of dicot weeds (m^{-2}) at 15 DAS of soybean

Tr.	Treatment Details	*Digera arvensis*			*Physalis minima*			*Melilotus alba*			*Other Dicots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	2.60 (6.33)	2.93 (8.33)	2.76 (7.33)	2.24 (4.56)	2.08 (3.89)	2.15 (4.22)	1.75 (2.67)	1.51 (1.78)	1.62 (2.22)	1.91 (3.22)	2.04 (3.67)	1.97 (3.44)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	2.62 (6.44)	2.95 (8.33)	2.78 (7.39)	2.21 (4.44)	2.09 (4.11)	2.14 (4.28)	1.78 (2.67)	1.45 (1.67)	1.61 (2.17)	1.93 (3.22)	2.01 (3.56)	1.96 (3.39)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	2.65 (6.56)	2.97 (8.44)	2.80 (7.50)	2.16 (4.22)	2.11 (4.11)	2.13 (4.17)	1.68 (2.33)	1.50 (1.78)	1.58 (2.06)	1.92 (3.22)	2.07 (3.78)	1.98 (3.50)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	1.38 (1.44)	1.88 (3.11)	1.62 (2.28)	1.22 (1.00)	0.96 (0.44)	1.08 (0.72)	1.03 (0.56)	0.85 (0.22)	0.93 (0.39)	1.03 (0.56)	1.18 (0.89)	1.10 (0.72)
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	2.58 (6.22)	2.99 (8.56)	2.78 (7.39)	2.13 (4.11)	2.05 (3.78)	2.08 (3.94)	1.65 (2.33)	1.47 (1.67)	1.55 (2.00)	1.87 (3.00)	2.05 (3.78)	1.95 (3.39)
T_6	Hand Weeding at 20 DAS	2.59 (6.33)	2.91 (8.22)	2.74 (7.28)	2.14 (4.22)	2.06 (3.89)	2.09 (4.06)	1.67 (2.33)	1.55 (1.89)	1.60 (2.11)	1.88 (3.11)	1.98 (3.44)	1.92 (3.28)
T_7	Control	2.61 (6.33)	2.98 (8.56)	2.79 (7.44)	2.20 (4.44)	2.10 (4.00)	2.14 (4.22)	1.77 (2.67)	1.53 (1.89)	1.64 (2.28)	1.89 (3.11)	1.99 (3.56)	1.93 (3.33)
	S.Em (±)	**0.124**	**0.092**	**0.095**	**0.094**	**0.099**	**0.095**	**0.055**	**0.050**	**0.049**	**0.071**	**0.080**	**0.072**
	C.D (P=0.05)	**0.381**	**0.283**	**0.276**	**0.289**	**0.306**	**0.278**	**0.168**	**0.153**	**0.142**	**0.218**	**0.246**	**0.209**

Table 4.7 Effect of WM treatments on population of monocot weeds (m^{-2}) at 15 DAS of green gram

Tr.	Treatment Details	*Digitaria sanguinalis*			*Dactyloctanium aegyptium*			*Echinochloa colona*			*Cyperus rotundus*			*Other Monocots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha $^{-1}$	1.99 (3.67)	2.33 (5.11)	2.18 (4.39)	1.55 (2.11)	1.88 (3.22)	1.72 (2.67)	1.96 (3.56)	1.66 (2.44)	1.82 (3.00)	4.46 (19.56)	4.29 (18.11)	4.37 (18.83)	2.13 (4.22)	2.57 (6.33)	2.36 (5.28)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha $^{-1}$	2.02 (3.78)	2.34 (5.11)	2.19 (4.44)	1.59 (2.22)	1.93 (3.44)	1.77 (2.83)	1.97 (3.56)	1.72 (2.67)	1.84 (3.11)	4.49 (19.89)	4.25 (17.78)	4.36 (18.83)	2.10 (4.11)	2.51 (6.00)	2.32 (5.06)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha $^{-1}$	1.96 (3.56)	2.30 (5.00)	2.14 (4.28)	1.52 (2.00)	1.91 (3.33)	1.74 (2.67)	1.93 (3.44)	1.59 (2.22)	1.77 (2.83)	4.47 (19.67)	4.26 (17.89)	4.35 (18.78)	2.18 (4.44)	2.55 (6.22)	2.37 (5.33)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha $^{-1}$	1.66 (2.44)	1.88 (3.22)	1.77 (2.83)	1.23 (1.22)	1.48 (1.89)	1.36 (1.56)	1.09 (0.89)	0.94 (0.56)	1.01 (0.72)	2.37 (5.33)	2.10 (4.11)	2.24 (4.72)	1.52 (2.00)	1.69 (2.56)	1.61 (2.28)
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	1.72 (2.67)	1.91 (3.33)	1.82 (3.00)	1.32 (1.44)	1.52 (2.00)	1.42 (1.72)	1.32 (1.44)	1.14 (1.00)	1.23 (1.22)	4.39 (19.00)	4.15 (16.89)	4.27 (17.94)	1.72 (2.67)	1.75 (2.78)	1.74 (2.73)
T_6	Hand Weeding at 20 DAS	2.02 (3.78)	2.20 (4.56)	2.11 (4.17)	1.66 (2.44)	1.82 (3.00)	1.74 (2.72)	1.88 (3.22)	2.02 (3.78)	1.95 (3.50)	4.47 (19.67)	4.26 (17.89)	4.37 (18.78)	2.28 (4.89)	2.57 (6.33)	2.43 (5.61)
T_7	Control	2.05 (3.89)	2.28 (4.89)	2.17 (4.39)	1.62 (2.33)	1.85 (3.11)	1.75 (2.72)	1.91 (3.33)	1.99 (3.67)	1.95 (3.50)	4.48 (19.78)	4.28 (18.00)	4.38 (18.89)	2.23 (4.67)	2.53 (6.11)	2.39 (5.39)
	S.Em (±)	**0.111**	**0.138**	**0.107**	**0.087**	**0.115**	**0.083**	**0.106**	**0.096**	**0.093**	**0.191**	**0.218**	**0.188**	**0.087**	**0.061**	**0.059**
	C.D (P=0.05)	**0.341**	**0.425**	**0.311**	**0.269**	**0.354**	**0.243**	**0.328**	**0.296**	**0.271**	**0.588**	**0.671**	**0.549**	**0.267**	**0.189**	**0.171**

Table 4.8 Effect of WM treatments on population of dicot weeds (m^{-2}) at 15 DAS of green gram

Tr.	Treatment Details	*Digera arvensis*			*Physalis minima*			*Trianthema portulecastrum*			*Other Dicots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha $^{-1}$	2.37 (5.33)	2.55 (6.22)	2.47 (5.78)	2.25 (4.78)	2.37 (5.33)	2.32 (5.06)	1.99 (3.67)	2.23 (4.67)	2.11 (4.17)	1.62 (2.33)	1.82 (3.00)	1.72 (2.67)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha $^{-1}$	2.42 (5.56)	2.57 (6.33)	2.50 (5.94)	2.28 (4.89)	2.39 (5.33)	2.34 (5.11)	2.02 (3.78)	2.18 (4.44)	2.10 (4.11)	1.66 (2.44)	1.88 (3.22)	1.77 (2.83)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha $^{-1}$	2.40 (5.44)	2.59 (6.33)	2.49 (5.89)	2.33 (5.11)	2.38 (5.33)	2.35 (5.22)	2.05 (3.89)	2.20 (4.56)	2.14 (4.22)	1.63 (2.33)	1.87 (3.22)	1.75 (2.78)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha $^{-1}$	1.23 (1.22)	1.40 (1.67)	1.32 (1.44)	1.09 (0.89)	1.55 (2.11)	1.34 (1.50)	0.98 (0.67)	1.23 (1.22)	1.11 (0.94)	0.86 (0.44)	1.19 (1.11)	1.04 (0.78)
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	2.33 (5.11)	2.49 (5.89)	2.41 (5.50)	2.20 (4.56)	2.23 (4.67)	2.22 (4.61)	1.91 (3.33)	2.13 (4.22)	2.02 (3.78)	1.55 (2.11)	1.79 (2.89)	1.67 (2.50)
T_6	Hand Weeding at 20 DAS	2.34 (5.11)	2.51 (6.00)	2.43 (5.56)	2.21 (4.56)	2.28 (4.89)	2.24 (4.72)	1.93 (3.44)	2.15 (4.22)	2.03 (3.83)	1.59 (2.22)	1.82 (3.00)	1.71 (2.61)
T_7	Control	2.38 (5.33)	2.58 (6.33)	2.48 (5.83)	2.30 (5.00)	2.40 (5.44)	2.36 (5.22)	2.00 (3.67)	2.20 (4.56)	2.12 (4.11)	1.69 (2.56)	1.85 (3.11)	1.78 (2.83)
	S.Em (±)	**0.319**	**0.323**	**0.321**	**0.192**	**0.211**	**0.177**	**0.152**	**0.166**	**0.150**	**0.114**	**0.133**	**0.115**
	C.D (P=0.05)	**0.982**	**0.996**	**0.938**	**0.593**	**0.651**	**0.518**	**0.468**	**0.512**	**0.439**	**0.352**	**0.411**	**0.336**

Table 4.9 Effect of WM treatments on population of monocot weeds (m^{-2}) at 15 DAS of black gram

Tr.	Treatment Details	*Digitaria sanguinalis*			*Echinochloa colona*			*Dactyloctenium aegyptium*			*Cyperus rotundus*			*Other Monocots*		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha $^{-1}$	2.21 (4.56)	2.30 (5.00)	2.25 (4.78)	2.22 (4.44)	2.37 (5.11)	2.30 (4.78)	1.93 (3.44)	1.81 (3.00)	1.88 (3.22)	4.65 (21.33)	4.67 (21.44)	4.64 (21.39)	1.72 (2.67)	1.88 (3.22)	1.80 (2.94)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha $^{-1}$	2.25 (4.78)	2.33 (5.11)	2.29 (4.94)	2.23 (4.44)	2.41 (5.33)	2.32 (4.89)	1.96 (3.56)	1.75 (2.78)	1.86 (3.17)	4.70 (21.78)	4.73 (22.00)	4.72 (21.89)	1.75 (2.78)	1.84 (3.00)	1.79 (2.89)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha $^{-1}$	2.23 (4.67)	2.31 (5.00)	2.26 (4.83)	2.25 (4.56)	2.38 (5.11)	2.31 (4.83)	1.97 (3.56)	1.79 (2.89)	1.89 (3.22)	4.68 (21.56)	4.71 (21.89)	4.69 (21.72)	1.69 (2.56)	1.85 (3.11)	1.77 (2.83)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha $^{-1}$	1.88 (3.22)	1.96 (3.56)	1.92 (3.39)	1.31 (1.22)	1.18 (0.89)	1.25 (1.06)	1.72 (2.67)	1.55 (2.11)	1.64 (2.39)	2.68 (6.89)	2.74 (7.22)	2.71 (7.06)	1.19 (1.11)	1.32 (1.44)	1.25 (1.28)
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	1.96 (3.56)	2.02 (3.78)	1.99 (3.67)	1.40 (1.67)	1.62 (2.33)	1.52 (2.00)	1.80 (2.89)	1.61 (2.33)	1.71 (2.61)	4.62 (21.00)	4.59 (21.00)	4.61 (21.00)	1.36 (1.56)	1.48 (1.89)	1.42 (1.73)
T_6	Hand Weeding at 20 DAS	2.23 (4.67)	2.37 (5.33)	2.30 (5.00)	2.20 (4.56)	2.40 (5.44)	2.30 (5.00)	1.93 (3.44)	1.69 (2.56)	1.82 (3.00)	4.63 (21.11)	4.61 (21.00)	4.60 (21.06)	1.66 (2.44)	1.83 (3.00)	1.74 (2.72)
T_7	Control	2.20 (4.56)	2.33 (5.11)	2.27 (4.83)	2.27 (4.67)	2.39 (5.22)	2.33 (4.94)	1.91 (3.33)	1.73 (2.67)	1.84 (3.00)	4.69 (21.67)	4.67 (21.56)	4.66 (21.61)	1.73 (2.67)	1.85 (3.11)	1.78 (2.89)
	S.Em (±)	**0.055**	**0.069**	**0.050**	**0.115**	**0.152**	**0.109**	**0.035**	**0.038**	**0.033**	**0.289**	**0.306**	**0.266**	**0.071**	**0.086**	**0.067**
	C.D (P=0.05)	**0.169**	**0.212**	**0.146**	**0.354**	**0.469**	**0.319**	**0.109**	**0.116**	**0.097**	**0.891**	**0.943**	**0.776**	**0.218**	**0.264**	**0.196**

Table 4.10 Effect of WM treatments on population of dicot weeds (m^{-2}) at 15 DAS of black gram

Tr.	Treatment Details	*Digera arvensis*			*Physalis minima*			*Trianthema portulecastrum*			*Other Dicots*		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha $^{-1}$	2.94 (8.33)	3.14 (9.56)	3.04 (8.94)	2.49 (5.89)	2.62 (6.56)	2.54 (6.22)	1.92 (3.33)	2.10 (4.11)	2.00 (3.72)	1.79 (2.89)	1.85 (3.11)	1.84 (3.00)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha $^{-1}$	2.96 (8.44)	3.17 (9.78)	3.07 (9.11)	2.53 (6.11)	2.60 (6.33)	2.56 (6.22)	1.91 (3.33)	2.13 (4.22)	2.02 (3.78)	1.75 (2.78)	1.86 (3.11)	1.80 (2.94)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha $^{-1}$	2.97 (8.44)	3.16 (9.67)	3.06 (9.06)	2.47 (5.78)	2.59 (6.33)	2.52 (6.06)	1.93 (3.44)	2.07 (4.00)	2.01 (3.72)	1.78 (2.89)	1.85 (3.11)	1.82 (3.00)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha $^{-1}$	1.48 (1.89)	1.55 (2.11)	1.52 (2.00)	1.32 (1.44)	1.19 (1.11)	1.26 (1.28)	1.14 (1.00)	1.09 (0.89)	1.11 (0.94)	0.93 (0.56)	0.98 (0.67)	0.95 (0.61)
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	2.88 (8.00)	3.07 (9.11)	2.98 (8.56)	2.44 (5.67)	2.52 (6.00)	2.48 (5.83)	1.90 (3.33)	2.05 (3.89)	1.98 (3.61)	1.75 (2.78)	1.87 (3.11)	1.80 (2.94)
T_6	Hand Weeding at 20 DAS	2.90 (8.11)	3.08 (9.11)	2.99 (8.61)	2.46 (5.78)	2.55 (6.22)	2.50 (6.00)	1.93 (3.33)	2.07 (4.00)	1.99 (3.67)	1.76 (2.78)	1.89 (3.11)	1.82 (2.94)
T_7	Control	2.95 (8.33)	2.92 (8.22)	2.93 (8.28)	2.51 (6.00)	2.61 (6.44)	2.57 (6.22)	1.94 (3.44)	2.14 (4.22)	2.03 (3.83)	1.75 (2.78)	1.90 (3.11)	1.81 (2.94)
	S.Em (±)	**0.238**	**0.289**	**0.241**	**0.180**	**0.193**	**0.165**	**0.148**	**0.163**	**0.145**	**0.184**	**0.176**	**0.173**
	C.D (P=0.05)	**0.734**	**0.891**	**0.702**	**0.554**	**0.596**	**0.483**	**0.457**	**0.502**	**0.422**	**0.566**	**0.542**	**0.505**

Table 4.11 Effect of WM treatments on population of monocot weeds (m^{-2}) at 30 DAS of groundnut

Tr.	Treatment Details	*Digitaria sanguinalis*			*Echinochloa colona*			*Dactyloctanium aegyptium*			*Cyperus rotundus*			*Other Monocots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha $^{-1}$	1.62 (2.56)	1.89 (3.76)	1.77 (3.16)	1.56 (2.33)	1.42 (1.67)	1.47 (2.00)	1.61 (2.67)	1.75 (3.00)	1.70 (2.84)	3.11 (11.33)	3.21 (10.56)	3.17 (10.95)	1.48 (2.11)	1.29 (1.33)	1.38 (1.72)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha $^{-1}$	2.06 (4.44)	2.32 (5.78)	2.19 (5.11)	1.86 (3.22)	1.69 (2.44)	1.78 (2.83)	1.98 (4.00)	2.23 (5.22)	2.11 (4.61)	4.75 (22.22)	5.39 (28.78)	5.08 (25.50)	1.75 (2.87)	1.54 (2.11)	1.65 (2.49)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha $^{-1}$	2.11 (4.67)	2.36 (6.00)	2.24 (5.34)	1.92 (3.44)	1.72 (2.67)	1.82 (3.06)	2.10 (4.56)	2.14 (4.78)	2.12 (4.67)	5.18 (26.56)	5.49 (29.89)	5.34 (28.23)	1.79 (3.00)	1.61 (2.33)	1.70 (2.67)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha $^{-1}$	3.19 (9.89)	3.84 (14.44)	3.53 (12.17)	2.12 (4.33)	1.86 (3.47)	2.03 (3.90)	2.98 (8.56)	3.16 (9.67)	3.07 (9.12)	3.83 (14.67)	3.98 (16.11)	3.93 (15.39)	2.62 (6.56)	2.15 (4.33)	2.40 (5.45)
T_5	*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*	3.51 (12.00)	4.17 (17.11)	3.85 (14.56)	3.05 (9.00)	2.99 (8.66)	3.02 (8.83)	3.21 (10.00)	3.48 (11.78)	3.35 (10.89)	5.41 (30.22)	6.20 (39.89)	5.82 (35.06)	2.66 (6.78)	2.20 (4.56)	2.44 (5.67)
T_6	Hand Weeding at 20 DAS	1.21 (1.22)	1.50 (2.11)	1.38 (1.67)	1.31 (1.11)	1.18 (0.89)	1.19 (1.00)	1.26 (1.33)	1.34 (1.56)	1.33 (1.45)	2.51 (5.67)	2.49 (5.78)	2.44 (5.73)	1.25 (1.00)	1.13 (0.89)	1.15 (0.95)
T_7	Control	4.19 (17.22)	4.42 (19.22)	4.30 (18.22)	4.36 (18.67)	3.94 (15.22)	4.15 (16.95)	3.82 (14.33)	3.91 (15.00)	3.87 (14.67)	5.95 (35.11)	6.40 (40.67)	6.18 (37.89)	3.19 (9.89)	2.86 (7.89)	3.03 (8.89)
S.Em (±)		**0.314**	**0.394**	**0.303**	**0.332**	**0.316**	**0.276**	**0.285**	**0.276**	**0.279**	**0.524**	**0.578**	**0.508**	**0.206**	**0.189**	**0.196**
C.D (P=0.05)		**0.968**	**1.213**	**0.883**	**1.023**	**0.973**	**0.805**	**0.879**	**0.851**	**0.813**	**1.613**	**1.781**	**1.482**	**0.634**	**0.581**	**0.572**

Table 4.12 Effect of WM treatments on population of dicot weeds (m^{-2}) at 30 DAS of groundnut

Tr.	Treatment Details	*Digera arvensis*			*Trianthema portulecastrum*			*Physalis minima*			*Other Dicots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha $^{-1}$	1.53 (2.22)	1.68 (2.78)	1.60 (2.50)	1.66 (2.44)	1.72 (2.67)	1.69 (2.56)	1.47 (2.00)	1.57 (2.33)	1.52 (2.17)	1.67 (2.44)	1.36 (1.44)	1.52 (1.94)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha $^{-1}$	3.08 (10.56)	3.32 (12.32)	3.20 (11.44)	2.99 (9.11)	3.20 (10.50)	3.10 (9.81)	2.72 (8.00)	2.92 (9.33)	2.82 (8.67)	3.04 (9.22)	2.51 (6.11)	2.79 (7.67)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha $^{-1}$	3.13 (10.89)	3.35 (12.56)	3.24 (11.73)	3.03 (9.33)	3.21 (10.56)	3.12 (9.95)	2.82 (8.67)	3.02 (10.00)	2.93 (9.34)	3.10 (9.56)	2.55 (6.33)	2.84 (7.95)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha $^{-1}$	2.01 (4.22)	2.15 (4.89)	2.08 (4.56)	2.02 (3.89)	2.22 (4.78)	2.12 (4.34)	1.88 (3.56)	1.99 (4.06)	1.94 (3.81)	2.02 (3.78)	1.77 (2.78)	1.90 (3.28)
T_5	*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*	3.26 (11.89)	3.36 (12.67)	3.31 (12.28)	3.16 (10.20)	3.24 (10.73)	3.20 (10.47)	2.86 (8.89)	3.07 (10.33)	2.97 (9.61)	3.18 (10.11)	2.57 (6.44)	2.89 (8.28)
T_6	Hand Weeding at 20 DAS	1.43 (1.89)	1.46 (2.00)	1.45 (1.95)	1.39 (1.56)	1.42 (1.67)	1.41 (1.62)	1.30 (1.44)	1.38 (1.67)	1.34 (1.56)	1.44 (1.67)	1.06 (0.67)	1.26 (1.17)
T_7	Control	3.27 (12.00)	3.39 (12.89)	3.33 (12.45)	3.21 (10.56)	3.26 (10.89)	3.24 (10.73)	2.92 (9.33)	3.15 (10.89)	3.04 (10.11)	3.29 (10.89)	2.61 (6.67)	2.97 (8.78)
S.Em (±)		**0.224**	**0.254**	**0.224**	**0.257**	**0.271**	**0.255**	**0.224**	**0.245**	**0.222**	**0.309**	**0.243**	**0.237**
C.D (P=0.05)		**0.689**	**0.782**	**0.653**	**0.791**	**0.835**	**0.743**	**0.689**	**0.756**	**0.647**	**0.951**	**0.749**	**0.692**

Table 4.13 Effect of WM treatments on population of monocot weeds (m^{-2}) at 30 DAS of soybean

Tr.	Treatment Details	*Dactyloctanium aegyptium*			*Digitaria sanguinalis*			*Echinochloa colona*			*Cyperus rotundus*			*Other Monocots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha $^{-1}$	1.61 (2.11)	1.70 (2.44)	1.65 (2.28)	1.13 (0.78)	1.21 (1.00)	1.16 (0.89)	1.49 (1.78)	1.42 (1.56)	1.45 (1.67)	3.02 (8.67)	3.34 (10.67)	3.17 (9.67)	1.71 (2.44)	1.76 (2.67)	1.73 (2.56)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha $^{-1}$	2.07 (3.78)	2.10 (3.89)	2.08 (3.83)	1.39 (1.44)	1.53 (1.89)	1.45 (1.67)	1.69 (2.44)	1.75 (2.56)	1.71 (2.50)	4.08 (16.33)	4.57 (20.56)	4.33 (18.45)	1.95 (3.33)	2.04 (3.67)	1.99 (3.50)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha $^{-1}$	2.08 (3.89)	2.16 (4.22)	2.11 (4.06)	1.31 (1.22)	1.43 (1.56)	1.36 (1.39)	1.78 (2.67)	1.80 (2.78)	1.78 (2.72)	4.23 (17.56)	4.52 (20.11)	4.37 (18.84)	2.01 (3.56)	2.19 (3.89)	2.09 (3.72)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha $^{-1}$	3.03 (8.89)	3.21 (10.00)	3.12 (9.45)	1.92 (3.22)	1.87 (3.00)	1.89 (3.11)	1.87 (3.00)	1.77 (2.67)	1.81 (2.83)	3.22 (9.89)	3.61 (12.56)	3.41 (11.22)	2.84 (7.78)	2.99 (8.67)	2.92 (8.23)
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	3.31 (10.67)	3.49 (11.89)	3.40 (11.28)	2.11 (4.00)	2.19 (4.33)	2.14 (4.17)	2.99 (8.67)	2.88 (8.00)	2.94 (8.34)	5.04 (25.00)	5.41 (28.78)	5.22 (26.89)	2.90 (8.11)	3.12 (9.44)	3.01 (8.78)
T_6	Hand Weeding at 20 DAS	1.21 (1.00)	1.27 (1.11)	1.23 (1.06)	0.97 (0.44)	1.03 (0.56)	0.99 (0.50)	1.17 (0.89)	1.12 (0.78)	1.14 (0.83)	2.78 (7.22)	2.83 (7.56)	2.80 (7.39)	1.46 (1.67)	1.61 (2.11)	1.53 (1.89)
T_7	Control	3.90 (14.89)	4.11 (16.56)	4.00 (15.73)	2.35 (5.22)	2.64 (6.67)	2.50 (5.95)	3.66 (13.11)	3.48 (11.78)	3.57 (12.45)	5.30 (27.78)	5.51 (30.11)	5.41 (28.95)	3.44 (11.56)	3.80 (14.11)	3.62 (12.84)
S.Em (±)		**0.293**	**0.302**	**0.305**	**0.151**	**0.167**	**0.151**	**0.226**	**0.244**	**0.229**	**0.258**	**0.280**	**0.223**	**0.195**	**0.224**	**0.200**
C.D (P=0.05)		**0.903**	**0.929**	**0.889**	**0.465**	**0.513**	**0.442**	**0.696**	**0.751**	**0.668**	**0.795**	**0.864**	**0.652**	**0.601**	**0.689**	**0.585**

Table 4.14 Effect of WM treatments on population of dicot weeds (m^{-2}) at 30 DAS of soybean

Tr.	Treatment Details	*Digera arvensis*			*Physalis minima*			*Melilotus alba*			*Other Dicots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha $^{-1}$	1.70 (2.44)	1.67 (2.33)	1.68 (2.39)	1.51 (1.78)	1.62 (2.11)	1.56 (1.94)	1.26 (1.11)	1.35 (1.33)	1.30 (1.22)	1.54 (1.89)	1.63 (2.22)	1.58 (2.06)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha $^{-1}$	2.93 (8.22)	3.12 (9.22)	3.02 (8.72)	2.72 (7.00)	2.89 (7.89)	2.80 (7.44)	2.25 (4.56)	2.45 (5.56)	2.34 (5.06)	2.82 (7.44)	2.96 (8.33)	2.88 (7.89)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha $^{-1}$	2.95 (8.33)	3.17 (9.56)	3.05 (8.94)	2.75 (7.11)	2.93 (8.22)	2.83 (7.67)	2.32 (4.89)	2.47 (5.67)	2.39 (5.28)	2.85 (7.67)	3.01 (8.56)	2.92 (8.11)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha $^{-1}$	1.92 (3.22)	2.07 (3.78)	1.99 (3.50)	1.71 (2.44)	1.87 (3.00)	1.78 (2.72)	1.55 (1.89)	1.67 (2.33)	1.60 (2.11)	1.72 (2.44)	2.00 (3.56)	1.85 (3.00)
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	2.97 (8.44)	3.15 (9.44)	3.05 (8.94)	2.87 (7.78)	2.90 (7.89)	2.88 (7.83)	2.35 (5.00)	2.52 (5.89)	2.43 (5.44)	2.89 (7.89)	3.02 (8.67)	2.95 (8.28)
T_6	Hand Weeding at 20 DAS	1.43 (1.56)	1.51 (1.78)	1.46 (1.67)	1.35 (1.33)	1.27 (1.11)	1.30 (1.22)	1.14 (0.78)	1.17 (0.89)	1.15 (0.83)	1.39 (1.44)	1.42 (1.56)	1.40 (1.50)
T_7	Control	2.99 (8.56)	3.19 (9.67)	3.08 (9.11)	2.92 (8.00)	3.00 (8.56)	2.94 (8.28)	2.41 (5.33)	2.57 (6.11)	2.48 (5.72)	2.95 (8.22)	3.11 (9.22)	3.02 (8.72)
S.Em (±)		**0.198**	**0.230**	**0.188**	**0.221**	**0.264**	**0.176**	**0.184**	**0.234**	**0.173**	**0.169**	**0.205**	**0.169**
C.D (P=0.05)		**0.611**	**0.709**	**0.548**	**0.682**	**0.814**	**0.513**	**0.567**	**0.721**	**0.505**	**0.521**	**0.632**	**0.492**

Table 4.15 Effect of WM treatments on population of monocot weeds (m^{-2}) at 30 DAS of green gram

Tr.	Treatment Details	*Digitaria sanguinalis*			*Dactyloctanium aegyptium*			*Echinochloa colona*			*Cyperus rotundus*			*Other Monocots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha $^{-1}$	1.40 (1.67)	1.62 (2.33)	1.54 (2.00)	1.19 (1.11)	1.69 (2.56)	1.46 (1.83)	1.72 (2.67)	1.36 (1.56)	1.55 (2.11)	2.90 (8.11)	2.35 (5.22)	2.64 (6.67)	1.40 (1.67)	1.85 (3.11)	1.64 (2.39)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha $^{-1}$	1.55 (2.11)	1.72 (2.67)	1.64 (2.39)	1.36 (1.56)	1.75 (2.78)	1.57 (2.17)	1.85 (3.11)	1.40 (1.67)	1.64 (2.39)	4.48 (19.78)	4.05 (16.11)	4.27 (17.95)	1.48 (1.89)	2.15 (4.33)	1.85 (3.11)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha $^{-1}$	1.59 (2.22)	1.82 (3.00)	1.71 (2.61)	1.44 (1.78)	1.82 (3.00)	1.64 (2.39)	1.91 (3.33)	1.48 (1.89)	1.71 (2.61)	4.53 (20.22)	4.06 (16.22)	4.30 (18.22)	1.55 (2.11)	2.20 (4.56)	1.91 (3.33)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha $^{-1}$	2.25 (4.33)	2.60 (6.44)	2.38 (5.39)	2.13 (4.22)	2.40 (5.44)	2.26 (4.83)	1.99 (3.67)	1.59 (2.22)	1.80 (2.94)	3.30 (10.56)	2.49 (5.89)	2.92 (8.22)	2.84 (7.78)	3.31 (10.67)	3.09 (9.22)
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	2.55 (6.22)	3.14 (9.56)	2.86 (7.89)	2.53 (6.11)	2.62 (6.56)	2.58 (6.34)	2.55 (6.22)	2.68 (6.89)	2.62 (6.56)	5.33 (28.11)	4.96 (24.33)	5.15 (26.22)	2.78 (7.44)	3.35 (10.89)	3.08 (9.17)
T_6	Hand Weeding at 20 DAS	1.19 (1.11)	1.52 (2.00)	1.36 (1.56)	1.09 (0.89)	1.52 (2.00)	1.32 (1.44)	1.55 (2.11)	1.23 (1.22)	1.42 (1.67)	2.07 (4.00)	1.75 (2.78)	1.92 (3.39)	1.28 (1.33)	1.59 (2.22)	1.44 (1.78)
T_7	Control	3.16 (9.67)	3.80 (14.11)	3.49 (11.89)	2.78 (7.44)	3.33 (10.78)	3.07 (9.11)	3.71 (13.44)	3.28 (10.44)	3.50 (11.94)	5.62 (31.33)	5.10 (25.67)	5.37 (28.50)	3.35 (10.89)	4.09 (16.44)	3.74 (13.67)
	S.Em (±)	**0.199**	**0.234**	**0.200**	**0.134**	**0.163**	**0.132**	**0.124**	**0.114**	**0.117**	**0.463**	**0.391**	**0.390**	**0.172**	**0.199**	**0.172**
	C.D (P=0.05)	**0.614**	**0.721**	**0.583**	**0.412**	**0.503**	**0.386**	**0.382**	**0.351**	**0.341**	**1.426**	**1.206**	**1.139**	**0.529**	**0.613**	**0.501**

Table 4.16 Effect of WM treatments on population of dicot weeds (m^{-2}) at 30 DAS of green gram

Tr.	Treatment Details	*Digera arvensis*			*Physalis minima*			*Trianthema portulecastrum*			*Other Dicots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha $^{-1}$	1.48 (1.89)	1.59 (2.22)	1.54 (2.06)	1.55 (2.11)	1.44 (1.78)	1.50 (1.94)	1.57 (2.11)	1.66 (2.44)	1.61 (2.28)	1.14 (1.00)	1.44 (1.78)	1.30 (1.39)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha $^{-1}$	2.80 (7.56)	2.90 (8.11)	2.85 (7.83)	2.80 (7.56)	2.66 (6.78)	2.73 (7.17)	2.92 (8.22)	3.14 (9.56)	3.03 (8.89)	2.35 (5.22)	2.86 (7.89)	2.62 (6.56)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha $^{-1}$	2.84 (7.78)	2.98 (8.56)	2.91 (8.17)	2.84 (7.78)	2.74 (7.22)	2.79 (7.50)	3.01 (8.78)	3.23 (10.11)	3.12 (9.44)	2.42 (5.56)	2.96 (8.44)	2.70 (7.00)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha $^{-1}$	1.82 (3.00)	1.89 (3.44)	1.88 (3.22)	1.88 (3.22)	1.72 (2.67)	1.80 (2.94)	1.88 (3.22)	2.15 (4.33)	2.02 (3.78)	1.40 (1.67)	1.62 (2.33)	1.52 (2.00)
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	2.98 (8.56)	3.07 (9.11)	3.02 (8.83)	2.96 (8.44)	2.84 (7.78)	2.90 (8.11)	3.05 (9.00)	3.28 (10.44)	3.17 (9.72)	2.49 (5.89)	3.05 (9.00)	2.78 (7.44)
T_6	Hand Weeding at 20 DAS	1.32 (1.44)	1.57 (2.11)	1.44 (1.78)	1.28 (1.33)	1.09 (0.89)	1.19 (1.11)	1.32 (1.44)	1.55 (2.11)	1.44 (1.78)	1.04 (0.78)	1.28 (1.33)	1.17 (1.06)
T_7	Control	2.99 (8.67)	3.10 (9.33)	3.05 (9.00)	2.99 (8.67)	2.88 (8.00)	2.94 (8.33)	3.12 (9.44)	3.36 (11.00)	3.24 (10.22)	2.60 (6.44)	3.12 (9.44)	2.87 (7.94)
	S.Em (±)	**0.172**	**0.152**	**0.155**	**0.218**	**0.231**	**0.223**	**0.200**	**0.235**	**0.205**	**0.137**	**0.163**	**0.133**
	C.D (P=0.05)	**0.529**	**0.469**	**0.451**	**0.672**	**0.713**	**0.651**	**0.615**	**0.724**	**0.598**	**0.421**	**0.503**	**0.389**

Table 4.17 Effect of WM treatments on population of monocot weeds (m^{-2}) at 30 DAS of black gram

Tr.	Treatment Details	*Digitaria sanguinalis*			*Echinochloa sp.*			*Dactyloctenium aegyptium*			*Cyperus rotundus*			*Other Monocots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha $^{-1}$	1.48 (1.89)	1.52 (2.00)	1.50 (1.95)	1.59 (2.22)	1.72 (2.67)	1.66 (2.44)	1.75 (2.78)	1.85 (3.11)	1.80 (2.94)	3.03 (8.89)	3.05 (9.00)	3.04 (8.94)	1.14 (1.00)	1.32 (1.44)	1.23 (1.22)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha $^{-1}$	1.88 (3.22)	1.93 (3.44)	1.91 (3.33)	1.96 (3.56)	2.02 (3.78)	1.99 (3.67)	1.91 (3.33)	1.93 (3.44)	1.92 (3.39)	4.52 (20.11)	4.44 (19.44)	4.48 (19.78)	1.32 (1.44)	1.40 (1.67)	1.36 (1.56)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha $^{-1}$	1.91 (3.33)	1.96 (3.56)	1.94 (3.45)	2.05 (3.89)	2.07 (4.00)	2.06 (3.94)	1.99 (3.67)	2.05 (3.89)	2.02 (3.78)	4.58 (20.67)	4.75 (22.22)	4.66 (21.45)	1.36 (1.56)	1.52 (2.00)	1.44 (1.78)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha $^{-1}$	2.88 (8.00)	3.30 (10.56)	3.10 (9.28)	2.06 (3.89)	2.13 (4.22)	2.09 (4.06)	2.86 (7.89)	3.07 (9.11)	2.97 (8.50)	3.57 (12.44)	3.66 (13.11)	3.62 (12.78)	2.07 (4.00)	2.15 (4.33)	2.11 (4.17)
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	3.01 (8.78)	3.36 (11.00)	3.19 (9.89)	3.03 (8.89)	3.23 (10.11)	3.13 (9.50)	2.98 (8.56)	3.26 (10.33)	3.12 (9.45)	5.59 (31.00)	5.63 (31.44)	5.61 (31.22)	2.28 (4.89)	2.40 (5.44)	2.34 (5.17)
T_6	Hand Weeding at 20 DAS	1.09 (0.89)	1.04 (0.78)	1.07 (0.84)	1.40 (1.67)	1.28 (1.33)	1.34 (1.50)	1.32 (1.44)	1.40 (1.67)	1.36 (1.56)	2.18 (4.44)	2.47 (5.78)	2.33 (5.11)	0.98 (0.67)	0.86 (0.44)	0.93 (0.56)
T_7	Control	3.63 (12.89)	3.87 (14.67)	3.75 (13.78)	4.19 (17.22)	4.48 (19.78)	4.34 (18.50)	3.62 (12.78)	4.00 (15.67)	3.81 (14.23)	5.79 (33.22)	5.84 (33.78)	5.81 (33.50)	2.53 (6.11)	2.82 (7.67)	2.68 (6.89)
	S.Em (±)	**0.296**	**0.358**	**0.306**	**0.235**	**0.281**	**0.248**	**0.264**	**0.258**	**0.260**	**0.464**	**0.429**	**0.447**	**0.184**	**0.233**	**0.183**
	C.D (P=0.05)	**0.913**	**1.104**	**0.893**	**0.725**	**0.867**	**0.723**	**0.813**	**0.795**	**0.759**	**1.428**	**1.321**	**1.305**	**0.568**	**0.719**	**0.534**

Table 4.18 Effect of WM treatments on population of dicot weeds (m^{-2}) at 30 DAS of black gram

Tr.	Treatment Details	*Digera arvensis*			*Physalis minima*			*Trianthema portulecastrum*			*Other Dicots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha $^{-1}$	1.88 (3.22)	1.99 (3.67)	1.93 (3.44)	1.75 (2.78)	1.66 (2.44)	1.71 (2.61)	1.36 (1.56)	1.48 (1.89)	1.42 (1.72)	1.23 (1.22)	1.09 (0.89)	1.17 (1.06)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha $^{-1}$	3.46 (11.67)	3.57 (12.44)	3.52 (12.06)	3.26 (10.33)	3.30 (10.56)	3.28 (10.44)	2.62 (6.56)	2.88 (8.00)	2.75 (7.28)	2.25 (4.78)	2.05 (3.89)	2.15 (4.33)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha $^{-1}$	3.51 (12.00)	3.62 (12.78)	3.56 (12.39)	3.28 (10.44)	3.35 (10.89)	3.31 (10.67)	2.70 (7.00)	2.92 (8.22)	2.81 (7.61)	2.28 (4.89)	2.15 (4.33)	2.22 (4.61)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha $^{-1}$	2.23 (4.67)	2.30 (5.00)	2.26 (4.83)	1.99 (3.67)	2.20 (4.56)	2.10 (4.11)	1.75 (2.78)	1.88 (3.22)	1.82 (3.00)	1.44 (1.78)	1.55 (2.11)	1.50 (1.94)
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	3.66 (13.11)	3.81 (14.22)	3.74 (13.67)	3.31 (10.67)	3.38 (11.11)	3.35 (10.89)	2.72 (7.11)	2.96 (8.44)	2.84 (7.78)	2.35 (5.22)	2.20 (4.56)	2.28 (4.89)
T_6	Hand Weeding at 20 DAS	1.66 (2.44)	1.48 (1.89)	1.57 (2.17)	1.40 (1.67)	1.55 (2.11)	1.48 (1.89)	1.19 (1.11)	1.28 (1.33)	1.23 (1.22)	1.09 (0.89)	0.98 (0.67)	1.04 (0.78)
T_7	Control	3.69 (13.33)	3.81 (14.22)	3.75 (13.78)	3.33 (10.78)	3.43 (11.44)	3.38 (11.11)	2.76 (7.33)	2.98 (8.56)	2.87 (7.94)	2.44 (5.67)	2.28 (4.89)	2.36 (5.28)
	S.Em (±)	**0.247**	**0.319**	**0.244**	**0.214**	**0.235**	**0.222**	**0.220**	**0.208**	**0.207**	**0.162**	**0.221**	**0.165**
	C.D (P=0.05)	**0.761**	**0.982**	**0.713**	**0.658**	**0.724**	**0.649**	**0.679**	**0.642**	**0.603**	**0.499**	**0.682**	**0.481**

4.1.2.3 Effect of weed management treatments on population of weeds at 45 DAS

Similar kind of trend like previous investigation stage was also observed in 45 DAS of weed population counting. The population of monocot weeds at 45 DAS as presented in Table 4.19 (groundnut), Table 4.21 (soybean) and Table 4.23 (black gram) revealed that the HW at 20 DAS (T_6) again found superior in minimizing the population the monocot weed flora followed by Imazethapyr 10 SL @ 100 g ha^{-1} (T_1). Quizalofop-ethyl 5 EC (T_2) and Fenoxaprop-p-ethyl 9 EC (T_3) also found better in controlling the monocot weed recorded at par result with T_1 & T_6. The lowest population m^{-2} (pooled) of *Digitaria sanguinalis, Echinochloa colona, Dactyloctenium aegyptium* and other monocots by HW treatment (T_6) were 6.50, 4.61, 4.89 & 2.83 (groundnut), 3.50, 2.89, 4.39 & 3.78 (soybean) and 3.89, 4.94 , 4.56 & 2.17 (black gram) respectively. The corresponding figures for Imazethapyr 10 SL @ 100 g ha^{-1} (T_1) treatment were 9.61, 5.95, 7.22 & 4.22 (groundnut), 4.78, 3.61, 7.28 & 4.67 (soybean) and 6.17, 6.11, 7.17 & 2.67 (black gram) respectively. Maximum monocot weed flora population was found in control (T_7).

Population of sedge also effectively minimize by HW (T_6) followed by Imazethapyr 10 SL and Oxyfluorfen 23.5 EC.

The effect of treatments on dicot weed flora (Table 4.20 for groundnut, Table 4.22 for soybean and Table 4.24 for black gram) showed almost similar trend as that recorded in monocot weed flora excepting the treatment T_2, T_3 and T_5. Quizalofop-ethyl 5 EC (T_2), Fenoxaprop-p-ethyl 9 EC (T_3) and *Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v* (T_5) did not show any response on dicot weeds and also did not differ significantly with control (T_7). The minimum population m^{-2} of *Digera arvensis, Physalis minima* and for other dicots were 6.11, 4.39 & 4.17 (groundnut), 4.72, 3.67 & 3.17 (soybean) and 5.89, 4.33 & 1.50 (black gram) recorded by the HW at 20 DAS (T_6) treatment. The corresponding figures for Imazethapyr 10 SL @ 100 g ha^{-1} treatment were 8.61, 6.39 & 5.95 (groundnut), 6.89, 5.11 & 5.00 (soybean) and 8.78, 7.11 & 2.50 (black gram). The minimum populations of *Trianthema portulecastrum* (m^{-2}) were 4.95 & 7.34 (groundnut) and 2.67 & 4.67 (black gram) recorded by HW at 20 DAS (T_6) and Imazethapyr 10 SL @ 100 g ha^{-1} treatment respectively.

From the recorded data it has been cleared that among all chemical treatments only Imazethapyr 10 SL @ 100 g ha^{-1} (T_1) found significantly effective in controlling population of all categories weed.

Table 4.19 Effect of WM treatments on population of monocot weeds (m^{-2}) at 45 DAS of groundnut

Tr.	Treatment Details	*Digitaria sanguinalis*			*Echinochloa colona*			*Dactyloctanium aegyptium*			*Cyperus rotundus*			*Other Monocots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha $^{-1}$	2.75 (8.33)	3.13 (10.89)	2.94 (9.61)	2.40 (5.67)	2.56 (6.22)	2.49 (5.95)	2.44 (6.33)	2.74 (8.11)	2.61 (7.22)	4.13 (17.44)	4.15 (17.56)	4.14 (17.50)	2.03 (4.00)	2.19 (4.44)	2.08 (4.22)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha $^{-1}$	2.82 (8.78)	3.19 (11.33)	3.01 (10.06)	2.46 (6.00)	2.63 (6.89)	2.55 (6.45)	2.55 (7.00)	2.61 (7.33)	2.58 (7.17)	5.62 (31.33)	5.83 (33.67)	5.73 (32.50)	2.08 (4.22)	2.2 (4.78)	2.14 (4.50)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha $^{-1}$	3.07 (9.11)	3.44 (11.56)	3.26 (10.34)	2.72 (7.44)	2.78 (7.78)	2.75 (7.61)	2.72 (7.11)	2.80 (7.56)	2.76 (7.34)	6.70 (32.67)	6.53 (36.22)	6.62 (34.45)	2.18 (4.44)	2.33 (5.11)	2.25 (4.78)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha $^{-1}$	4.19 (17.22)	4.44 (19.44)	4.32 (18.33)	3.19 (9.89)	3.16 (9.67)	3.17 (9.78)	3.19 (11.11)	3.45 (13.08)	3.32 (12.10)	4.70 (21.78)	4.73 (22.11)	4.72 (21.95)	3.30 (11.44)	3.32 (11.56)	3.31 (11.50)
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	4.29 (18.11)	4.52 (20.11)	4.41 (19.11)	3.57 (12.44)	3.41 (11.33)	3.49 (11.89)	3.66 (13.11)	4.15 (16.89)	3.91 (15.00)	6.77 (47.67)	7.10 (52.44)	6.94 (50.06)	3.43 (11.44)	3.41 (11.33)	3.42 (11.39)
T_6	Hand Weeding at 20 DAS	2.34 (5.89)	2.55 (7.11)	2.45 (6.50)	2.05 (4.00)	2.23 (5.22)	2.15 (4.61)	2.19 (5.00)	2.14 (4.78)	2.17 (4.89)	3.83 (14.89)	3.88 (15.11)	3.84 (15.00)	1.64 (2.44)	1.71 (3.22)	1.72 (2.83)
T_7	Control	5.36 (28.44)	5.81 (33.44)	5.59 (30.94)	4.33 (19.56)	4.73 (23.44)	4.53 (21.50)	4.46 (19.56)	4.76 (22.33)	4.61 (20.95)	6.87 (49.00)	7.26 (54.89)	7.07 (51.95)	3.75 (14.89)	3.5 (12.89)	3.59 (13.61)
	S.Em (±)	**0.270**	**0.296**	**0.283**	**0.233**	**0.262**	**0.224**	**0.200**	**0.228**	**0.207**	**0.224**	**0.233**	**0.234**	**0.184**	**0.208**	**0.188**
	C.D (P=0.05)	**0.831**	**0.913**	**0.826**	**0.719**	**0.808**	**0.653**	**0.617**	**0.701**	**0.603**	**0.691**	**0.717**	**0.682**	**0.567**	**0.641**	**0.548**

Table 4.20 Effect of WM treatments on population of dicot weeds (m^{-2}) at 45 DAS of groundnut

Tr.	Treatment Details	*Digera arvensis*			*Trianthema portulecastrum*			*Physalis minima*			*Other Dicots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha $^{-1}$	2.86 (8.89)	2.75 (8.33)	2.80 (8.61)	2.78 (7.78)	2.63 (6.89)	2.70 (7.34)	2.46 (6.44)	2.44 (6.33)	2.45 (6.39)	2.65 (6.89)	2.29 (5.00)	2.48 (5.95)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha $^{-1}$	3.96 (17.78)	4.31 (21.11)	4.14 (19.45)	3.81 (14.89)	3.99 (16.56)	3.89 (15.73)	3.16 (10.56)	3.62 (14.56)	3.37 (12.56)	3.47 (12.11)	3.51 (12.44)	3.49 (12.28)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha $^{-1}$	4.00 (18.11)	4.36 (21.67)	4.18 (19.89)	3.83 (15.22)	4.03 (16.89)	3.93 (16.06)	3.22 (11.44)	3.74 (15.56)	3.49 (13.50)	3.53 (12.56)	3.56 (12.78)	3.54 (12.67)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha $^{-1}$	3.46 (13.44)	3.74 (15.78)	3.60 (14.61)	3.52 (12.78)	3.59 (13.33)	3.56 (13.06)	2.92 (9.22)	3.42 (12.89)	3.18 (11.06)	3.47 (12.11)	3.33 (11.11)	3.40 (11.61)
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	4.01 (18.22)	4.55 (23.67)	4.29 (20.95)	3.90 (15.78)	4.19 (18.33)	4.05 (17.06)	3.28 (11.89)	3.79 (16.00)	3.55 (13.95)	3.64 (13.41)	3.67 (13.67)	3.66 (13.54)
T_6	Hand Weeding at 20 DAS	2.41 (6.44)	2.29 (5.78)	2.31 (6.11)	2.29 (5.33)	2.13 (4.56)	2.25 (4.95)	2.19 (5.11)	1.90 (3.67)	2.06 (4.39)	2.28 (5.11)	1.85 (3.22)	2.11 (4.17)
T_7	Control	4.15 (19.56)	4.58 (24.00)	4.37 (21.78)	3.95 (16.22)	4.25 (18.89)	4.10 (17.56)	3.37 (12.56)	3.89 (16.89)	3.64 (14.73)	3.76 (14.33)	3.79 (14.56)	3.77 (14.45)
	S.Em (±)	**0.175**	**0.210**	**0.174**	**0.232**	**0.299**	**0.237**	**0.137**	**0.245**	**0.143**	**0.184**	**0.223**	**0.140**
	C.D (P=0.05)	**0.538**	**0.646**	**0.509**	**0.715**	**0.921**	**0.691**	**0.421**	**0.754**	**0.416**	**0.567**	**0.688**	**0.408**

Table 4.21 Effect of WM treatments on Population of monocot weeds (m^{-2}) at 45 DAS of soybean

Tr.	Treatment Details	*Dactyloctanium aegyptium*			*Digitaria sanguinalis*			*Echinochloa colona*			*Cyperus rotundus*			*Other Monocots*		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	2.70 (7.00)	2.80 (7.56)	2.75 (7.28)	2.15 (4.33)	2.35 (5.22)	2.25 (4.78)	2.10 (3.89)	1.96 (3.33)	2.03 (3.61)	4.26 (17.89)	4.30 (18.22)	4.28 (18.06)	2.18 (4.44)	2.28 (4.89)	2.23 (4.67)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	2.78 (7.44)	2.84 (7.78)	2.81 (7.61)	2.20 (4.56)	2.55 (6.22)	2.39 (5.39)	2.20 (4.33)	2.04 (3.67)	2.12 (4.00)	5.27 (27.44)	5.48 (29.78)	5.38 (28.61)	2.25 (4.78)	2.40 (5.44)	2.33 (5.11)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	2.82 (7.67)	3.01 (8.78)	2.92 (8.23)	2.28 (4.89)	2.57 (6.33)	2.43 (5.61)	2.22 (4.44)	2.10 (3.89)	2.16 (4.17)	5.45 (29.44)	5.51 (29.78)	5.47 (29.61)	2.30 (5.00)	2.42 (5.56)	2.36 (5.28)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	3.69 (13.33)	3.93 (15.11)	3.81 (14.22)	3.19 (9.89)	3.28 (10.44)	3.23 (10.17)	2.72 (6.89)	2.82 (7.44)	2.77 (7.17)	4.53 (20.22)	4.57 (20.56)	4.55 (20.39)	3.17 (9.78)	3.37 (10.56)	3.24 (10.17)
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	4.00 (15.67)	4.20 (17.33)	4.10 (16.50)	3.21 (10.00)	3.62 (12.78)	3.42 (11.39)	2.90 (8.11)	2.96 (8.44)	2.93 (8.28)	6.71 (44.78)	6.65 (43.89)	6.68 (44.33)	3.30 (10.56)	3.39 (11.22)	3.35 (10.89)
T_6	Hand Weeding at 20 DAS	2.10 (4.11)	2.23 (4.67)	2.17 (4.39)	1.85 (3.11)	2.05 (3.89)	1.95 (3.50)	1.98 (3.44)	1.68 (2.33)	1.84 (2.89)	3.75 (13.78)	3.78 (14.00)	3.77 (13.89)	1.93 (3.44)	2.10 (4.11)	2.02 (3.78)
T_7	Control	4.93 (24.00)	5.10 (25.67)	5.01 (24.83)	4.23 (17.56)	4.39 (19.00)	4.31 (18.28)	4.05 (15.89)	3.91 (14.78)	3.98 (15.33)	6.75 (45.33)	6.66 (44.11)	6.71 (44.72)	4.05 (16.11)	4.25 (17.78)	4.15 (16.94)
	S.Em (±)	**0.249**	**0.219**	**0.223**	**0.190**	**0.199**	**0.193**	**0.125**	**0.207**	**0.115**	**0.277**	**0.297**	**0.285**	**0.187**	**0.222**	**0.189**
	C.D (P=0.05)	**0.768**	**0.675**	**0.652**	**0.586**	**0.613**	**0.562**	**0.386**	**0.639**	**0.335**	**0.854**	**0.916**	**0.831**	**0.576**	**0.684**	**0.553**

Table 4.22 Effect of WM treatments on population of dicot weeds (m^{-2}) at 45 DAS of soybean

Tr.	Treatment Details	*Digera arvensis*			*Physalis minima*			*Melilotus alba*			*Other Dicots*		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	2.64 (6.67)	2.72 (7.11)	2.68 (6.89)	2.35 (5.22)	2.30 (5.00)	2.33 (5.11)	1.90 (3.11)	2.01 (3.56)	1.96 (3.33)	2.20 (4.56)	2.40 (5.44)	2.30 (5.00)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	4.13 (16.78)	4.26 (17.89)	4.20 (17.33)	3.51 (12.00)	3.57 (12.44)	3.54 (12.22)	2.72 (6.89)	2.99 (8.44)	2.86 (7.67)	3.36 (11.00)	3.44 (11.56)	3.40 (11.28)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	4.17 (17.11)	4.32 (18.33)	4.24 (17.72)	3.55 (12.33)	3.68 (13.22)	3.62 (12.78)	2.84 (7.56)	3.05 (8.78)	2.94 (8.17)	3.44 (11.56)	3.68 (13.22)	3.56 (12.39)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	3.43 (11.44)	3.46 (11.67)	3.44 (11.56)	3.14 (9.56)	3.23 (10.11)	3.18 (9.83)	2.68 (6.67)	2.82 (7.44)	2.75 (7.06)	3.14 (9.56)	3.35 (10.89)	3.24 (10.22)
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	4.36 (18.67)	4.51 (20.00)	4.43 (19.33)	3.74 (13.67)	3.87 (14.67)	3.80 (14.17)	2.90 (7.89)	3.10 (9.11)	3.00 (8.50)	3.57 (12.44)	3.69 (13.33)	3.63 (12.89)
T_6	Hand Weeding at 20 DAS	2.20 (4.56)	2.28 (4.89)	2.24 (4.72)	1.91 (3.33)	2.07 (4.00)	1.99 (3.67)	1.51 (1.78)	1.71 (2.44)	1.62 (2.11)	1.79 (2.89)	1.93 (3.44)	1.86 (3.17)
T_7	Control	4.39 (19.00)	4.53 (20.22)	4.46 (19.61)	3.82 (14.33)	3.90 (14.89)	3.86 (14.61)	2.97 (8.33)	3.17 (9.56)	3.07 (8.94)	3.71 (13.44)	3.85 (14.56)	3.78 (14.00)
	S.Em (±)	**0.222**	**0.228**	**0.213**	**0.231**	**0.270**	**0.231**	**0.210**	**0.233**	**0.193**	**0.275**	**0.296**	**0.262**
	C.D (P=0.05)	**0.685**	**0.701**	**0.621**	**0.712**	**0.831**	**0.673**	**0.648**	**0.719**	**0.563**	**0.846**	**0.913**	**0.764**

Table 4.23 Effect of WM treatments on population of monocot weeds (m^{-2}) at 45 DAS of black gram

Tr.	Treatment Details	*Digitaria sanguinalis*			*Echinochloa sp.*			*Dactyloctenium aegyptium*			*Cyperus rotundus*			*Other Monocots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha $^{-1}$	2.51 (6.00)	2.57 (6.33)	2.54 (6.17)	2.55 (6.22)	2.51 (6.00)	2.53 (6.11)	2.64 (6.67)	2.82 (7.67)	2.73 (7.17)	3.80 (14.11)	3.84 (14.44)	3.82 (14.28)	1.55 (2.11)	1.88 (3.22)	1.72 (2.67)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha $^{-1}$	2.55 (6.22)	2.64 (6.67)	2.60 (6.44)	2.64 (6.67)	2.57 (6.33)	2.61 (6.50)	2.76 (7.33)	2.98 (8.56)	2.87 (7.94)	5.53 (30.33)	5.78 (33.11)	5.66 (31.72)	1.69 (2.56)	1.93 (3.44)	1.82 (3.00)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha $^{-1}$	2.62 (6.56)	2.70 (7.00)	2.66 (6.78)	2.68 (6.89)	2.64 (6.67)	2.66 (6.78)	2.80 (7.56)	2.99 (8.44)	2.88 (8.00)	5.70 (32.22)	5.83 (33.67)	5.77 (32.95)	1.79 (2.89)	1.99 (3.67)	1.89 (3.28)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha $^{-1}$	3.46 (11.67)	3.43 (11.44)	3.44 (11.56)	3.35 (10.89)	3.93 (15.11)	3.65 (13.00)	3.55 (12.33)	3.77 (13.89)	3.66 (13.11)	4.57 (20.56)	4.78 (22.56)	4.68 (21.56)	2.40 (5.44)	2.72 (7.11)	2.57 (6.28)
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	3.65 (13.00)	3.84 (14.44)	3.74 (13.72)	4.24 (17.67)	4.51 (20.00)	4.37 (18.84)	3.90 (14.89)	4.00 (15.67)	3.95 (15.28)	6.41 (40.78)	6.55 (42.56)	6.48 (41.67)	2.49 (5.89)	2.51 (6.00)	2.50 (5.94)
T_6	Hand Weeding at 20 DAS	2.10 (4.11)	1.99 (3.67)	2.05 (3.89)	2.20 (4.56)	2.37 (5.33)	2.29 (4.94)	2.13 (4.22)	2.28 (4.89)	2.20 (4.56)	3.46 (11.67)	3.30 (10.56)	3.38 (11.11)	1.36 (1.56)	1.75 (2.78)	1.57 (2.17)
T_7	Control	4.54 (20.33)	4.69 (21.67)	4.62 (21.00)	5.34 (28.22)	5.43 (29.22)	5.39 (28.72)	4.32 (18.33)	4.65 (21.33)	4.49 (19.83)	6.54 (42.44)	6.61 (43.44)	6.58 (42.94)	2.74 (7.22)	2.88 (8.00)	2.81 (7.61)
	S.Em (±)	**0.265**	**0.234**	**0.235**	**0.192**	**0.223**	**0.199**	**0.225**	**0.246**	**0.234**	**0.204**	**0.259**	**0.200**	**0.184**	**0.199**	**0.188**
	C.D (P=0.05)	**0.816**	**0.721**	**0.686**	**0.591**	**0.687**	**0.581**	**0.694**	**0.758**	**0.683**	**0.627**	**0.798**	**0.583**	**0.567**	**0.612**	**0.548**

Table 4.24 Effect of WM treatments on population of dicot weeds (m^{-2}) at 45 DAS of black gram

Tr.	Treatment Details	*Digera arvensis*			*Physalis minima*			*Trianthema portulecastrum*			*Other Dicots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha $^{-1}$	2.94 (8.33)	3.09 (9.22)	3.01 (8.78)	2.68 (6.89)	2.76 (7.33)	2.72 (7.11)	2.15 (4.33)	2.30 (5.00)	2.23 (4.67)	1.62 (2.33)	1.72 (2.67)	1.67 (2.50)
T_2	Quizalofop-ethyl 5 EC @ 50 g ha $^{-1}$	4.70 (21.78)	4.86 (23.33)	4.78 (22.56)	4.12 (16.67)	4.20 (17.33)	4.16 (17.00)	3.19 (9.89)	3.49 (11.89)	3.35 (10.89)	2.49 (5.89)	2.60 (6.44)	2.54 (6.17)
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha $^{-1}$	4.90 (23.67)	4.91 (23.78)	4.90 (23.72)	4.16 (17.00)	4.24 (17.67)	4.20 (17.33)	3.30 (10.56)	3.54 (12.22)	3.42 (11.39)	2.53 (6.11)	2.62 (6.56)	2.57 (6.33)
T_4	Oxyfluorfen 23.5 EC @ 200 g ha $^{-1}$	3.90 (14.89)	3.93 (15.11)	3.91 (15.00)	3.65 (13.00)	3.78 (14.00)	3.71 (13.50)	3.01 (8.78)	3.23 (10.11)	3.12 (9.44)	2.55 (6.22)	2.47 (5.78)	2.51 (6.00)
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	5.05 (25.22)	5.14 (26.11)	5.10 (25.67)	4.34 (18.56)	4.42 (19.22)	4.38 (18.89)	3.36 (11.00)	3.60 (12.67)	3.48 (11.83)	2.68 (6.89)	2.70 (7.00)	2.69 (6.94)
T_6	Hand Weeding at 20 DAS	2.51 (6.00)	2.47 (5.78)	2.49 (5.89)	2.05 (3.89)	2.25 (4.78)	2.15 (4.33)	1.66 (2.44)	1.79 (2.89)	1.72 (2.67)	1.40 (1.67)	1.28 (1.33)	1.34 (1.50)
T_7	Control	5.07 (25.44)	5.18 (26.56)	5.13 (26.00)	4.41 (19.11)	4.48 (19.78)	4.44 (19.44)	3.43 (11.44)	3.68 (13.22)	3.55 (12.33)	2.78 (7.44)	2.80 (7.56)	2.79 (7.50)
	S.Em (±)	**0.221**	**0.263**	**0.226**	**0.267**	**0.298**	**0.249**	**0.192**	**0.212**	**0.181**	**0.152**	**0.200**	**0.148**
	C.D (P=0.05)	**0.682**	**0.811**	**0.659**	**0.824**	**0.917**	**0.727**	**0.592**	**0.653**	**0.527**	**0.468**	**0.615**	**0.431**

4.1.3 Dry weight of weeds

Dry matter production or dry weight of weeds gives a real picture of weed growth. Species wise weed dry weights were recorded at 15DAS, 30 DAS and 45 DAS.

4.1.3.1 Effect of weed management treatments on dry weight of weeds at 15 DAS

The species wise dry weight (g m^{-2}) of monocot weed flora at 15 DAS has presented in the Table 4.25 (groundnut), Table 4.27 (soybean), Table 4.29 (green gram) and Table 4.31 (black gram) indicated that significantly lower dry weight of monocot weed were recorded by PE applied T_4 (Oxyflourfen) and T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) treatments. There was no significant response found by treatments T_1, T_2, T_3, T_6 and T_7 in respect of the dry weight of monocot weeds at 15 DAS in all the four crops and in both years as well as in pooled data. The dry weight (pooled) of *Digitaria sanguinalis, Echinochloa colona, Dactyloctenium aegyptium* and other monocots (g m^{-2}) recorded by Oxyfluorfen 23.5 EC @ 200 g ha^{-1} (T_4) were 0.67, 0.20, 0.38& 0.38 (groundnut), 2.68, 0.75, 1.64 & 1.17 (soybean) and 0.95, 0.39 , 0.94 & 2.00 (green gram) respectively. The corresponding figures for T_5 treatment were 0.75, 0.25, 0.40 & 0.36 (groundnut), 2.75, 0.97, 1.66 & 1.29 (soybean) and 1.11, 0.79, 1.07 & 2.41 (green gram) respectively.

Regarding sedge weed flora T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) treatment did not show any effect in reducing the dry weight of *Cyperus rotundus*. The lowest dry matter (g m^{-2}) of sedge weed flora (pooled data) recorded by Oxyfluorfen 23.5 EC @ 200 g ha^{-1} (T_4) were 1.00 (groundnut), 2.06 (soybean), 2.01 (green gram) and 3.03 (black gram).

Almost similar trend as that recorded in monocot weed flora also found in dicot weed dry weight (Table 4.26 for groundnut, Table 4.28 for soybean, Table 4.30 for green gram and Table 4.32 for black gram) excepting the treatment T_5, where the *Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v* applied as pre emergence. The lowest dry weight (pooled) of dicot *Digera arvensis* (g m^{-2}) were recorded from the PE chemical treatment Oxyfluorfen 23.5 EC for 0.45 (groundnut), 0.87 (soybean), 0.87 (green gram) and 0.77 (black gram). The corresponding figures for *Physalis minima* 0.26 (groundnut), 0.50 (soybean), 0.79 (green gram) and 0.49 (black gram), for *Trianthema portulecastrum* 0.35 (groundnut), 0.44 (green gram) and 0.38 (black gram), for *Melilotus alba* 0.24 (soybean) and for other dicots 0.30 (groundnut), 0.60 (soybean), 0.92 (green gram) and 0.24 (black gram). T_1, T_2, T_3, T_6 and T_7 found ineffective in reducing the dry weight of dicot weed flora at 15 DAS.

Table 4.25 Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 15 DAS of groundnut

Tr.	Treatment Details	*Digitaria sanguinalis*			*Echinochloa colona*			*Dactyloctanium aegyptium*			*Cyperus rotundus*			*Other Monocots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	1.12	1.28	1.20	0.71	0.78	0.75	0.52	0.59	0.56	4.45	4.90	4.68	0.87	1.11	0.99
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	1.09	1.25	1.17	0.72	0.79	0.76	0.54	0.61	0.58	4.55	5.01	4.78	0.88	1.12	1.00
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	1.08	1.24	1.16	0.69	0.77	0.73	0.53	0.57	0.55	4.52	4.99	4.76	0.86	1.10	0.98
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0.57	0.76	0.67	0.18	0.21	0.20	0.34	0.41	0.38	0.92	1.07	1.00	0.31	0.45	0.38
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	0.61	0.89	0.75	0.21	0.28	0.25	0.37	0.42	0.40	4.32	4.66	4.49	0.33	0.38	0.36
T_6	Hand Weeding at 20 DAS	1.09	1.27	1.18	0.71	0.77	0.74	0.51	0.58	0.55	4.48	4.92	4.70	0.85	1.13	0.99
T_7	Control	1.11	1.29	1.20	0.73	0.78	0.76	0.55	0.60	0.58	4.54	4.98	4.76	0.86	1.14	1.00
	S.Em (±)	**0.041**	**0.035**	**0.035**	**0.049**	**0.060**	**0.049**	**0.028**	**0.019**	**0.014**	**0.290**	**0.311**	**0.249**	**0.022**	**0.029**	**0.017**
	C.D (P=0.05)	**0.126**	**0.107**	**0.102**	**0.151**	**0.185**	**0.142**	**0.085**	**0.059**	**0.042**	**0.894**	**0.957**	**0.726**	**0.068**	**0.089**	**0.051**

Table 4.26 Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 15 DAS of groundnut

Tr.	Treatment Details	*Digera arvensis*			*Trianthema portulecastrum*			*Physalis minima*			*Other Dicots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	1.74	2.24	1.99	1.36	1.56	1.46	1.00	1.13	1.07	1.29	1.57	1.43
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	1.78	2.29	2.04	1.35	1.55	1.45	1.01	1.14	1.08	1.26	1.55	1.41
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	1.77	2.28	2.03	1.33	1.54	1.44	1.12	1.16	1.14	1.28	1.51	1.40
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0.39	0.51	0.45	0.32	0.37	0.35	0.25	0.27	0.26	0.27	0.33	0.30
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	1.65	2.11	1.88	1.27	1.58	1.43	0.94	1.06	1.00	1.21	1.54	1.38
T_6	Hand Weeding at 20 DAS	1.76	2.24	2.00	1.39	1.59	1.49	1.16	1.11	1.14	1.26	1.57	1.42
T_7	Control	1.75	2.25	2.00	1.37	1.57	1.47	1.14	1.15	1.15	1.27	1.54	1.41
	S.Em (±)	**0.114**	**0.119**	**0.112**	**0.101**	**0.135**	**0.096**	**0.093**	**0.101**	**0.084**	**0.095**	**0.139**	**0.075**
	C.D (P=0.05)	**0.352**	**0.368**	**0.327**	**0.311**	**0.416**	**0.281**	**0.285**	**0.312**	**0.246**	**0.293**	**0.429**	**0.219**

Table 4.27 Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 15 DAS of soybean

Tr.	Treatment Details	*Dactyloctanium aegyptium*			*Digitaria sanguinalis*			*Echinochloa colona*			*Cyperus rotundus*			*Other Monocots*		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	2.16	2.49	2.33	2.93	3.86	3.40	1.75	2.16	1.96	8.56	9.45	9.01	2.27	2.96	2.62
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	2.17	2.48	2.33	2.89	3.84	3.37	1.79	2.20	2.00	8.75	9.23	8.99	2.38	2.78	2.58
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	2.14	2.45	2.30	2.91	3.89	3.40	1.77	2.11	1.94	8.42	9.68	9.05	2 53	2.81	2.67
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	1.53	1.75	1.64	2.48	2.88	2.68	0.68	0.81	0.75	1.78	2.34	2.06	1.04	1.29	1.17
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	1.62	1.69	1.66	2.55	2.94	2.75	0.92	1.02	0.97	7.59	8.11	7.85	1 15	1.43	1.29
T_6	Hand Weeding at 20 DAS	2.12	2.57	2.35	2.94	3.63	3.29	1.70	2.18	1.94	8.85	9.55	9.20	2.21	2.86	2.54
T_7	Control	2.14	2.52	2.33	2.92	3.73	3.33	1.74	2.12	1.93	8.92	9.52	9.22	2.26	2.85	2.56
	S.Em (±)	**0.039**	**0.056**	**0.035**	**0.111**	**0.097**	**0.087**	**0.080**	**0.106**	**0.047**	**0.546**	**0.648**	**0.484**	**0.080**	**0.124**	**0.074**
	C.D (P=0.05)	**0.119**	**0.171**	**0.103**	**0.341**	**0.298**	**0.253**	**0.248**	**0.326**	**0.137**	**1.682**	**1.997**	**1.413**	**0.248**	**0.382**	**0.217**

Table 4.28 Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 15 DAS of soybean

Tr.	Treatment Details	*Digera arvensis*			*Physalis minima*			*Melilotus alba*			*Other Dicots*		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	3.44	4.35	3.90	2.49	1.72	2.11	1.26	1.07	1.17	2.46	2.97	2.72
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	3.52	4.41	3.97	2.29	1.95	2.12	1.32	1.01	1.17	2.54	2.85	2.70
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	3.69	4.58	4.14	2.17	1.89	2.03	1.14	1.11	1.13	2.57	3.09	2.83
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0.77	0.96	0.87	0.56	0.43	0.50	0.35	0.12	0.24	0.51	0.69	0.60
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	3.35	4.72	4.04	2.11	1.65	1.88	1.11	1.03	1.07	2.22	3 03	2.63
T_6	Hand Weeding at 20 DAS	3.48	4.24	3.86	2.21	1.68	1.95	1.28	1.07	1.18	2.37	2.68	2.53
T_7	Control	3.46	4.69	4.08	2.33	1.70	2.02	1.27	1.10	1.19	2.36	2.75	2.56
	S.Em (±)	**0.290**	**0.312**	**0.258**	**0.167**	**0.139**	**0.132**	**0.068**	**0.063**	**0.059**	**0.187**	**0.198**	**0.151**
	C.D (P=0.05)	**0.893**	**0.961**	**0.753**	**0.514**	**0.427**	**0.385**	**0.211**	**0.195**	**0.172**	**0.576**	**0.611**	**0.442**

Table 4.29 Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 15 DAS of green gram

Tr.	Treatment Details	*Digitaria sanguinalis*			*Dactyloctanium aegyptium*			*Echinochloa colona*			*Cyperus rotundus*			*Other Monocots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	1.91	2.22	2.07	1.25	1.61	1.43	2.39	1.53	1.96	7.75	6.45	7.10	2.76	3.47	3.12
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	1.92	2.31	2.12	1.28	1.73	1.51	2.48	1.65	2.07	8.13	6.27	7.20	2.57	3.33	2.95
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	1.86	2.18	2.02	1.19	1.68	1.44	2.33	1.38	1.86	7.91	6.39	7.15	2.82	3.41	3.12
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0.89	1.01	0.95	0.81	1.08	0.95	0.37	0.41	0.39	2.11	1.91	2.01	1.84	2.16	2.00
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	1.17	1.05	1.11	0.98	1.16	1.07	0.73	0.85	0.79	7.33	5.77	6.55	2.14	2.67	2.41
T_6	Hand Weeding at 20 DAS	1.89	2.13	2.01	1.37	1.53	1.45	2.26	1.85	2.06	7.89	6.46	7.18	2.97	3.31	3.14
T_7	Control	1.95	2.16	2.06	1.35	1.56	1.46	2.28	1.81	2.05	7.96	6.41	7.19	2.94	3.38	3.16
	S.Em (±)	**0.078**	**0.119**	**0.078**	**0.041**	**0.038**	**0.037**	**0.352**	**0.249**	**0.257**	**0.388**	**0.492**	**0.355**	**0.156**	**0.198**	**0.147**
	C.D (P=0.05)	**0.241**	**0.367**	**0.228**	**0.127**	**0.116**	**0.107**	**1.085**	**0.768**	**0.751**	**1.195**	**1.517**	**1.035**	**0.482**	**0.611**	**0.429**

Table 4.30 Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 15 DAS of green gram

Tr.	Treatment Details	*Digera arvensis*			*Physalis minima*			*Trianthema portulecastrum*			*Other Dicots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	3.47	4.39	3.93	3.35	3.79	3.57	1.71	2.94	2.33	4.02	4.86	4.44
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	3.62	4.48	4.05	3.28	3.63	3.46	1.79	2.81	2.30	3.95	4.72	4.34
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	3.54	4.45	4.00	3.24	3.73	3.49	1.88	2.79	2.34	4.16	4.88	4.52
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0.78	0.96	0.87	0.77	0.81	0.79	0.43	0.45	0.44	0.83	1.01	0.92
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	3.21	4.06	3.64	3.04	3.47	3.26	1.44	1.58	1.51	3.84	4.56	4.20
T_6	Hand Weeding at 20 DAS	3.52	4.39	3.96	3.33	3.65	3.49	1.66	2.83	2.25	3.93	4.93	4.43
T_7	Control	3.51	4.42	3.97	3.34	3.75	3.55	1.64	2.89	2.27	4.00	4.81	4.41
	S.Em (±)	**0.182**	**0.221**	**0.176**	**0.129**	**0.145**	**0.157**	**0.069**	**0.076**	**0.064**	**0.139**	**0.172**	**0.140**
	C.D (P=0.05)	**0.561**	**0.682**	**0.514**	**0.398**	**0.446**	**0.459**	**0.212**	**0.235**	**0.186**	**0.427**	**0.529**	**0.409**

Table 4.31 Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 15 DAS of black gram

Tr.	Treatment Details	*Digitaria sanguinalis*			*Echinochloa colona*			*Dactyloctenium aegyptium*			*Cyperus rotundus*			*Other Monocots*		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	1.70	1.93	1.82	1.65	1.97	1.81	1.27	1.18	1.23	7.94	8.26	8.10	0.99	1.24	1.12
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	1.79	1.96	1.88	1.67	2.05	1.86	1.34	1.07	1.21	8.17	8.46	8.32	1.04	1.15	1.10
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	1.76	1.94	1.85	1.72	1.98	1.85	1.34	1.12	1.23	8.14	8.48	8.31	1.06	1.18	1.12
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	1.03	0.95	0.99	0.46	0.34	0.40	0.93	0.81	0.87	2.83	3.22	3.03	0.59	0.54	0.57
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	1.12	1.17	1.15	0.83	0.46	0.65	1.02	0.91	0.97	7.43	7.89	7.66	0.65	0.72	0.69
T_6	Hand Weeding at 20 DAS	1.74	1.92	1.83	1.78	2.00	1.89	1.24	1.05	1.15	8.17	8.21	8.19	1.02	1.26	1.14
T_7	Control	1.71	1.96	1.84	1.75	2.01	1.88	1.25	1.03	1.14	8.13	8.29	8.21	1.00	1.20	1.10
	S.Em (±)	**0.049**	**0.068**	**0.051**	**0.157**	**0.172**	**0.147**	**0.041**	**0.046**	**0.041**	**0.635**	**0.601**	**0.519**	**0.072**	**0.081**	**0.063**
	C.D (P=0.05)	**0.152**	**0.211**	**0.149**	**0.485**	**0.531**	**0.429**	**0.127**	**0.141**	**0.119**	**1.956**	**1.853**	**1.516**	**0.223**	**0.251**	**0.185**

Table 4.32 Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 15 DAS of black gram

Tr.	Treatment Details	*Digera arvensis*			*Physalis minima*			*Trianthema portulecastrum*			*Other Dicots*		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	3.18	3.68	3.43	2.19	2.53	2.36	1.24	1.58	1.41	1.08	1.29	1.19
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	3.17	3.76	3.47	2.29	2.43	2.36	1.26	1.62	1.44	1.04	1.23	1.14
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	3.19	3.74	3.47	2.17	2.45	2.31	1.29	1.55	1.42	1.09	1.26	1.18
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0.71	0.83	0.77	0.54	0.43	0.49	0.42	0.34	0.38	0.21	0.26	0.24
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	2.98	3.51	3.25	2.11	2.31	2.21	1.25	1.50	1.38	1.06	1.22	1.14
T_6	Hand Weeding at 20 DAS	3.15	3.52	3.34	2.27	2.40	2.34	1.32	1.54	1.43	1.02	1.28	1.15
T_7	Control	3.12	3.46	3.29	2.25	2.47	2.36	1.31	1.64	1.48	1.07	1.21	1.14
	S.Em (±)	**0.276**	**0.297**	**0.279**	**0.189**	**0.209**	**0.178**	**0.115**	**0.095**	**0.096**	**0.081**	**0.090**	**0.074**
	C.D (P=0.05)	**0.851**	**0.916**	**0.813**	**0.582**	**0.643**	**0.519**	**0.354**	**0.294**	**0.281**	**0.251**	**0.278**	**0.216**

4.1.3.2 Effect of weed management treatments on dry weight of weeds at 30 DAS

At 30 DAS remarkable reduction of all categories weed dry weight (g m^{-2}) was found in case of treatment receiving HW at 20 DAS (T_6) followed by Imazethapyr 10 SL @ 100 g ha^{-1} (T_1) treated plot were statistically at par among themselves (Table 4.33 & 4.34 for groundnut, Table 4.35 & 4.36 for soybean, Table 4.37 & 4.38 for green gram and Table 4.39 & 4.40 for black gram). Among chemical herbicides regarding monocot weed (*Digitaria sanguinalis* , *Echinochloa colona, Dactyloctanium aegyptium, Cyperus rotundus and* other grasses) dry weight Imazethapyr 10 SL (T_1) recorded lowest value in all experiments during both the year as well as in pooled data. Quizalofop-ethyl 5 EC @ 50 g ha^{-1} (T_2) and Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1} (T_3) also found better in minimizing the dry weight of monocots and statistically at par with T_1 and T_6. The lowest dry weight (pooled) of *Digitaria sanguinalis, Echinochloa colona, Dactyloctenium aegyptium* and other monocots (g m^{-2}) recorded by HW treatment (T_6) were 0.55, 0.46, 0.66 & 0.45 (groundnut), 0.66, 0.81, 0.82 & 0.91 (soybean), 0.68, 0.85 , 0.74 & 1.03 (green gram) and 0.47, 0.84, 0.86 & 0.36 (black gram) respectively. The corresponding figures for Imazethapyr 10 SL @ 100 g ha^{-1} (T_1) treatment were 0.67, 0.59, 0.76 & 0.58 (groundnut), 0.78, 0.95, 0.93 & 1.10 (soybean), 0.82, 0.99, 0.81 & 1.19 (green gram) and 0.69, 1.00, 1.07 & 0.50 (black gram) respectively. Application of *Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v* (T_5) recorded significantly lesser monocot grassy weed dry weight than control treatment (T_7). Oxyfluorfen 23.5 EC @ 200 g ha^{-1} (T_4) was also significantly reducing the dry weight of monocot weeds and statistically at par with T_5. Maximum monocot weed dry weight was recorded by control treatment (T_7).

Dry matter accumulation of sedge weed *Cyperus rotundus* was effectively reduced by the HW at 20DAS (T_6) treatment followed by Imazethapyr 10 SL (T_1) applied plot. The minimum dry weight (g m^{-2}) of sedge weed flora (pooled data) was 2.53 & 2.97 (groundnut), 2.03 & 2.16 (soybean), 2.03 & 2.32 (green gram) and 2.40 & 2.67 (black gram) found against T_6 and T_1. The next minimum value regarding this parameter was obtained from Oxyfluorfen 23.5 EC, found more effective in reducing the dry mass of sedge weed flora as compared with Quizalofop-ethyl 5 EC (T_2) and Fenoxaprop-p-ethyl 9 EC (T_3). Botanicals did not show any response in reducing the sedge weed dry mass and significantly not varied with control (T_7).

Dry weight of dicot weed flora also effectively reduced by HW at 20DAS (T_6) recorded the lowest value followed by T_1 & T_4 (Imazethapyr 10 SL and Oxyfluorfen 23.5 EC respectively). The lowest dry weight of *Digera arvensis, Physalis minima* and for other dicots (g m^{-2}) were 1.20, 0.90 & 0.85 (groundnut), 1.10, 0.93 & 0.95 (soybean), 1.34, 1.29 & 1.70 (green gram) and 0.98, 0.77 & 0.31 (black gram) recorded by the HW at 20 DAS (T_6) treatment. The corresponding figures for Imazethapyr 10 SL @ 100 g ha^{-1} treatment were 1.39, 1.02 & 1.03 (groundnut), 1.24, 1.20 & 1.13 (soybean), 1.46, 1.44 & 1.80 (green gram) and 1.25, 0.96 & 0.42 (black gram). The minimum dry weight of *Trianthema portulecastrum* (g m^{-2}) were 1.04 & 1.17 (groundnut), 0.92 & 1.03 (green gram) and 0.50 & 0.71 (black gram) recorded by HW at 20 DAS (T_6) and Imazethapyr 10 SL @ 100 g ha^{-1} (T_1) treatment respectively. No effect of botanicals has found in reducing the dry weight of dicot weed flora in all the experiment during both the year as well as in pooled data. Quizalofop-ethyl 5 EC (T_2) and Fenoxaprop-p-ethyl 9 EC (T_2) also had no response on dicot weeds dry weight.

4.1.3.3 Effect of weed management treatments on dry weight of weeds at 45 DAS

Almost nearest trend like 30 DAS was also observed at this stage of weed dry weight measurement. The monocot weeds dry weight (g m^{-2}) at 45 DAS has presented in Table 4.41 (groundnut), Table 4.43 (soybean) and Table 4.45 (black gram) revealed that the HW at 20 DAS (T_6) again found best in reducing the dry weight of monocot weed flora followed by Imazethapyr 10 SL @ 100 g ha^{-1} (T_1). The minimum dry weight (pooled) of *Digitaria sanguinalis, Echinochloa colona, Dactyloctenium aegyptium* and other monocots (g m^{-2}) recorded by HW treatment (T_6) were 4.71, 3.23, 3.07 & 2.74 (groundnut), 4.10, 3.64, 3.98 & 3.20 (soybean) and 2.27, 2.65 , 2.68 & 1.73 (black gram) respectively. The corresponding figures for Imazethapyr 10 SL @ 100 g ha^{-1} (T_1) treatment were 5.18, 3.50, 3.62 & 3.39 (groundnut), 4.60, 4.11, 4.78 & 3.70 (soybean) and 2.51, 2.98, 2.89 & 1.94 (black gram) respectively. Highest monocot weed flora dry weight was found in control (T_7). Quizalofop-ethyl 5 EC (T_2) and Fenoxaprop-p-ethyl 9 EC (T_3) also found better in controlling the monocot weed recorded at par result with T_1 & T_6.

Dry weight of sedge was also effectively reduced by HW (T_6) followed by Imazethapyr 10 SL and Oxyfluorfen 23.5 EC. The minimum sedge weed dry weight

Table 4.33 Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 30 DAS of groundnut

Tr.	Treatment Details	*Digitaria sanguinalis*			*Echinochloa colona*			*Dactyloctanium aegyptium*			*Cyperus rotundus*			*Other Monocots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0.64	0.69	0.67	0.61	0.56	0.59	0.68	0.83	0.76	2.87	3.07	2.97	0.62	0.53	0.58
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0.88	1.03	0.96	0.79	0.75	0.77	0.85	1.07	0.96	6.31	6.72	6.52	0.82	0.70	0.76
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0.97	1.18	1.08	0.84	0.82	0.83	0.91	1.17	1.04	6.48	6.92	6.70	0.93	0.81	0.87
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	2.46	3.04	2.75	0.92	0.83	0.88	1.65	1.32	1.49	4.68	4.36	4.52	2.67	2.29	2.48
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	4.29	5.17	4.73	2.95	2.72	2.84	2.87	3.87	3.37	13.79	15.56	14.68	3.36	2.88	3.12
T_6	Hand Weeding at 20 DAS	0.48	0.62	0.55	0.43	0.49	0.46	0.56	0.75	0.66	2.19	2.86	2.53	0.42	0.47	0.45
T_7	Control	5.98	6.89	6.44	5.39	5.27	5.33	4.14	5.26	4.70	14.63	16.48	15.56	3.68	3.15	3.42
	S.Em (±)	**0.178**	**0.201**	**0.184**	**0.135**	**0.158**	**0.140**	**0.158**	**0.172**	**0.141**	**0.464**	**0.395**	**0.409**	**0.202**	**0.189**	**0.181**
	C.D (P=0.05)	**0.548**	**0.618**	**0.537**	**0.416**	**0.487**	**0.409**	**0.486**	**0.529**	**0.413**	**1.429**	**1.218**	**1.195**	**0.622**	**0.581**	**0.527**

Table 4.34 Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 30 DAS of groundnut

Tr.	Treatment Details	*Digera arvensis*			*Trianthema portulecastrum*			*Physalis minima*			*Other Dicots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	1.41	1.37	1.39	1.08	1.26	1.17	0.96	1.07	1.02	1.17	0.88	1.03
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	6.02	6.71	6.37	5.27	6.57	5.92	4.29	4.95	4.62	4.98	3.76	4.37
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	6.09	6.85	6.47	5.39	6.77	6.08	4.49	5.31	4.90	5.07	3.94	4.51
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	1.89	2.14	2.02	1.65	2.52	2.09	1.83	2.39	2.11	1.96	1.35	1.66
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	6.18	6.89	6.54	5.32	6.84	6.08	4.65	5.37	5.01	5.31	4.00	4.66
T_6	Hand Weeding at 20 DAS	1.13	1.26	1.20	0.92	1.15	1.04	0.83	0.96	0.90	0.97	0.73	0.85
T_7	Control	6.51	7.24	6.88	5.59	6.97	6.28	4.95	5.71	5.33	5.82	4.41	5.12
	S.Em (±)	**0.352**	**0.297**	**0.296**	**0.395**	**0.485**	**0.380**	**0.440**	**0.481**	**0.445**	**0.349**	**0.311**	**0.295**
	C.D (P=0.05)	**1.083**	**0.914**	**0.863**	**1.216**	**1.493**	**1.108**	**1.356**	**1.481**	**1.298**	**1.074**	**0.959**	**0.861**

Table 4.35 Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 30 DAS of soybean

Tr.	Treatment Details	*Dactyloctanium aegyptium*			*Digitaria sanguinalis*			*Echinochloa colona*			*Cyperus rotundus*			*Other Monocots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0.83	1.03	0.93	0.74	0.81	0.78	0.78	1.12	0.95	2.11	2.21	2.16	0.95	1.25	1.10
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	1.56	1.79	1.68	1.02	1.14	1.08	1.31	1.41	1.36	6.64	6.16	6.40	1.36	1.63	1.5
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	1.64	1.87	1.76	1.09	1.21	1.15	1.46	1.67	1.57	6.92	6.46	6.69	1.45	1.72	1.59
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	2.95	3.34	3.15	2.55	2.89	2.72	1.51	1.86	1.69	4.35	4.64	4.00	2.64	2.96	2.80
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	4.24	5.02	4.63	3.41	3.91	3.66	2.84	3.89	3.37	11.41	12.65	12.03	3.57	4.42	4.00
T_6	Hand Weeding at 20 DAS	0.79	0.85	0.82	0.69	0.63	0.66	0.74	0.87	0.81	1.98	2.07	2.03	0.89	0.92	0.91
T_7	Control	5.71	6.59	6.15	4.91	5.62	5.27	4.46	5.34	4.9	11.99	13.22	12.61	4.84	5.71	5.28
	S.Em (±)	**0.347**	**0.398**	**0.336**	**0.168**	**0.197**	**0.172**	**0.304**	**0.330**	**0.309**	**0.684**	**0.773**	**0.705**	**0.224**	**0.279**	**0.232**
	C.D (P=0.05)	**1.069**	**1.227**	**0.982**	**0.519**	**0.607**	**0.503**	**0.936**	**1.016**	**0.901**	**2.106**	**2.382**	**2.059**	**0.689**	**0.861**	**0.677**

Table 4.36 Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 30 DAS of soybean

Tr.	Treatment Details	*Digera arvensisis*			*Physalis minima*			*Melilotus alba*			*Other Dicots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	1.21	1.26	1.24	1.08	1.31	1.20	1.02	1.28	1.15	0.93	1.32	1.13
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	7.49	6.25	6.87	5.23	4.69	4.96	5.27	5.27	5.27	5.69	5.08	5.39
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	7.64	6.41	7.03	5.36	4.82	5.09	5.58	5.65	5.62	5.82	5.22	5.52
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	3.29	3.05	3.17	1.91	2.58	2.25	1.98	2.37	2.18	1.95	2.25	2.10
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	8.03	7.96	8.00	6.75	7.25	7.00	5.74	6.83	6.29	6.17	5.58	5.88
T_6	Hand Weeding at 20 DAS	1.12	1.08	1.10	0.97	0.89	0.93	0.95	1.13	1.04	0.88	1.02	0.95
T_7	Control	8.22	8.08	8.15	6.92	7.41	7.17	5.98	8.14	7.06	6.53	5.97	6.25
	S.Em (±)	**0.264**	**0.394**	**0.271**	**0.313**	**0.264**	**0.260**	**0.184**	**0.234**	**0.173**	**0.404**	**0.320**	**0.318**
	C.D (P=0.05)	**0.813**	**1.213**	**0.791**	**0.965**	**0.814**	**0.759**	**0.567**	**0.721**	**0.505**	**1.246**	**0.985**	**0.927**

Table 4.37 Effect of WM treatments on dry weight of monocot weeds m^{-2} at 30 DAS of green gram

Tr.	Treatment Details	*Digitaria sanguinalis*			*Dactyloctanium aegyptium*			*Echinochloa colona*			*Cyperus rotundus*			*Other Monocots*		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0.74	0.89	0.82	0.65	0.96	0.81	0.81	1.16	0.99	2.52	2.11	2.32	1.09	1.29	1.19
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	1.12	1.65	1.39	1.23	1.37	1.30	1.16	2.18	1.67	8.35	8.93	8.64	1.13	1.89	1.51
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	1.19	1.57	1.38	1.16	1.29	1.23	1.35	2.43	1.89	8.82	9.58	9.20	1.29	2.01	1.65
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	3.02	3.45	3.24	3.53	3.69	3.61	1.39	2.62	2.01	3.52	4.64	4.43	4.22	4.99	4.61
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	3.65	4.33	3.99	3.99	4.54	4.27	3.76	4.9	4.33	12.12	13.19	12.66	4.31	6.31	5.31
T_6	Hand Weeding at 20 DAS	0.61	0.74	0.68	0.57	0.91	0.74	0.72	0.98	0.85	2.16	1.89	2.03	0.93	1.13	1.03
T_7	Control	4.82	6.41	5.62	5.37	6.76	6.07	4.98	7.06	6.02	12.91	14.73	13.82	5.71	7.52	6.62
	S.Em (±)	**0.244**	**0.282**	**0.248**	**0.201**	**0.189**	**0.183**	**0.475**	**0.517**	**0.451**	**1.158**	**1.304**	**1.129**	**0.231**	**0.300**	**0.227**
	C.D (P=0.05)	**0.752**	**0.869**	**0.723**	**0.619**	**0.582**	**0.534**	**1.463**	**1.592**	**1.316**	**3.569**	**4.016**	**3.295**	**0.711**	**0.925**	**0.662**

Table 4.38 Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 30 DAS of green gram

Tr.	Treatment Details	*Digera arvensis*			*Physalis minima*			*Trianthema portulecastrum*			*Other Dicots*		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	1.18	1.73	1.46	1.29	1.58	1.44	0.91	1.15	1.03	1.45	2.15	1.80
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	5.56	6.33	5.95	5.88	6.51	6.20	3.70	4.57	4.14	7.65	8.29	7.97
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	5.68	6.46	6.07	6.02	6.66	6.34	3.93	4.84	4.39	7.87	8.53	8.20
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	1.31	2.03	1.67	1.65	1.86	1.76	1.19	1.37	1.28	1.72	2.69	2.21
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	6.23	7.08	6.66	6.54	7.23	6.89	4.09	5.04	4.57	8.41	9.08	8.75
T_6	Hand Weeding at 20 DAS	1.05	1.63	1.34	1.16	1.41	1.29	0.83	1.01	0.92	1.34	2.06	1.70
T_7	Control	6.30	7.17	6.74	6.74	7.45	7.10	4.26	5.25	4.76	9.02	9.75	9.39
	S.Em (±)	**0.134**	**0.189**	**0.123**	**0.191**	**0.200**	**0.186**	**0.138**	**0.134**	**0.135**	**0.194**	**0.212**	**0.179**
	C.D (P=0.05)	**0.413**	**0.582**	**0.359**	**0.589**	**0.615**	**0.544**	**0.426**	**0.413**	**0.395**	**0.599**	**0.652**	**0.523**

Table 4.39 Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 30 DAS of black gram

Tr.	Treatment Details	*Digitaria sanguinalis*			*Echinochloa colona*			*Dactyloctenium aegyptium*			*Cyperus rotundus*			*Other Monocots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0.62	0.76	0.69	0.83	1.17	1.00	0.89	1.24	1.07	2.05	3.28	2.67	0.37	0.63	0.50
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	1.21	1.52	1.37	1.34	1.73	1.54	1.25	1.68	1.47	7.39	8.62	8.01	0.54	0.86	0.70
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	1.25	1.56	1.41	1.46	1.79	1.63	1.38	1.71	1.55	7.67	8.75	8.21	0.59	0.89	0.74
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	2.91	4.04	3.48	1.46	1.85	1.66	2.96	4.00	3.48	4.78	5.79	5.29	1.51	1.92	1.72
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	3.86	5.03	4.45	3.82	5.08	4.45	3.16	5.86	4.51	11.29	13.81	12.55	1.75	2.39	2.07
T_6	Hand Weeding at 20 DAS	0.38	0.55	0.47	0.69	0.98	0.84	0.63	1.08	0.86	1.81	2.98	2.40	0.25	0.47	0.36
T_7	Control	4.09	5.6	4.85	6.09	7.96	7.03	4.42	6.7	5.56	12.1	14.66	13.38	1.92	3.41	2.67
	S.Em (±)	**0.320**	**0.394**	**0.328**	**0.271**	**0.289**	**0.275**	**0.254**	**0.280**	**0.246**	**0.969**	**1.021**	**0.977**	**0.133**	**0.156**	**0.134**
	C.D (P=0.05)	**0.985**	**1.213**	**0.956**	**0.834**	**0.889**	**0.803**	**0.782**	**0.864**	**0.718**	**2.986**	**3.145**	**2.851**	**0.409**	**0.481**	**0.392**

Table 4.40 Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 30 DAS of black gram

Tr.	Treatment Details	*Digera arvensis*			*Physalis minima*			*Trianthema portulecastrum*			*Other Dicots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	1.19	1.30	1.25	0.84	1.07	0.96	0.58	0.83	0.71	0.45	0.39	0.42
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	4.39	5.55	4.97	3.89	4.66	4.28	2.47	3.53	3.00	1.80	1.81	1.81
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	4.50	5.60	5.05	3.92	4.78	4.35	2.63	3.6	3.12	1.83	1.89	1.86
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	1.54	1.81	1.68	1.07	1.46	1.27	0.85	1.27	1.06	0.67	0.53	0.60
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	4.89	6.25	5.57	3.87	4.88	4.38	2.48	3.71	3.10	1.79	2.01	1.90
T_6	Hand Weeding at 20 DAS	0.91	1.04	0.98	0.62	0.92	0.77	0.42	0.58	0.50	0.33	0.28	0.31
T_7	Control	5.01	6.60	5.81	4.05	5.49	4.77	2.75	4.46	3.61	2.13	2.15	2.14
	S.Em (±)	**0.258**	**0.315**	**0.246**	**0.182**	**0.257**	**0.178**	**0.199**	**0.278**	**0.202**	**0.149**	**0.106**	**0.109**
	C.D (P=0.05)	**0.794**	**0.971**	**0.717**	**0.561**	**0.792**	**0.519**	**0.614**	**0.857**	**0.589**	**0.459**	**0.328**	**0.317**

Table 4.41 Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 45 DAS of groundnut

Tr.	Treatment Details	*Digitaria sanguinalis*			*Echinochloa colona*			*Dactyloctanium aegyptium*			*Cyperus rotundus*			*Other Monocots*		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	4.78	5.57	5.18	3.58	3.42	3.50	3.19	4.05	3.62	9.13	10.29	9.71	3.63	3.15	3.39
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	5.16	5.98	5.57	3.93	4.16	4.05	3.49	4.34	3.92	14.77	16.88	15.83	3.76	3.21	4.49
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	5.36	6.23	6.80	4.09	4.23	4.16	3.71	4.62	4.17	15.92	15.40	15.66	4.08	3.43	5.26
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	7.33	8.23	7.78	6.69	6.53	6.61	5.33	6.21	5.77	10.79	10.67	10.73	5.83	6.28	6.06
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	9.84	13.37	11.61	14.08	12.35	13.22	5.87	8.48	7.18	23.4	26.71	25.06	5.95	5.82	5.89
T_6	Hand Weeding at 20 DAS	4.19	5.23	4.71	3.15	3.31	3.23	2.24	3.89	3.07	8.27	9.63	8.95	2.87	2.61	2.74
T_7	Control	12.90	15.03	13.97	17.56	17.83	17.70	7.97	10.00	8.99	24.49	27.59	26.04	6.31	5.41	5.86
	S.Em (±)	**0.427**	**0.399**	**0.379**	**0.431**	**0.496**	**0.443**	**0.502**	**0.453**	**0.416**	**0.979**	**1.106**	**1.022**	**0.426**	**0.391**	**0.383**
	C.D (P=0.05)	**1.315**	**1.228**	**1.107**	**1.328**	**1.527**	**1.292**	**1.546**	**1.395**	**1.214**	**3.016**	**3.408**	**2.983**	**1.311**	**1.205**	**1.118**

Table 4.42 Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 45 DAS of groundnut

Tr.	Treatment Details	*Digera arvensis*			*Trianthema portulecastrum*			*Physalis minima*			*Other Dicots*		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	3.94	4.41	4.18	3.81	4.74	4.28	3.31	3.82	3.57	2.89	2.18	2.54
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	15.15	16.88	16.02	14.06	17.53	15.80	11.07	12.78	11.93	8.86	8.68	8.77
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	15.41	17.21	16.31	14.18	17.64	15.91	11.55	13.38	12.47	9.07	8.88	8.98
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	8.09	9.13	8.61	6.16	7.69	6.93	5.18	6.76	5.97	4.84	3.66	4.25
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	15.47	17.83	16.65	14.09	17.58	15.84	11.82	14.95	13.39	9.55	9.19	9.37
T_6	Hand Weeding at 20 DAS	3.76	4.19	3.98	3.47	4.32	3.90	3.19	3.69	3.44	2.79	2.11	2.45
T_7	Control	16.67	18.55	17.61	14.30	17.83	16.07	12.20	16.08	14.14	10.10	9.66	9.88
	S.Em (±)	**0.606**	**0.763**	**0.603**	**0.568**	**0.719**	**0.552**	**0.437**	**0.644**	**0.362**	**0.460**	**0.460**	**0.463**
	C.D (P=0.05)	**1.867**	**2.351**	**1.759**	**1.751**	**2.214**	**1.611**	**1.346**	**1.983**	**1.057**	**1.417**	**1.416**	**1.351**

Table 4.43 Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 45 DAS of soybean

Tr.	Treatment Details	*Dactyloctanium aegyptium*			*Digitaria sanguinalis*			*Echinochloa colona*			*Cyperus rotundus*			*Other Monocots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	4.31	5.25	4.78	4.06	5.13	4.60	4.05	4.16	4.11	7.56	9.16	8.36	3.21	4.19	3.70
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	4.86	5.81	5.34	4.48	5.47	4.98	4.29	4.41	4.35	11.83	15.84	13.84	3.54	4.61	4.08
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	4.98	6.07	5.53	4.56	5.59	5.08	4.39	4.56	4.48	11.63	17.02	14.33	3.63	4.37	4.00
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	7.26	8.31	7.79	5.63	6.79	6.21	4.55	4.82	4.69	8.34	11.17	9.76	5.59	6.28	5.94
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	8.14	10.27	9.21	6.53	7.29	6.91	6.22	7.31	6.77	19.04	20.94	19.99	6.06	7.32	7.69
T_6	Hand Weeding at 20 DAS	3.85	4.11	3.98	3.62	4.57	4.10	3.41	3.86	3.64	5.58	8.94	7.26	2.56	3.84	3.20
T_7	Control	10.88	12.42	11.65	6.92	8.55	7.74	8.78	9.72	9.25	20.17	21.82	21.00	7.31	8.59	7.95
	S.Em (±)	**0.546**	**0.675**	**0.549**	**0.334**	**0.365**	**0.342**	**0.408**	**0.426**	**0.379**	**1.066**	**0.947**	**0.878**	**0.549**	**0.562**	**0.433**
	C.D (P=0.05)	**1.681**	**2.081**	**1.601**	**1.029**	**1.125**	**0.998**	**1.256**	**1.312**	**1.106**	**3.284**	**2.918**	**2.563**	**1.692**	**1.731**	**1.263**

Table 4.44 Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 45 DAS of soybean

Tr.	Treatment Details	*Digera arvensis*			*Physalis minima*			*Melilotus alba*			*Other Dicots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	3.76	3.22	3.49	2.46	2.12	2.29	2.48	2.25	2.37	2.12	2.44	2.18
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	9.43	10.62	10.03	6.96	7.43	7.20	6.51	7.46	6.99	5.87	6.08	5.98
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	9.67	10.86	10.27	7.21	7.61	7.41	6.85	7.99	7.42	6.03	6.24	6.14
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	6.02	5.18	5.60	3.21	3.09	3.15	3.65	3.25	3.45	3.24	3.07	3.16
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	10.01	11.81	10.91	7.17	8.27	7.72	6.77	8.25	7.51	6.24	6.67	6.46
T_6	Hand Weeding at 20 DAS	3.59	2.92	3.26	2.18	2.05	2.12	2.06	1.91	1.99	1.87	1.57	1.72
T_7	Control	10.68	12.02	11.35	7.82	8.55	8.19	7.12	8.68	7.90	6.67	7.13	6.90
	S.Em (±)	**0.377**	**0.266**	**0.275**	**0.198**	**0.300**	**0.200**	**0.352**	**0.312**	**0.292**	**0.311**	**0.232**	**0.235**
	C.D (P=0.05)	**1.162**	**0.819**	**0.803**	**0.611**	**0.924**	**0.583**	**1.085**	**0.962**	**0.851**	**0.959**	**0.716**	**0.686**

Table 4.45 Effect of WM treatments on dry weight of monocot weeds (g m^{-2}) at 45 DAS of black gram

Tr.	Treatment Details	*Digitaria sanguinalis*			*Echinochloa colona*			*Dactyloctenium aegyptium*			*Cyperus rotundus*			*Other Monocots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	2.56	2.45	2.51	2.64	3.32	2.98	2.81	2.97	2.89	5.31	5.59	5.45	1.79	2.09	1.94
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	3.23	2.96	3.10	3.06	3.63	3.35	3.35	3.59	3.12	10.88	10.81	10.85	1.96	2.42	2.19
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	3.44	3.08	3.26	3.38	3.81	3.60	3.36	4.11	4.74	10.82	11.43	11.13	2.04	2.63	2.34
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	4.91	5.38	5.15	3.78	4.07	3.93	5.62	6.71	6.17	7.69	6.67	7.18	2.58	3.21	2.90
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	6.46	7.06	6.76	8.07	8.79	8.43	6.01	7.06	6.54	14.89	15.85	15.37	2.07	2.46	2.27
T_6	Hand Weeding at 20 DAS	2.13	2.41	2.27	2.24	3.05	2.65	2.47	2.88	2.68	4.12	4.21	4.17	1.38	2.07	1.73
T_7	Control	7.63	8.37	8.00	10.68	11.18	10.93	6.88	8.24	7.56	15.94	16.77	16.36	2.71	3.09	2.90
	S.Em (±)	**0.459**	**0.391**	**0.309**	**0.297**	**0.277**	**0.242**	**0.335**	**0.434**	**0.335**	**1.175**	**1.071**	**1.065**	**0.198**	**0.192**	**0.173**
	C.D (P=0.05)	**1.415**	**1.206**	**0.902**	**0.914**	**0.853**	**0.707**	**1.032**	**1.337**	**0.979**	**3.619**	**3.301**	**3.109**	**0.611**	**0.591**	**0.506**

Table 4.46 Effect of WM treatments on dry weight of dicot weeds (g m^{-2}) at 45 DAS of black gram

Tr.	Treatment Details	*Digera arvensis*			*Physalis minima*			*Trianthema portulecastrum*			*Other Dicots*		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	2.52	3.15	2.84	2.68	2.82	2.75	2.32	2.42	2.37	1.87	1.53	1.70
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	8.69	9.03	8.86	6.27	6.71	6.49	3.72	4.60	4.16	2.22	2.49	2.36
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	8.88	9.14	9.01	6.38	6.79	6.59	3.96	4.70	4.33	2.29	2.52	2.41
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	3.27	5.81	4.54	3.36	3.38	3.37	3.19	3.89	3.54	2.36	2.24	2.30
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	9.32	10.06	9.69	6.92	7.31	7.12	3.81	4.68	4.25	2.47	2.7	2.59
T_6	Hand Weeding at 20 DAS	2.23	2.15	2.19	2.26	2.54	2.40	1.71	2.11	1.91	1.42	1.19	1.31
T_7	Control	9.55	10.25	9.90	7.18	7.64	7.41	4.30	5.10	4.70	2.79	2.92	2.86
	S.Em (±)	**0.231**	**0.355**	**0.235**	**0.198**	**0.170**	**0.162**	**0.246**	**0.395**	**0.199**	**0.153**	**0.221**	**0.146**
	C.D (P=0.05)	**0.712**	**1.095**	**0.687**	**0.611**	**0.524**	**0.473**	**0.759**	**1.217**	**0.582**	**0.471**	**0.682**	**0.425**

in g m^{-2} (pooled data) 8.95 & 9.71 (groundnut), 7.26 & 8.36 (soybean) and 4.17 & 5.45 (black gram) were found against T_6 and T_1.

The effect of treatments on dry weight of dicot weed flora (Table 4.42 for groundnut, Table 4.44 for soybean and Table 4.46 for black gram) showed almost similar trend as that recorded in monocot weed flora. But the treatments T_2, T_3 and T_5 recorded no response in reducing the dry weight of dicot weeds and significantly not differed with control treatment (T_7). The dry weight of *Digera arvensis, Physalis minima* and for other dicots (g m^{-2}) were 3.98, 3.44 & 2.45 (groundnut), 3.26, 2.12 & 1.72 (soybean) and 2.19, 2.40 & 1.31 (black gram) recorded by the HW at 20 DAS (T_6) treatment. The corresponding figures for Imazethapyr 10 SL @ 100 g ha^{-1} treatment were 4.18, 3.57 & 2.54 (groundnut), 3.49, 2.29 & 2.18 (soybean) and 2.84, 2.75 & 1.70 (black gram). The minimum dry weight *Trianthema portulecastrum* (g m^{-2}) was 3.90 & 4.28 (groundnut) and 1.91 & 2.37 (black gram) recorded by HW at 20 DAS (T_6) and Imazethapyr 10 SL @ 100 g ha^{-1} treatment respectively.

4.2 Studies on nodulation

Groundnut, soybean, green gram and black gram being leguminous crop, can fix atmospheric nitrogen through symbiotic nitrogen fixation process. The extent of nitrogen fixation is determined by nodule formation. Nodules are degenerated after flowering.

4.2.1 Effect of weed management methods on number of nodule $plant^{-1}$

The number of nodule $plant^{-1}$ in groundnut, soybean, green gram and black gram crop was recorded at 15 days interval starting from 30 DAS. The nodule number $plant^{-1}$ as presented in Table 4.47 (groundnut), Table 4.48 (soybean), Table 4.49 (green gram) and Table 4.50 (black gram) showed that the treatment T_6 (HW at 20 DAS) recorded maximum number of nodule (pooled) in all experimental legumes during all dates of observation followed by T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) and T_7 (control). Treatments where PE & POE chemical herbicides applied produced significantly lower number of nodule in respect to T_5, T_6 & T_7 during both years of experiment as well as in pooled data. Regarding this aspect all the chemical herbicide treated plots were statistically at par among themselves. The minimum nodule number during all investigation stage was recorded by Quizalofop-ethyl 5 EC (T_2) for all experimental legumes.

During peak flowering time all the crops produced maximum number of nodules. So, according to flowering time the maximum nodule produced by groundnut, soybean, green gram and black gram at 60, 60, 45 & 60 DAS respectively. The maximum number of nodules plant^{-1} (pooled) recorded by T_6 (HW at 20 DAS) were 181.50 (groundnut at 60 DAS), 19.07 (soybean at 60 DAS), 33.87 (green gram at 45 DAS) and 35.00 (black gram at 60 DAS). The corresponding figures for minimum nodule number plant^{-1} (pooled) at peak flowering stage were 157.60 (groundnut at 60 DAS), 16.03 (soybean at 60 DAS), 29.10 (green gram at 45 DAS) and 30.77 (black gram at 60 DAS) recorded by treatment T_2 (Quizalofop-ethyl 5 EC). Among the PE & POE chemicals applied in all the experiments, PE application of Oxyfluorfen 23.5 EC @ 200 g ha^{-1} (T_4) produced comparatively higher nodules plant^{-1} with in comparison to POE chemicals but still found at par among them in all dates of investigation. Treatments receiving natural botanicals (T_5) did not show harmful effect on reduction of number nodules and statistically at par with T_6.

Almost similar results were recorded at subsequent stages of nodule counting. After peak flowering stage, the nodules started to degenerate, as a result the total nodule number of all legumes became lowered.

4.2.2 Effect of weed management methods on dry weight of nodule plant^{-1}

Nodule dry weight was differed according to the number of nodule plant^{-1}. Dry mass of the nodule increased with the advancement of the crop age, but after flowering stage the value has decreased. The effect of treatments on dry weight of nodule plant^{-1} (Table 4.51 for groundnut, Table 4.52 for soybean, Table 4.53 for green gram and Table 4.54 for black gram) indicated that T_6 (HW at 20 DAS) recorded maximum dry weight of nodule during both experimental year as well as in pooled data. In case of groundnut the maximum nodule dry weight (g plant^{-1}) were 0.111 (30 DAS), 0.291 (45 DAS), 0.307 (60 DAS), 0.295 (75 DAS) and 0.281 (90 DAS) recorded by T_6. The corresponding figures for soybean were 0.156 (30 DAS), 0.174 (45 DAS), 0.258 (60 DAS), 0.225 (75 DAS) & 0.213 (90 DAS), for green gram 0.601 (30 DAS), 0.675 (45 DAS) & 0.495 (60 DAS) and for black gram 0.532 (30 DAS), 0.621 (45 DAS), 0.669 (60 DAS) & 0.623 (75 DAS). Application of botanicals *i.e.* T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) also recorded higher nodule dry weight and gave statistically at par value with T_6.

Table 4.47 Effect of WM treatments on nodule number of groundnut

Tr.	Treatment Details	No. of nodule plant^{-1} of groundnut														
		30 DAS			45 DAS			60 DAS			75 DAS			90 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	83.87	87.67	85.77	135.47	143.07	139.27	161.13	158.00	159.57	151.20	159.20	155.20	147.00	151.07	149.04
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	82.73	87.20	84.97	133.93	140.13	137.03	159.87	155.33	157.60	149.80	156.33	153.07	143.73	148.20	145.97
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	83.80	86.93	85.37	134.60	141.13	137.87	161.93	157.80	159.87	151.07	157.87	154.47	144.80	149.87	147.34
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	87.93	89.66	88.80	138.93	150.67	144.80	163.67	165.53	164.60	154.00	160.20	157.10	147.33	153.53	150.43
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	101.33	105.27	103.30	157.60	168.40	163.00	176.47	184.53	180.50	167.47	175.73	171.60	161.20	165.80	163.50
T_6	Hand Weeding at 20 DAS	101.67	105.66	103.67	158.67	167.93	163.30	177.00	186.00	181.50	169.27	178.93	174.10	162.93	168.60	165.77
T_7	Control	100.47	104.93	102.70	157.47	163.27	160.37	175.40	180.07	177.74	164.13	173.20	168.67	157.13	164.20	160.67
	S.Em (±)	**3.782**	**4.668**	**3.618**	**5.405**	**3.694**	**3.618**	**3.625**	**4.201**	**3.719**	**2.976**	**3.941**	**3.034**	**3.122**	**3.073**	**3.037**
	C.D (P=0.05)	**11.652**	**14.382**	**10.561**	**16.652**	**11.382**	**10.561**	**11.168**	**12.943**	**10.856**	**9.168**	**12.143**	**8.856**	**9.618**	**9.467**	**8.863**

Table 4.48 Effect of WM treatments on nodule number of soybean

Tr.	Treatment Details	No. of nodule plant^{-1} of soybean														
		30 DAS			45 DAS			60 DAS			75 DAS			90 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	9.53	8.13	8.83	13.20	12.47	12.84	16.60	15.87	16.24	13.87	13.20	13.54	13.00	12.33	12.67
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	9.47	7.93	8.70	12.93	12.33	12.63	16.33	15.73	16.03	13.73	12.87	13.30	12.80	12.20	12.50
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	9.47	8.07	8.77	13.07	12.40	12.74	16.60	15.93	16.27	13.60	13.13	13.37	12.87	12.27	12.57
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	10.33	8.73	9.53	14.22	13.73	14.98	17.60	16.40	17.00	14.47	13.47	13.97	13.87	13.33	13.60
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	12.60	11.87	12.24	16.73	15.93	16.33	19.40	18.53	18.97	16.33	15.87	16.10	15.33	14.47	14.90
T_6	Hand Weeding at 20 DAS	12.80	12.07	12.44	17.00	16.13	16.57	19.53	18.60	19.07	16.60	16.00	16.30	15.53	14.47	15.00
T_7	Control	12.60	11.73	12.17	16.47	15.60	16.04	18.93	18.47	18.70	16.13	15.73	15.93	15.33	14.33	14.83
	S.Em (±)	**0.668**	**0.704**	**0.638**	**0.491**	**0.574**	**0.483**	**0.406**	**0.614**	**0.379**	**0.460**	**0.683**	**0.451**	**0.359**	**0.296**	**0.263**
	C.D (P=0.05)	**2.059**	**2.168**	**1.861**	**1.512**	**1.769**	**1.409**	**1.251**	**1.893**	**1.106**	**1.418**	**2.104**	**1.317**	**1.106**	**0.913**	**0.768**

Table 4.49 Effect of WM treatments on nodule number of green gram

Tr.	Treatment Details	No. of nodule $plant^{-1}$ of green gram								
		30 DAS			45 DAS			60 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	24.67	25.87	25.27	29.73	29.13	29.43	25.80	26.33	26.07
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	24.27	25.67	24.97	29.53	28.67	29.10	24.93	25.87	25.40
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	24.60	25.73	25.17	29.60	29.07	29.34	25.27	26.07	25.67
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	25.60	27.27	26.44	30.40	29.93	30.17	26.07	26.83	26.45
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	30.07	31.07	30.57	33.07	34.13	33.60	28.60	28.93	28.77
T_6	Hand Weeding at 20 DAS	30.13	31.53	30.83	32.87	34.87	33.87	28.67	30.07	29.37
T_7	Control	29.87	30.80	30.34	32.33	34.20	33.27	27.93	28.53	28.23
	S.Em (±)	**1.141**	**1.002**	**1.022**	**0.602**	**1.281**	**0.619**	**0.525**	**0.513**	**0.502**
	C.D (P=0.05)	**3.516**	**3.088**	**2.983**	**1.854**	**3.946**	**1.806**	**1.616**	**1.582**	**1.465**

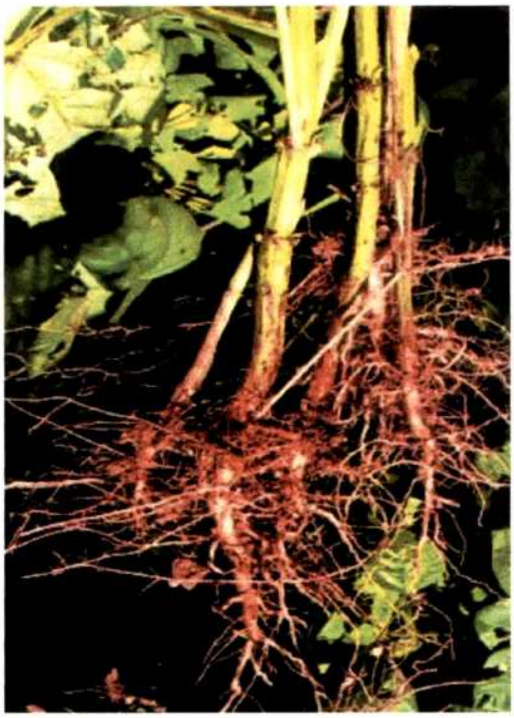
Table 4.50 Effect of WM treatments on nodule number of black gram

Tr.	Treatment Details	No. of nodule $plant^{-1}$ of black gram											
		30 DAS			45 DAS			60 DAS			75 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	18.00	18.80	18.40	30.20	29.80	30.00	31.07	31.33	31.20	28.20	29.00	28.60
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	17.60	18.60	18.10	29.73	29.20	29.47	30.73	30.80	30.77	27.80	28.47	28.13
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	17.87	18.67	18.27	29.93	29.60	29.77	30.93	31.13	31.03	27.60	28.80	28.20
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	18.53	18.87	18.70	30.87	30.40	30.63	32.13	31.67	31.90	29.00	29.27	29.13
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	21.80	22.53	22.17	33.40	35.20	34.30	34.33	34.60	34.47	30.93	31.80	31.37
T_6	Hand Weeding at 20 DAS	21.67	22.80	22.23	33.60	35.47	34.53	34.73	35.27	35.00	31.00	32.40	31.70
T_7	Control	21.53	22.33	21.93	32.87	34.87	33.87	33.67	34.13	33.90	30.20	31.53	30.87
	S.Em (±)	**1.153**	**1.272**	**1.186**	**0.990**	**1.710**	**1.022**	**1.163**	**1.261**	**1.133**	**0.816**	**1.043**	**0.839**
	C.D (P=0.05)	**3.552**	**3.918**	**3.461**	**3.051**	**5.269**	**2.982**	**3.582**	**3.886**	**3.308**	**2.513**	**3.214**	**2.448**

Root nodule of groundnut

Root nodule of soybean

Root nodule of green gram



Root nodule of black gram

Plate 4.2 Nodule of different legume crops

Table 4.51 Effect of WM treatments on dry weight of groundnut nodule

Tr.	Treatment Details	Dry weight of nodule (g plant^{-1}) of groundnut														
		30 DAS			45 DAS			60 DAS			75 DAS			90 DAS		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0.085	0.089	0.087	0.236	0.251	0.244	0.265	0.283	0.274	0.257	0.271	0.264	0.244	0.265	0.255
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0.084	0.089	0.087	0.232	0.242	0.237	0.262	0.272	0.267	0.252	0.262	0.257	0.239	0.262	0.251
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0.087	0.091	0.089	0.234	0.247	0.241	0.264	0.281	0.273	0.255	0.266	0.261	0.241	0.265	0.253
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0.089	0.096	0.093	0.242	0.256	0.249	0.268	0.291	0.280	0.259	0.273	0.266	0.247	0.269	0.258
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	0.107	0.109	0.108	0.273	0.292	0.283	0.288	0.318	0.303	0.283	0.296	0.290	0.265	0.286	0.276
T_6	Hand Weeding at 20 DAS	0.106	0.115	0.111	0.279	0.302	0.291	0.287	0.326	0.307	0.284	0.305	0.295	0.267	0.295	0.281
T_7	Control	0.104	0.108	0.106	0.275	0.286	0.281	0.286	0.309	0.298	0.281	0.290	0.286	0.262	0.281	0.272
	S.Em (±)	**0.0044**	**0.0037**	**0.0036**	**0.0101**	**0.0092**	**0.0086**	**0.0054**	**0.0043**	**0.0043**	**0.0066**	**0.0053**	**0.0046**	**0.0043**	**0.0039**	**0.0037**
	C.D (P=0.05)	**0.0135**	**0.0113**	**0.0104**	**0.0312**	**0.0283**	**0.0251**	**0.0167**	**0.0134**	**0.0126**	**0.0204**	**0.0162**	**0.0134**	**0.0133**	**0.0119**	**0.0107**

Table 4.52 Effect of WM treatments on dry weight of soybean nodule

Tr.	Treatment Details	Dry weight of nodule (g plant^{-1}) of soybean														
		30 DAS			45 DAS			60 DAS			75 DAS			90 DAS		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0.127	0.121	0.124	0.146	0.140	0.143	0.224	0.219	0.222	0.201	0.197	0.199	0.195	0.187	0.191
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0.125	0.118	0.122	0.136	0.132	0.134	0.221	0.214	0.218	0.198	0.193	0.196	0.186	0.178	0.182
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0.125	0.121	0.123	0.137	0.130	0.134	0.221	0.218	0.220	0.199	0.194	0.197	0.188	0.181	0.185
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0.137	0.122	0.130	0.149	0.141	0.145	0.221	0.224	0.223	0.205	0.199	0.202	0.198	0.190	0.194
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	0.154	0.151	0.153	0.173	0.163	0.168	0.258	0.248	0.253	0.220	0.216	0.218	0.218	0.202	0.210
T_6	Hand Weeding at 20 DAS	0.158	0.154	0.156	0.179	0.168	0.174	0.260	0.256	0.258	0.231	0.219	0.225	0.221	0.205	0.213
T_7	Control	0.153	0.148	0.151	0.169	0.162	0.166	0.257	0.242	0.250	0.227	0.216	0.222	0.211	0.192	0.202
	S.Em (±)	**0.0049**	**0.0046**	**0.0044**	**0.0064**	**0.0069**	**0.0047**	**0.0081**	**0.0071**	**0.0069**	**0.0043**	**0.0052**	**0.0042**	**0.0055**	**0.0034**	**0.0033**
	C.D (P=0.05)	**0.0152**	**0.0141**	**0.0129**	**0.0197**	**0.0212**	**0.0138**	**0.0249**	**0.0218**	**0.0201**	**0.0132**	**0.0161**	**0.0122**	**0.0169**	**0.0105**	**0.0097**

Table 4.53 Effect of WM treatments on dry weight of green gram nodule

Tr.	Treatment Details	Dry weight of nodule (g plant^{-1}) of green gram								
		30 DAS			45 DAS			60 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0.477	0.506	0.492	0.593	0.582	0.588	0.422	0.439	0.431
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0.467	0.495	0.481	0.582	0.572	0.577	0.413	0.428	0.421
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0.474	0.498	0.486	0.587	0.577	0.582	0.419	0.432	0.426
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0.489	0.533	0.511	0.614	0.617	0.616	0.431	0.443	0.437
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	0.582	0.603	0.593	0.657	0.678	0.668	0.479	0.481	0.480
T_6	Hand Weeding at 20 DAS	0.589	0.612	0.601	0.653	0.697	0.675	0.481	0.509	0.495
T_7	Control	0.578	0.599	0.589	0.646	0.681	0.664	0.473	0.478	0.476
	S.Em (±)	**0.0210**	**0.0192**	**0.0185**	**0.0101**	**0.0150**	**0.0101**	**0.0127**	**0.0113**	**0.0115**
	C.D (P=0.05)	**0.0648**	**0.0592**	**0.0541**	**0.0311**	**0.0463**	**0.0294**	**0.0392**	**0.0348**	**0.0337**

Table 4.54 Effect of WM treatments on dry weight of black gram nodule

Tr.	Treatment Details	Dry weight of nodule (g plant^{-1}) of black gram											
		30 DAS			45 DAS			60 DAS			75 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0.419	0.436	0.428	0.508	0.535	0.522	0.553	0.621	0.587	0.542	0.586	0.564
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0.405	0.428	0.417	0.496	0.515	0.506	0.539	0.611	0.575	0.531	0.579	0.555
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0.413	0.428	0.421	0.503	0.526	0.515	0.546	0.609	0.578	0.535	0.582	0.559
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0.432	0.459	0.446	0.518	0.563	0.541	0.586	0.632	0.609	0.556	0.594	0.575
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	0.516	0.527	0.522	0.584	0.622	0.603	0.593	0.678	0.636	0.593	0.632	0.613
T_6	Hand Weeding at 20 DAS	0.511	0.553	0.532	0.597	0.645	0.621	0.652	0.685	0.669	0.593	0.652	0.623
T_7	Control	0.504	0.519	0.512	0.589	0.618	0.604	0.597	0.666	0.632	0.588	0.621	0.605
	S.Em (±)	**0.0244**	**0.0329**	**0.0234**	**0.0264**	**0.0320**	**0.0268**	**0.0277**	**0.0201**	**0.0199**	**0.0158**	**0.0211**	**0.0162**
	C.D (P=0.05)	**0.0751**	**0.1013**	**0.0682**	**0.0814**	**0.0987**	**0.0783**	**0.0854**	**0.0619**	**0.0582**	**0.0487**	**0.0651**	**0.0472**

Like nodule number plant^{-1} application of chemical herbicides recorded significantly lower dry weight of nodule (g plant^{-1}) as compared with T_5, T_6 & T_7 in all the experiments during both year. Among the chemicals treatment T_2 (Quizalofop-ethyl 5 EC) recorded the minimum nodule dry weight value during both the year as well as in pooled.

The minimum nodule dry weight (g plant^{-1}) found in groundnut and soybean (pooled) by T_2 was 0.087 & 0.122 (30 DAS), 0.237 & 0.134 (45 DAS), 0.267 & 0.218 (60 DAS), 0.257 & 0.196 (75 DAS) and 0.251 & 0.182 (90 DAS). The corresponding figures for green gram was 0.481 (30 DAS), 0.577 (45 DAS) & 0.421 (60 DAS) and for black gram was 0.417 (30 DAS), 0.506 (45 DAS), 0.575 (60 DAS) & 0.555 (75 DAS). All the chemical herbicide treatment (T_1, T_2, T_3 and T_4) were statistically at par among them regarding nodule dry weight in case of all legume crops during both years as well as in pooled data.

Control treatment (T_7) also recorded significantly higher nodule dry weight than chemical applied treatment (T_1, T_2, T_3 and T_4).

4.2.3 Effect of weed management methods on Leghemoglobin content (mg g^{-1}) nodule

Leghemoglobin content (mg g^{-1}) of nodules was recorded at 15 days interval started from 30 DAS has been presented in Table 4.55 (groundnut), Table 4.56 (soybean), Table 4.57 (green gram) and Table 4.58 (black gram). From the Table, it was revealed that HW at 20 DAS (T_6) recorded significantly higher leghemoglobin content in comparison with chemical herbicide treatment for all legume crops during both the years as well as in pooled data. The maximum leghemoglobin content (mg g^{-1}) as pooled data by T_6 was 166.5 & 126.8 (30 DAS), 184.4 & 135.8 (45 DAS), 197.0 & 142.9 (60 DAS), 187.5 & 135.4 (75 DAS) and 183.2 & 134.9 (90 DAS) in groundnut and soybean respectively. The corresponding figures for green gram was 224.9 (30 DAS), 245.4 (45 DAS) & 195.4 (60 DAS) and for black gram was 183.6 (30 DAS), 199.0 (45 DAS), 207.5 (60 DAS) & 175.0 (75 DAS). T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) also recorded higher leghemoglobin value in all the stages and significantly not differ with T_6.

Table 4.55 Effect of WM treatments on leghemoglobin content of groundnut nodule

Tr.	Treatment Details	Leghemoglobin content (mg g^{-1}) of groundnut nodules														
		30 DAS			45 DAS			60 DAS			75 DAS			90 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	141.8	145.8	143.8	155.2	162.8	159.0	180.7	191.4	186.1	171.5	178.1	174.8	163.7	174.8	169.8
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	128.2	136.4	132.3	141.0	150.1	145.6	177.1	184.2	180.7	168.9	174.1	171.5	157.5	170.7	164.1
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	130.8	140.0	135.4	144.5	157.9	151.2	178.5	184.6	181.6	170.7	174.6	172.7	162.6	171.3	167.0
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	142.0	148.6	145.3	158.4	163.8	161.1	182.2	191.9	187.1	174.2	178.8	176.5	165.9	176.7	171.3
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	161.1	171.4	166.3	179.7	188.6	184.2	190.1	202.8	196.5	182.7	192.6	187.7	175.3	188.7	182.0
T_6	Hand Weeding at 20 DAS	161.6	171.4	166.5	179.9	188.9	184.4	190.2	203.7	197.0	183.1	191.9	187.5	176.9	189.5	183.2
T_7	Control	160.1	169.1	164.6	179.2	188.5	183.9	189.8	203.1	196.5	181.9	191.3	186.6	174.8	187.7	181.3
	S.Em (±)	**5.365**	**4.743**	**4.767**	**6.400**	**7.350**	**5.909**	**2.398**	**3.311**	**2.379**	**2.307**	**3.416**	**2.358**	**2.581**	**3.263**	**2.575**
	C.D (P=0.05)	**16.528**	**14.613**	**13.914**	**19.718**	**22.643**	**17.247**	**7.389**	**10.201**	**6.945**	**7.107**	**10.524**	**6.882**	**7.952**	**10.053**	**7.516**

Table 4.56 Effect of WM treatments on leghemoglobin content of soybean nodule

Tr.	Treatment Details	Leghemoglobin content (mg g^{-1}) of soybean nodules														
		30 DAS			45 DAS			60 DAS			75 DAS			90 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	114.8	109.4	112.1	122.1	115.1	118.6	134.5	132.9	133.7	127.9	125.1	126.5	123.1	121.3	122.2
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	110.7	105.9	108.3	116.5	111.6	114.1	131.8	130.2	131.0	124.2	122.8	123.5	115.2	112.7	114.0
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	112.1	107.9	110.0	118.4	113.8	116.1	132.1	131.3	131.7	125.6	123.2	124.4	118.3	116.3	117.3
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	115.1	109.7	112.4	122.4	117.9	120.2	137.7	133.9	135.8	128.3	125.7	127.0	124.2	121.1	122.7
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	129.5	123.5	126.5	137.9	132.8	135.4	145.4	139.5	142.5	135.0	134.3	134.7	135.7	132.8	134.3
T_6	Hand Weeding at 20 DAS	129.8	123.8	126.8	138.1	133.4	135.8	145.7	140.1	142.9	135.8	134.9	135.4	136.3	133.4	134.9
T_7	Control	127.9	123.1	125.5	137.8	132.6	135.2	145.3	139.8	142.6	135.5	133.8	134.7	135.3	132.6	134.0
	S.Em (±)	**4.082**	**3.936**	**4.150**	**4.876**	**4.683**	**4.869**	**2.019**	**1.904**	**1.796**	**2.075**	**1.693**	**1.478**	**3.373**	**3.651**	**3.535**
	C.D (P=0.05)	**12.576**	**12.127**	**12.113**	**15.021**	**14.429**	**14.212**	**6.219**	**5.867**	**5.241**	**6.392**	**5.217**	**4.315**	**10.391**	**11.249**	**10.318**

Table 4.57 Effect of WM treatments on leghemoglobin content of green gram nodule

Tr.	Treatment Details	Leghemoglobin content (mg g^{-1}) of green gram nodules								
		30 DAS			45 DAS			60 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	190.8	202.4	196.6	214.3	222.3	218.3	173.5	176.1	174.8
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	183.6	195.9	189.8	198.8	209.3	204.1	168.7	170.1	169.4
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	185.2	198.4	191.8	202.7	212.1	207.4	170.5	173.6	172.1
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	193.4	207.2	200.3	216.7	228.5	222.6	178.3	179.8	179.1
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	217.0	229.1	223.1	239.4	250.1	244.8	191.1	199.8	195.5
T_6	Hand Weeding at 20 DAS	217.9	231.9	224.9	240.7	250.1	245.4	192.0	198.8	195.4
T_7	Control	215.9	232.2	224.1	240.8	250.1	245.5	191.6	198.4	195.0
	S.Em (±)	**7.141**	**7.995**	**7.488**	**7.500**	**6.435**	**6.377**	**4.257**	**5.490**	**4.408**
	C.D (P=0.05)	**22.001**	**24.631**	**21.856**	**23.107**	**19.824**	**18.613**	**13.116**	**16.914**	**12.865**

Table 4.58 Effect of WM treatments on leghemoglobin content of black gram nodule

Tr.	Treatment Details	Leghemoglobin content (mg g^{-1}) of black gram nodules											
		30 DAS			45 DAS			60 DAS			75 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	141.1	146.6	143.9	167.4	172.5	170.0	168.9	182.9	175.9	143.8	141.7	142.8
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	128.7	139.8	134.3	150.1	159.1	154.6	156.3	160.1	158.2	135.6	138.6	137.1
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	135.1	142.0	138.6	159.6	161.5	160.6	160.9	166.1	163.5	137.1	138.6	137.9
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	145.3	149.0	147.2	169.7	176.9	173.3	171.8	183.8	177.8	145.6	149.4	147.5
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	178.0	183.2	180.6	186.6	196.9	191.8	205.4	201.4	203.4	170.3	176.5	173.4
T_6	Hand Weeding at 20 DAS	182.6	184.5	183.6	195.7	202.2	199.0	209.3	205.7	207.5	172.7	177.3	175.0
T_7	Control	177.6	180.8	179.2	194.9	198.4	196.7	206.1	204.9	205.5	169.3	175.9	172.6
	S.Em (±)	**7.244**	**8.146**	**7.336**	**7.003**	**6.798**	**6.400**	**9.664**	**6.144**	**6.117**	**7.252**	**7.991**	**7.574**
	C.D (P=0.05)	**22.319**	**25.098**	**21.412**	**21.574**	**20.943**	**18.679**	**29.772**	**18.929**	**17.854**	**22.342**	**24.618**	**22.106**

Application of chemical herbicides treatment (T_1, T_2, T_3 and T_4) recorded significantly lower leghemoglobin content in comparison with nonchemical treated plot in all legumes during both experimental years. T_1 (Imazethapyr 10 SL), T_2 (Quizalofop-ethyl 5 EC), T_3 (Fenoxaprop-p-ethyl 9 EC) and T_4 (Oxyfluorfen 23.5 EC) did not differ significantly among them in respect of nodule leghemoglobin content. The lowest leghemoglobin content (mg g^{-1}) for groundnut and soybean (pooled) were 132.3 & 108.3 (30 DAS), 145.6 & 114.1 (45 DAS), 180.7 & 131.0 (60 DAS), 171.5 & 123.5 (75 DAS) and 164.1 & 114.0 (90 DAS) recorded by T_2 (Quizalofop-ethyl 5 EC). The corresponding figures for green gram was 189.8 (30 DAS), 204.1 (45 DAS) & 169.4 (60 DAS) and for black gram was 134.3 (30 DAS), 154.6 (45 DAS), 158.2(60 DAS) & 137.1 (75 DAS).

The leghemoglobin content recorded by the control plot (T_7) was statistically at par with T_5 and T_6.

4.3 Studies on growth characters of legumes

4.3.1 Effect of weed management methods on plant height

Groundnut

Heights of the groundnut crop were recorded at 30DAS, 60 DAS, 90 DAS and at the time of the harvesting to determine the progress of the growth stages.

Data on plant height of groundnut have been presented in Table 4.59, from the recorded data; it appeared that the treatment differences were significant and spraying of herbicides had positive effect on plant height at all stages of crop growth.

At 30 DAS maximum plant height *i.e.* 14.63 cm (pooled) was recorded with T_6 treatment where HW was done at 20 DAS and minimum plant height *i.e.* 10.48 (pooled) was recorded in control (T_7). T_1 (Imazethapyr 10 SL) produced significantly taller plant (13.96 cm) than T_2, T_3, T_4, T_5 and T_6 and recorded at par result with T_6, during both 2009 & 2010.

At subsequent stages of crop growth (*i.e.* 60DAS) HW at 20 DAS (T_6) had positive and significant effect on plant height recorded (pooled) highest plant height (29.29 cm). There was no significant difference among the treatments T_1

(Imazethapyr 10 SL) and T_6 at 60 DAS. At this stage T_2 and T_3 treatments were statistically at par among themselves.

Almost similar trend was observed at 90DAS and harvesting of the crop. The maximum plant height (36.41 & 44.80 cm respectively) was recorded again by treatment T_6 where HW was done at 20DAS followed by T_1 (35.91 & 44.11 cm respectively) were statistically at par among themselves. T_4 treatment (Oxyfluorfen 23.5 EC @ 200 g ha^{-1}) was also recoded significantly higher plant height over T_2, T_3, T_5 and T_7. At 90DAS and harvesting the minimum plant height (26.37 & 31.15 cm respectively) was recorded from control (T_7). Other treatments, like T_2 (Quizalofop-ethyl 5 EC @ 50 g ha^{-1}) and T_3 (Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}) were recorded significantly higher plant height against untreated control (T_7).

Treatment where botanicals were applied *i.e.* T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) recorded higher plant height over control (T_7) at significant level during all the investigation stage of both 2009 & 2010 as well as in pooled data.

Soybean

The plant height of soybean presented in Table 4.60 showed significant variations among different treatment at all stages.

Plant heights were recorded at 30, 60, 90 DAS and at the time of harvesting. At 30 DAS maximum plant height was recorded from treatment T_6 (HW at 20 DAS) which was statistically at par with T_1 treatment (Imazethapyr 10 SL) during both the year as well as in pooled data. The plant height of soybean (cm) as pooled data by T_6 and T_1 were 16.64 & 15.79 (30 DAS), 43.26 & 42.69 (60 DAS), 57.07 & 55.46 (90 DAS) and 58.81 & 57.79 (harvesting) respectively. The minimum plant height (pooled) of soybean recorded by control (T_7). T_4 (Oxyfluorfen 23.5 EC @ 200 g ha^{-1}) recorded significantly taller plant over control (T_7) treatment throughout all observation time during both years. T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) recorded significantly higher plant height over control (T_7) during both experimental year.

Table 4.59 Effect of WM treatments on plant height of groundnut

Tr.	Treatment Details	Plant height (cm) of Groundnut											
		30 DAS			60 DAS			90 DAS			Harvest		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	13.64	14.27	13.96	27.83	29.40	28.62	34.52	37.29	35.91	42.84	45.38	44.11
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	12.14	12.59	12.37	24.05	25.18	24.62	30.34	32.47	31.41	37.35	38.96	38.16
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	12.02	12.67	12.35	23.95	25.11	24.53	30.03	32.09	31.06	37.37	38.83	38.10
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	12.95	13.58	13.27	26.07	28.00	27.04	33.27	35.19	34.23	40.15	41.88	41.02
T_5	*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*	11.36	11.87	11.62	22.08	22.89	22.49	28.65	29.59	29.12	33.71	34.92	34.32
T_6	Hand Weeding at 20 DAS	14.19	15.06	14.63	28.67	29.90	29.29	34.76	38.05	36.41	43.88	45.71	44.80
T_7	Control	9.97	10.39	10.18	19.62	21.03	20.33	25.32	27.42	26.37	30.93	31.36	31.15
	S.Em (±)	**0.376**	**0.436**	**0.343**	**0.517**	**0.417**	**0.484**	**0.392**	**0.652**	**0.375**	**0.817**	**1.106**	**0.759**
	C.D (P=0.05)	**1.159**	**1.343**	**1.002**	**1.592**	**1.284**	**1.413**	**1.207**	**2.008**	**1.095**	**2.517**	**3.406**	**2.216**

Table 4.60 Effect of WM treatments on plant height of soybean

Tr.	Treatment Details	Plant height (cm) of soybean											
		30 DAS			60 DAS			90 DAS			Harvest		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	16.59	14.99	15.79	44.88	40.50	42.69	57.75	53.17	55.46	59.41	56.17	57.79
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	15.54	14.14	14.84	38.72	35.66	37.19	52.01	47.47	49.74	53.62	49.04	51.33
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	16.31	14.71	15.51	39.37	35.93	37.65	52.17	48.53	50.35	53.84	50.08	51.96
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	16.43	14.83	15.63	42.53	38.83	40.68	54.60	50.96	52.78	56.05	52.83	54.44
T_5	*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*	15.25	13.81	14.53	37.32	34.24	35.78	51.21	45.93	48.57	52.85	47.33	50.09
T_6	Hand Weeding at 20 DAS	17.53	15.75	16.64	45.28	41.23	43.26	58.52	55.62	57.07	59.94	57.68	58.81
T_7	Control	13.89	12.45	13.17	35.55	32.61	34.08	48.07	42.41	45.24	49.26	44.26	47.76
	S.Em (±)	**0.331**	**0.290**	**0.283**	**0.557**	**0.536**	**0.546**	**0.991**	**0.712**	**0.701**	**1.054**	**0.993**	**0.939**
	C.D (P=0.05)	**1.021**	**0.893**	**0.826**	**1.716**	**1.651**	**1.595**	**3.053**	**2.194**	**2.047**	**3.248**	**3.059**	**2.741**

Green gram

The plant height of green gram recorded under different weed management methods showed a significant variation (Table 4.61). At 30 DAS, the maximum plant height (pooled) recorded under HW at 20 DAS (T_6) treatment closely followed by the PE application of Oxyfluorfen 23.5 EC (T_4) and POE Imazethapyr 10 SL (T_1) applied plot (20.68, 20.03 and 19.90 cm respectively).

At later stages of observation (45 DAS & 60 DAS) highest value was recorded from HW at 20DAS (T_6) treatment followed by Imazethapyr 10 SL (T_1). The plant height (pooled) recorded by T_6 and T_1 were 40.88 & 40.36 (45 DAS) and 59.91 & 58.61 (60 DAS) respectively. Oxyfluorfen 23.5 EC @ 200 g ha^{-1} (T_4) also showed higher plant height and statistically at par with T_1 at 45 DAS during both experimental years. The minimum green gram plant height was obtained from control (T_7) during all the investigation stage of both 2009 & 2010. The botanical applied treatment T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) and T_2 and T_3 produced significantly taller plant over untreated plot (T_7).

Black gram

The height of the black gram crop was recorded at 20 days interval starting from DAS and the data are presented in Table 4.62. The height of the plant increased gradually and it was significantly influenced by the weed management methods.

During all observation time the minimum plant height was recorded from untreated control (T_7) and maximum was recorded from HW at 20DAS (T_6) treatment, which did not varied significantly with the plant height of POE Imazethapyr 10 SL (T_1) treatment. The plant height (pooled) recorded by T_6 and T_1 were 12.18 & 11.61 (30 DAS), 46.57 & 45.93 (50 DAS), 53.44 & 52.18 (70 DAS) and 56.84 & 55.31 (harvesting) respectively. Treatment T_4 (Oxyfluorfen 23.5 EC) also recorded higher plant height over T_2, T_3, T_5 and T_7 at significant level and able to keep the third position according to superiority throughout the growth period. Treatments T_2 (Quizalofop-ethyl 5 EC) and T_3 (Fenoxaprop-p-ethyl 9 EC) were produced significantly higher plant height than PE *Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v* (T_5) treatment and control (T_7); in other hand the botanicals *i.e. Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v* (T_5) recorded significantly taller plant against T_7.

Table 4.61: Effect of WM treatments on plant height of green gram

Tr.	Treatment Details	Plant height (cm) of green gram								
		30 DAS			45 DAS			60 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	18.89	20.91	19.90	38.81	41.91	40.36	56.28	60.94	58.61
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	17.85	19.29	18.57	33.43	36.25	34.84	49.13	52.8	50.97
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	17.66	19.03	18.35	33.61	36.06	34.84	49.17	52.55	50.86
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	18.99	21.07	20.03	37.48	41.39	39.44	52.93	58.31	55.62
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	17.74	18.83	18.29	28.69	30.22	29.46	48.09	51.51	49.80
T_6	Hand Weeding at 20 DAS	19.67	21.69	20.68	39.05	42.70	40.88	57.46	62.36	59.91
T_7	Control	17.12	18.02	17.57	27.11	28.46	27.79	44.48	47.44	45.96
	S.Em (±)	**0.192**	**0.177**	**0.182**	**0.492**	**0.702**	**0.476**	**1.003**	**0.819**	**0.793**
	C.D (P=0.05)	**0.591**	**0.546**	**0.532**	**1.516**	**2.163**	**1.389**	**3.089**	**2.524**	**2.316**

Table 4.62 Effect of WM treatments on plant height of black gram

Tr.	Treatment Details	Plant height (cm) of black gram											
		30 DAS			50 DAS			70 DAS			Harvest		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	11.82	11.39	11.61	44.78	47.08	45.93	50.19	54.17	52.18	53.76	56.85	55.31
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	10.42	10.16	10.29	38.54	40.21	39.38	43.66	46.62	45.14	46.90	48.65	47.78
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	10.53	9.93	10.23	38.93	40.65	39.79	44.11	47.17	45.64	46.87	48.81	47.84
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	11.24	10.69	10.97	41.95	44.87	43.41	48.37	51.12	49.75	49.18	52.87	51.03
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% *v/v*	9.83	9.31	9.57	35.54	36.74	36.14	41.65	42.99	42.32	42.30	43.75	43.03
T_6	Hand Weeding at 20 DAS	12.28	12.08	12.18	45.32	47.82	46.57	50.95	55.92	53.44	54.79	58.88	56.84
T_7	Control	9.19	8.59	8.89	32.18	34.37	33.28	36.81	40.74	38.78	37.81	39.54	38.68
	S.Em (±)	**0.179**	**0.222**	**0.178**	**0.835**	**0.713**	**0.711**	**0.574**	**0.945**	**0.550**	**1.400**	**1.185**	**1.167**
	C.D (P=0.05)	**0.553**	**0.685**	**0.519**	**2.571**	**2.198**	**2.076**	**1.768**	**2.911**	**1.605**	**4.312**	**3.651**	**3.406**

4.3.2 Effect of weed management methods on LAI

Groundnut

Data on Leaf Area Index (LAI) of the groundnut crop recorded at 30 DAS, 60 DAS, 90 DAS have been presented in Table 4.63 revealed that LAI of groundnut crop gradually increased with the progress of the growth up to 60 DAS.

At 30 DAS LAI of the groundnut crop ranged from 0.172 to 0.243 (pooled); the lowest value was recorded from control (T_7) and the highest value was recorded from treatment T_6 (HW at 20DAS) followed by T_1 (0.239) where POE Imazethapyr 10 SL was applied @ 100 g ha^{-1}. T_6 and T_1 treatments were statistically at par at this stage. Other treatments produced higher LAI over the T_7. Treatment T_2, T_3, T_4 and T_5 were statistically at par among themselves.

At 60 and 90 DAS, almost similar trend was noticed like former observation, again the treatment T_6 (HW at 20DAS) recorded the highest LAI. Next highest value of LAI was observed in T_1 (Imazethapyr 10 SL). The LAI value recorded by T_6 and T_1 were 2.637 & 2.590 (60 DAS) and 2.209 & 2.105 (90 DAS) respectively. *Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v* (T_5) showed higher LAI values against control (T_7) at significant level. During these two stages T_4 (Oxyfluorfen 23.5 EC) recorded significantly higher LAI than T_2, T_3, T_5 and T_7. Treatments T_2 (Quizalofop-ethyl 5 EC) and T_3 (Fenoxaprop-p-ethyl 9 EC) were also produced statistically higher LAI against T_5 and T_7.

Soybean

Data on Leaf Area Index (LAI) is an important production capacity factor of a crop. LAI was determined at three occasions, first at 30 DAS second at 60 DAS and finally at 90 DAS during both experimental year (presented in Table 4.64).

The lowest LAI value at 30 DAS was recorded in treatment T_7 and the highest value was recorded in T_6 treatment (HW at 20DAS) were 0.313 & 0.444 respectively (pooled). T_1 (Imazethapyr 10 SL @ 100 g ha^{-1}) was also recorded promising results (0.435) which were also statistically at par with T_6 treatment.

At 60 DAS and 90 DAS, treatments T_6 (HW at 20DAS), T_1 (Imazethapyr 10 SL) and T_4 (Oxyfluorfen 23.5 EC) recorded the same trend. Maximum LAI value recorded from treatment T_6, and T_1 gave the next highest value in other hand T_4 (Oxyfluorfen 23.5 EC) hold third position regarding superiority was also recorded significantly higher LAI value against rest of the treatments (T_2, T_3, T_5 and T_7). The minimum LAI obtained from control (T_7) treatment. Treatments T_2 (Quizalofop-ethyl 5 EC @ 50 g ha^{-1}) and T_3 (Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}) also obtained promising LAI value and proved their efficiency over control (T_7). The LAI obtained from *Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v* (T_5) treatment was higher than T_7 at significant level.

Green gram

Leaf Area Index (LAI) of the green gram crop recorded at three stages of crop growth *i.e.* 30, 45, 60 DAS and presented in the Table 4.65. LAI of the green gram crop continued to increase up to certain stages of crop growth and there after began to fall at a slower rate.

Data at 30 DAS showed that the maximum LAI was recorded in the treatment T_6 (HW at 20 DAS) that was followed by T_1 (Imazethapyr 10 SL @ 100 g ha^{-1}) treatment and statistically at par among them. Other treatments T_2, T_3 and T_4 produced significantly higher LAI value than rest of the treatments. Control (T_7) showed the lowest LAI.

In case of other two stages *i.e.* at 45 DAS and 60 DAS here also treatment T_6 (HW at 20 DAS) recorded the highest and T_7 recorded the lowest LAI value during both year of experimentation as well as in pooled data. T_1 (Imazethapyr 10 SL) also showed promising result regarding this parameter and found at par with T_6 treatment. Oxyfluorfen 23.5 EC (T_4) recorded the third highest value of LAI during both 2009 & 2010 and pooled data. Treatments T_2 (Quizalofop-ethyl 5 EC), T_3 (Fenoxaprop-p-ethyl 9 EC) and T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) also showed higher LAI value against control (T_7).

Black gram

The cultivated summer black gram crop was treated with different weed management practices, observations on LAI at 30, 50, and 70 DAS were significant (Table 4.66).

At 30 DAS, lowest value was recorded in treatment T_7 (control) and the highest value was recorded in treatment T_6 (HW at 20 DAS). T_1 (Imazethapyr 10 SL @ 100 g ha^{-1}) also recorded promising results which was also statistically at par with T_6. Treatments where PE Oxyfluorfen 23.5 EC (T_4) and POE Quizalofop-ethyl 5 EC (T_2) and Fenoxaprop-p-ethyl 9 EC (T_3) were applied produced higher LAI over rest of the treatment. Botanicals (T_5) also recorded higher LAI against control (T_7).

Table 4.63 Effect of WM treatments on LAI of groundnut

Tr.	Treatment Details	Leaf Area Index (LAI) of groundnut								
		30 DAS			60 DAS			90 DAS		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0.234	0.243	0.239	2.516	2.663	2.590	2.066	2.144	2.105
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0.189	0.199	0.194	2.062	2.162	2.112	1.713	1.780	1.747
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0.189	0.196	0.193	2.025	2.120	2.073	1.667	1.739	1.703
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0.199	0.207	0.203	2.262	2.478	2.370	1.780	1.969	1.875
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	0.173	0.181	0.177	1.874	1.943	1.909	1.544	1.599	1.572
T_6	Hand Weeding at 20 DAS	0.238	0.248	0.243	2.551	2.722	2.637	2.161	2.257	2.209
T_7	Control	0.168	0.175	0.172	1.611	1.735	1.673	1.292	1.361	1.327
	S.Em (±)	**0.0125**	**0.0122**	**0.0125**	**0.0792**	**0.0568**	**0.0569**	**0.0867**	**0.0540**	**0.0475**
	C.D (P=0.05)	**0.0386**	**0.0377**	**0.0364**	**0.2441**	**0.1749**	**0.1661**	**0.2671**	**0.1664**	**0.1385**

Table 4.64 Effect of WM treatments on LAI of soybean

Tr.	Treatment Details	Leaf Area Index (LAI) of soybean								
		30 DAS			60 DAS			90 DAS		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0.443	0.427	0.435	4.841	4.587	4.714	3.909	3.753	3.831
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0.363	0.345	0.354	3.929	3.759	3.844	3.245	3.115	3.180
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0.357	0.343	0.350	3.854	3.692	3.773	3.170	3.028	3.099
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0.381	0.361	0.371	4.504	4.124	4.314	3.568	3.236	3.402
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	0.330	0.314	0.322	3.532	3.416	3.474	2.915	2.807	2.861
T_6	Hand Weeding at 20 DAS	0.451	0.437	0.444	4.906	4.704	4.805	4.159	3.899	4.029
T_7	Control	0.319	0.307	0.313	3.117	2.901	3.009	2.446	2.312	2.379
	S.Em (±)	**0.0221**	**0.0237**	**0.0224**	**0.1068**	**0.1487**	**0.1034**	**0.1093**	**0.1343**	**0.1022**
	C.D (P=0.05)	**0.0681**	**0.0729**	**0.0653**	**0.3291**	**0.4582**	**0.3017**	**0.3367**	**0.4139**	**0.2984**

Table 4.65 Effect of WM treatments on LAI of green gram

Tr.	Treatment Details	Leaf Area Index (LAI) of green gram								
		30 DAS			45 DAS			60 DAS		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	3.235	3.357	3.296	4.342	4.569	4.456	3.979	4.086	4.033
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	2.613	2.749	2.681	3.560	3.708	3.634	3.301	3.409	3.355
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	2.613	2.708	2.661	3.496	3.635	3.566	3.211	3.329	3.270
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	2.751	2.807	2.779	4.172	4.416	4.294	3.426	3.747	3.587
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	2.392	2.501	2.447	3.237	3.337	3.287	3.279	3.369	3.324
T_6	Hand Weeding at 20 DAS	3.290	3.425	3.358	4.484	4.643	4.564	3.991	4.197	4.094
T_7	Control	2.323	2.418	2.371	2.925	3.122	3.024	2.873	2.992	2.933
	S.Em (±)	**0.1209**	**0.1386**	**0.1100**	**0.0711**	**0.0553**	**0.0568**	**0.1668**	**0.1123**	**0.1137**
	C.D (P=0.05)	**0.3725**	**0.4269**	**0.3211**	**0.2191**	**0.1705**	**0.1658**	**0.5138**	**0.3461**	**0.3319**

Table 4.66 Effect of WM treatments on LAI of black gram

Tr.	Treatment Details	Leaf Area Index (LAI) of black gram								
		30 DAS			50 DAS			70 DAS		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0.495	0.516	0.506	3.216	3.407	3.312	2.522	2.615	2.569
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0.400	0.429	0.415	2.636	2.766	2.701	2.097	2.171	2.134
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0.400	0.416	0.408	2.588	2.713	2.651	2.045	2.121	2.083
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0.421	0.448	0.435	2.891	3.109	3.000	2.168	2.387	2.278
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	0.366	0.384	0.375	2.395	2.486	2.441	1.981	2.051	2.016
T_6	Hand Weeding at 20 DAS	0.504	0.527	0.516	3.377	3.671	3.524	2.645	2.701	2.673
T_7	Control	0.356	0.372	0.364	2.011	2.176	2.094	1.718	1.824	1.771
	S.Em (±)	**0.0183**	**0.0194**	**0.0178**	**0.1008**	**0.0958**	**0.0969**	**0.1104**	**0.0710**	**0.0697**
	C.D (P=0.05)	**0.0564**	**0.0599**	**0.0521**	**0.3107**	**0.2952**	**0.2827**	**0.3401**	**0.2187**	**0.2035**

Almost similar kind of results were found during 50 & 70 DAS, here also treatment T_6 (HW at 20 DAS) found best, followed by T_1 (Imazethapyr 10 SL) were statistically at par among themselves in both 2009 and 2010. Treatment T_4 (Oxyfluorfen 23.5 EC) also recorded better effect in respect of LAI value during this observation stage. As usual control plots (T_7) gave the lowest value of LAI during this observation period. T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) recorded significantly higher LAI value against control (T_7).

4.3.3 Effect of weed management methods on dry matter production of crop

Groundnut

Dry matter production or dry mass of different parts of plants gives a real picture of crop growth. It was measured at 30, 60, 90 DAS. Bio mass of the groundnut crop increased remarkably with the advancement age of the crop. Different methods of weed management had conspicuous and significant effect on dry matter production (Table 4.67)

At 30 DAS, 60 DAS and 90 DAS the dry matter production (g m^{-2}) by treatment T_6 (HW at 20 DAS) was maximum; whereas the next highest value regarding this parameter was recorded by T_1 (Imazethapyr 10 SL). The dry matter (g m^{-2}) produced by T_6 and T_1 (pooled) were 41.26 & 39.07 (30 DAS), 168.46 & 165.66 (60 DAS) and 281.84 & 278.74 (90 DAS) respectively. All the treatments receiving botanical in the form as *Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v* (T_5) showed higher dry matter production as compared with control (T_7). T_4 (Oxyfluorfen 23.5 EC) also gave higher dry matter value at significant level during all observation time in both 2009 and 2010. POE Quizalofop-ethyl 5 EC (T_2) and Fenoxaprop-p-ethyl 9 EC (T_3) also produced higher dry matter in respect of T_7 and T_5.

Soybean

Dry matter of the soybean was recorded at 30, 60, 90 DAS and presented in the Table 4.68

From the Table, it has been cleared that the treatment T_6 (HW at 20 DAS) gave always highest dry matter in comparison to other treatments at all the stages of the crop growth. Lowest value obtained from the T_7 (control) at every stages of data recording. T_1 (Imazethapyr 10 SL) recorded higher crop dry matter found at par with T_6. Among the other treatments, only T_4 (Oxyfluorfen 23.5 EC) showed to some extent consistence result at all the stages. Botanicals produced significantly higher dry matter against control (T_7).

Table 4.67 Effect of WM treatments on dry matter production of groundnut

Tr.	Treatment Details	Dry matter production of groundnut (g m^{-2})								
		30 DAS			60 DAS			90 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	38.21	39.92	39.07	161.94	169.38	165.66	269.82	287.65	278.74
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	33.65	35.48	34.57	135.07	141.63	138.35	228.65	244.34	236.50
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	33.98	35.24	34.61	133.70	139.96	136.83	225.90	241.73	233.82
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	35.17	36.87	36.02	149.14	157.52	153.33	253.19	266.91	260.05
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	31.94	33.28	32.61	130.61	134.97	132.79	212.38	229.21	220.80
T_6	Hand Weeding at 20 DAS	40.96	41.56	41.26	164.31	172.60	168.46	272.38	291.29	281.84
T_7	Control	29.44	30.58	30.01	116.20	124.15	120.18	193.81	209.86	201.84
	S.Em (±)	**1.845**	**1.512**	**1.509**	**4.069**	**3.493**	**3.473**	**4.983**	**6.087**	**4.139**
	C.D (P=0.05)	**5.683**	**4.657**	**4.405**	**12.538**	**10.762**	**10.137**	**15.351**	**18.752**	**12.082**

Table 4.68 Effect of WM treatments on dry matter production of soybean

Tr.	Treatment Details	Dry matter production of soybean (g m^{-2})								
		30 DAS			60 DAS			90 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	45.27	44.07	44.67	215.58	215.08	215.33	487.12	473.58	480.35
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	43.05	40.57	41.81	206.12	200.50	203.31	416.24	395.73	405.99
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	41.95	39.47	40.71	202.77	195.41	199.09	407.87	391.58	399.73
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	43.25	42.89	43.07	216.52	206.38	211.45	468.21	446.11	457.16
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	39.13	37.97	38.55	170.21	167.85	169.03	362.92	354.18	358.55
T_6	Hand Weeding at 20 DAS	46.67	45.49	46.08	222.00	213.56	217.78	495.63	478.81	487.22
T_7	Control	36.92	36.58	36.75	154.38	150.44	152.41	338.11	326.93	332.52
	S.Em (±)	**0.925**	**0.838**	**0.829**	**1.730**	**2.083**	**1.707**	**5.828**	**8.251**	**5.763**
	C.D (P=0.05)	**2.849**	**2.581**	**2.419**	**5.329**	**6.418**	**4.983**	**17.956**	**25.419**	**16.821**

Green gram

Total dry matter accumulation of the experimental green gram crop was recorded after 30 DAS and then consecutive 15 days of first observation (Table 4.69) during both the year of experimentation.

At first observation date the highest dry matter was obtained in T_6 *i.e.* HW at 20 DAS treatment closely followed by T_1 (Imazethapyr 10 SL @ 100 g ha^{-1}) treatment were statistically at par among them during both 2009 and 2010.

At later stages (45 and 60 DAS) of investigation similar trend was noticed like 30 DAS. At these time T_6 (HW at 20 DAS) recorded highest dry matter value and able to keep its position during both year as well as in pooled. Treatment T_1 (Imazethapyr 10 SL) also produced higher dry matter of green gram crop which was statistically at par with T_6. The dry matter (g m^{-2}) produced by T_6 and T_1 (pooled) were 45.77 & 43.34 (30 DAS), 234.86 & 229.89 (45 DAS) and 310.79 & 306.12 (60 DAS) respectively. T_4 (Oxyfluorfen 23.5 EC) also found better in respect of this parameter and gave significantly higher value against rest of the treatments. The lowest dry matter was showed by control (T_7) in all observation stage during both 2009 & 2010 as well as in pooled.

Black gram

The data pertaining to accumulation of dry matter at various growth stages of black gram were influenced significantly by different weed management methods during both the years as well as in pooled data (Table 4.70). Implication of weed management methods increased dry matter production at all stages of growth.

During all observation time (30, 50 & 70 DAS) HW at 20 DAS (T_6) recorded maximum dry matter accumulation (g m^{-2}) which was closely followed by T_1 (Imazethapyr 10 SL), were statistically at par among them. The dry matter (g m^{-2}) produced by T_6 and T_1 (pooled) were 35.41 & 33.41 (30 DAS), 184.71 & 180.88 (50 DAS) and 253.93 & 249.71 (70 DAS) respectively. Lowest value regarding dry matter accumulation was obtained from the T_7 (control) at every stages of data recording. T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) recorded significantly higher dry matter against control (T_7). Treatments where PE Oxyfluorfen 23.5 EC (T_4) and POE Quizalofop-ethyl 5 EC (T_2) & Fenoxaprop-p-ethyl 9 EC (T_3) were applied produced higher dry mass of black gram over T_5 & T_7.

Table 4.69 Effect of WM treatments on dry matter production of green gram

Tr.	Treatment Details	Dry matter production of green gram (g m^{-2})								
		30 DAS			45 DAS			60 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	42.42	44.26	43.34	225.03	234.75	229.89	298.14	314.09	306.12
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	37.34	39.32	38.33	190.53	201.36	195.95	253.21	268.38	260.80
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	37.73	39.07	38.40	188.54	199.33	193.94	250.03	265.32	257.68
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	39.02	40.17	39.60	204.46	222.62	213.54	277.26	291.82	284.54
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	33.22	34.68	33.95	175.08	178.44	176.76	230.09	235.31	232.70
T_6	Hand Weeding at 20 DAS	45.46	46.08	45.77	231.65	238.07	234.86	304.23	317.34	310.79
T_7	Control	32.67	33.91	33.29	161.37	172.11	166.74	204.24	219.54	211.89
	S.Em (±)	**1.045**	**1.167**	**1.045**	**3.445**	**3.648**	**3.104**	**6.966**	**7.142**	**6.793**
	C.D (P=0.05)	**3.219**	**3.596**	**3.049**	**10.614**	**11.238**	**9.061**	**21.461**	**22.003**	**19.827**

Table 4.70 Effect of WM treatments on dry matter production of black gram

Tr.	Treatment Details	Dry matter production of black gram (g m^{-2})								
		30 DAS			50 DAS			70 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	32.72	34.09	33.41	177.84	183.92	180.88	242.32	257.09	249.71
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	28.81	30.49	29.65	148.33	155.28	151.81	209.94	218.73	214.34
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	29.15	30.27	29.71	146.83	153.45	150.14	205.47	212.42	208.95
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	30.12	31.65	30.89	162.71	165.51	164.11	217.66	238.83	228.25
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	25.64	26.59	26.12	131.26	135.82	133.54	185.87	191.76	188.82
T_6	Hand Weeding at 20 DAS	35.09	35.72	35.41	179.78	189.63	184.71	247.83	260.02	253.93
T_7	Control	25.21	26.25	25.73	115.61	126.12	120.87	160.71	177.87	169.29
	S.Em (±)	**1.465**	**1.251**	**1.237**	**4.403**	**5.535**	**4.430**	**7.334**	**5.844**	**5.809**
	C.D (P=0.05)	**4.512**	**3.853**	**3.611**	**13.564**	**17.053**	**12.929**	**22.594**	**18.003**	**16.954**

4.3.4 Effect of weed management methods on Crop growth rate (CGR)

Groundnut

The Crop Growth Rate (CGR) of groundnut crop in different treatments was calculated after a fixed period of time irrespective of the previous growth rate. Here it is taken at 30-60 DAS and also at 60-90 DAS and presented in the Table 4.71

At 30-60 DAS the highest CGR value was recorded in the treatment T_6 (HW at 20 DAS) followed by T_1 (Imazethapyr 10 SL) and the lowest value recorded in the control (T_7) treatment. T_4 (Oxyfluorfen 23.5 EC) also produced significantly higher CGR value than other weed management treatment. Similar kind of result was also found in 60-90 DAS of investigation.

Soybean

At all observation stages (30-60 & 60-90 DAS) the highest CGR value were recorded in the treatment T_6 (HW at 20 DAS) which was statistically at par with T_1 (Imazethapyr 10 SL) and the lowest value recorded in the T_7 treatment (control) during both experimental year as well as in pooled data (Table 4.72). Other weed management treatments (T_2, T_3, T_4 & T_5) showed significantly higher CGR value against control (T_7).

From the recorded data revealed that there consistency of the treatments in the performance of results between two stages during both 2009 and 2010.

Green gram

HW at 20 DAS (T_6) recorded highest CGR value in 30-45 DAS during both the year of experiment as well as in pooled data (Table 4.73). T_1 recorded statistically at par result with T_6. At 45-60 DAS Imazethapyr 10 SL (T_1) gave highest CGR value closely followed by HW at 20 DAS (T_6) during both 2009 & 2010 and in pooled data. Oxyfluorfen 23.5 EC (T_4) showed significantly higher CGR over T_2, T_3, T_5 & T_7 in all stages of data recording.

Botanicals *i.e.* T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) recorded significantly higher CGR against control (T_7). The control (T_7) recorded lowest CGR value of green gram crop in all observation stage during both the years as well as in pooled data.

Table 4.71 Effect of WM treatments on CGR of groundnut

Tr.	Treatment Details	Crop growth rate (CGR) of Groundnut (g m^{-2} day^{-1})					
		30 – 60 DAS			60 – 90 DAS		
		2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	4.12	4.32	4.22	3.60	3.94	3.77
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	3.38	3.54	3.46	3.12	3.42	3.27
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	3.32	3.49	3.41	3.07	3.39	3.23
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	3.80	4.02	3.91	3.47	3.65	3.56
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	3.29	3.39	3.34	2.73	3.14	2.93
T_6	Hand Weeding at 20 DAS	4.11	4.37	4.24	3.60	3.96	3.78
T_7	Control	2.89	3.12	3.01	2.59	2.86	2.72
	S.Em (±)	**0.103**	**0.087**	**0.086**	**0.079**	**0.081**	**0.071**
	C.D (P=0.05)	**0.318**	**0.268**	**0.251**	**0.243**	**0.251**	**0.206**

Table 4.72 Effect of WM treatments on CGR of soybean

Tr.	Treatment Details	Crop growth rate (CGR) of Soybean (g m^{-2} day^{-1})					
		30 – 60 DAS			60 – 90 DAS		
		2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	5.68	5.70	5.69	9.05	8.62	8.83
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	5.44	5.33	5.38	7.00	6.51	6.76
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	5.36	5.20	5.28	6.84	6.54	6.69
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	5.78	5.45	5.61	8.39	7.99	8.19
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	4.37	4.33	4.35	6.42	6.21	6.32
T_6	Hand Weeding at 20 DAS	5.84	5.60	5.72	9.12	8.84	8.98
T_7	Control	3.92	3.80	3.86	6.12	5.88	6.00
	S.Em (±)	**0.038**	**0.046**	**0.037**	**0.142**	**0.216**	**0.144**
	C.D (P=0.05)	**0.116**	**0.142**	**0.109**	**0.437**	**0.665**	**0.421**

Table 4.73 Effect of WM treatments on CGR of green gram

Tr.	Treatment Details	Crop growth rate (CGR) of green gram (g m^{-2} day^{-1})					
		30 – 45 DAS			45 – 60 DAS		
		2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	12.17	12.70	12.44	4.87	5.29	5.08
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	10.21	10.80	10.51	4.18	4.47	4.32
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	10.05	10.68	10.37	4.10	4.40	4.25
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	11.03	12.16	11.60	4.85	4.61	4.73
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	9.46	9.58	9.52	3.67	3.79	3.73
T_6	Hand Weeding at 20 DAS	12.41	12.80	12.61	4.84	5.28	5.06
T_7	Control	8.58	9.21	8.90	2.86	3.16	3.01
	S.Em (±)	**0.276**	**0.266**	**0.275**	**0.189**	**0.194**	**0.136**
	C.D (P=0.05)	**0.851**	**0.819**	**0.803**	**0.583**	**0.598**	**0.398**

Table 4.74 Effect of WM treatments on CGR of black gram

Tr.	Treatment Details	Crop growth rate (CGR) of black gram (g m^{-2} day^{-1})					
		30 – 50 DAS			50 – 70 DAS		
		2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	7.26	7.49	7.37	3.22	3.66	3.44
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	5.98	6.24	6.11	3.08	3.17	3.13
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	5.88	6.16	6.02	2.93	2.95	2.94
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	6.63	6.69	6.66	2.75	3.67	3.21
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	5.28	5.46	5.37	2.73	2.80	2.76
T_6	Hand Weeding at 20 DAS	7.23	7.70	7.47	3.40	3.52	3.46
T_7	Control	4.52	4.99	4.76	2.26	2.59	2.42
	S.Em (±)	**0.167**	**0.248**	**0.168**	**0.103**	**0.133**	**0.105**
	C.D (P=0.05)	**0.513**	**0.765**	**0.489**	**0.316**	**0.409**	**0.307**

Black gram

CGR of black gram crop was analyzed at 30-50 and 50-70 DAS (Table 4.74). At both stage of data recording HW at 20 DAS (T_6) showed the highest value which was closely followed by Imazethapyr 10 SL (T_1) and Oxyfluorfen 23.5 EC (T_4) in both 2009 & 2010. Treatment T_7 (control) again produce minimum CGR value throughout the observation of black gram growth. POE Quizalofop-ethyl 5 EC (T_2) & Fenoxaprop-p-ethyl 9 EC (T_3) and PE botanicals (T_5) were produced significantly higher CGR over T_7.

4.3.5 Effect of weed management methods on root volume of crop

Groundnut

Root volume (g cc^{-1}) of the groundnut crop was recorded at 30, 45 and 60DAS and presented in Table 4. 75.

At 30 DAS maximum volume was recorded from the treatment T_6, where HW was done at 20 DAS closely followed by T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) during both the year of experiment. Among chemical herbicide treated plot maximum value was recorded from Oxyfluorfen 23.5 EC (T_4) treated plot. Lowest value recorded from the plot treated with Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1} (T_3) applied plot during both experimental year.

During next observation dates (45 & 60 DAS) again HW showed the highest value but T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) unable to prove its efficiency regarding this parameter. Treatment received Imazethapyr 10 SL (T_1) recorded significantly higher root volume was found statistically at par with T_6. Chemical herbicide treated plot recorded significantly higher root volume value than the botanical herbicide treated plot at this stage during both 2009 and 2010. The lowest root volume was recorded by control (T_7).

Soybean

Almost similar trend like groundnut has also observed during investigation of soybean root volume. Here also HW at 20 DAS (T_6) found highest at 30, 45 and 60 DAS (Table 4.76). At first stage of measurement T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) recorded higher root volume against T_1, T_2, T_3, T_4 & T_7.

At 30 and 45 DAS minimum volume of soybean root were observed from Fenoxaprop-p-ethyl 9 EC (T_3) applied plot, and at 60 DAS T_7 (Control) recorded the lowest during both experimental year. Imazethapyr 10 SL (T_1) recorded the next highest root volume value during both the year of experiment was also statistically at par with T_6.

From the data it has been observed that treatment where chemical herbicide was applied showed lower root growth initially but recovered in advancement of crop growth.

Green gram

Here HW at 20 DAS (T_6) found highest in all observation stage (30, 45 and 60 DAS) during both the year of experiment (Table 4.77). At 30 DAS Oxyfluorfen 23.5 EC (T_4) treated green gram crop recorded statistically at par root volume with HW treatment (T_6) and T_5, T_7 in both 2009 and 2010 as well as in pooled data. But at later observation stages T_4 produced significantly lower value than T_6. During 45 & 60 DAS Imazethapyr 10 SL (T_1) produced at par root volume with HW at 20 DAS (T_6). At this stage the minimum root volume was obtained from control (T_7).

At all stage of measurement T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) gave higher root volume than T_7 at significant level.

Black gram

Root volume of black gram was recorded at 30, 45 and 60 DAS. At 30 DAS highest root volume of black gram was noticed from HW at 20 DAS (T_6) treated plot which was statistically at par with T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) and Oxyfluorfen 23.5 EC (T_4) treatment during 2009 and 2010 and also in pooled data (Table 4.78).

At 45 and 60 DAS again HW at 20 DAS (T_6) treatment found superior over others and statistically at par with T_1. The lowest root volume was recorded from control (T_7). Treatments T_2, T_3, T_4 & T_5 also recorded significantly higher root volume against control (T_7).

Table 4.75 Effect of WM treatments on root volume of groundnut

Tr.	Treatment Details	Root volume (g cc^{-1}) of groundnut crop								
		30 DAS			45 DAS			60 DAS		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	1.093	1.140	1.117	1.927	2.020	1.974	2.985	3.227	3.106
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	1.089	1.134	1.112	1.817	1.936	1.877	2.797	2.912	2.855
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	1.075	1.130	1.103	1.811	1.928	1.870	2.737	2.884	2.811
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	1.273	1.334	1.304	1.826	1.943	1.885	2.821	2.972	2.897
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	1.317	1.368	1.343	1.619	1.721	1.670	2.367	2.674	2.521
T_6	Hand Weeding at 20 DAS	1.431	1.505	1.468	2.107	2.285	2.196	3.048	3.315	3.182
T_7	Control	1.306	1.365	1.336	1.512	1.617	1.565	2.187	2.447	2.317
	S.Em (±)	**0.0507**	**0.0550**	**0.0420**	**0.0546**	**0.0441**	**0.0442**	**0.0494**	**0.0703**	**0.0511**
	C.D (P=0.05)	**0.1562**	**0.1693**	**0.1334**	**0.1681**	**0.1359**	**0.1291**	**0.1521**	**0.2167**	**0.1491**

Table 4.76 Effect of WM treatments on root volume of soybean

Tr.	Treatment Details	Root volume (g cc^{-1}) of soybean crop								
		30 DAS			45 DAS			60 DAS		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0.596	0.538	0.567	1.662	1.574	1.618	2.683	2.654	2.669
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0.601	0.533	0.567	1.596	1.481	1.539	2.481	2.390	2.436
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0.593	0.525	0.559	1.589	1.473	1.531	2.437	2.395	2.416
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0.702	0.614	0.658	1.604	1.489	1.547	2.541	2.504	2.523
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	0.719	0.646	0.683	1.657	1.557	1.607	2.379	2.334	2.357
T_6	Hand Weeding at 20 DAS	0.724	0.652	0.688	1.729	1.635	1.682	2.702	2.669	2.686
T_7	Control	0.715	0.640	0.678	1.659	1.552	1.606	2.219	2.177	2.198
	S.Em (±)	**0.0328**	**0.0243**	**0.0242**	**0.0212**	**0.0192**	**0.0201**	**0.0431**	**0.0376**	**0.0379**
	C.D (P=0.05)	**0.1012**	**0.0749**	**0.0706**	**0.0653**	**0.0591**	**0.0586**	**0.1328**	**0.1157**	**0.1106**

Table 4.77 Effect of WM treatments on root volume of green gram

Tr.	Treatment Details	Root volume (g cc^{-1}) of green gram crop								
		30 DAS			45 DAS			60 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0.357	0.371	0.364	2.568	2.687	2.628	2.117	2.219	2.168
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0.354	0.366	0.360	2.344	2.469	2.407	2.068	2.135	2.102
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0.349	0.368	0.359	2.339	2.464	2.402	2.011	2.112	2.062
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0.413	0.435	0.424	2.454	2.568	2.511	2.051	2.179	2.115
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	0.427	0.444	0.436	2.215	2.355	2.285	1.882	2.034	1.958
T_6	Hand Weeding at 20 DAS	0.428	0.451	0.440	2.591	2.704	2.648	2.165	2.238	2.202
T_7	Control	0.424	0.443	0.434	2.120	2.265	2.193	1.797	1.914	1.856
	S.Em (±)	**0.0118**	**0.0199**	**0.0115**	**0.0331**	**0.0304**	**0.0319**	**0.0167**	**0.0102**	**0.0102**
	C.D (P=0.05)	**0.0364**	**0.0612**	**0.0337**	**0.1051**	**0.0938**	**0.0931**	**0.0513**	**0.0315**	**0.0297**

Table 4.78 Effect of WM treatments on root volume of black gram

Tr.	Treatment Details	Root volume (g cc^{-1}) of black gram crop								
		30 DAS			45 DAS			60 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0.331	0.344	0.338	2.138	2.274	2.21	2.504	2.714	2.609
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0.330	0.341	0.336	2.046	2.143	2.09	2.371	2.513	2.442
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0.327	0.342	0.335	2.031	2.140	2.09	2.449	2.525	2.487
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0.386	0.403	0.395	2.097	2.105	2.10	2.428	2.603	2.516
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	0.399	0.413	0.406	1.939	2.062	2.00	2.385	2.647	2.516
T_6	Hand Weeding at 20 DAS	0.409	0.415	0.412	2.161	2.312	2.24	2.546	2.782	2.664
T_7	Control	0.397	0.412	0.405	1.835	1.946	1.891	2.228	2.405	2.317
	S.Em (±)	**0.0136**	**0.0171**	**0.0138**	**0.0127**	**0.0344**	**0.0126**	**0.0242**	**0.0354**	**0.0251**
	C.D (P=0.05)	**0.0419**	**0.0527**	**0.0403**	**0.0391**	**0.1061**	**0.0368**	**0.0746**	**0.1092**	**0.0733**

4.3.6 Effect of weed management methods on phytotoxicity of legume crops

The observation regarding phytotoxicity study on the crop indicated that there was no phytotoxicity symptom in groundnut, soybean, green gram and black gram plant due to application of different herbicides. There was no evidence of phytotoxic symptoms as epinasty, hyponasty, leaf tp and surface injury, chlortic and necrotic symptoms on leaves and stunting growth of crop plants and stand loss and all the crop plants looked healthy in the experimental field during both years (Table 4.79 to 4.82).

4.4 Studies on yield

4.4.1 Effect of weed management methods on yield attributing characters of crop

4.4.1.1 Number of branches plant^{-1}

The number of branches plant^{-1} at harvesting as presented in Table 4.83 (groundnut) and Table 4.84 (soybean) revealed that the treatments T_6 (Here HW at 20 DAS) and T_1 (Imazethapyr 10 SL) recorded significantly higher number of branches in comparison to all other treatments and also found statistically at par among themselves. HW at 20 DAS (T_6) and Imazethapyr 10 SL (T_1) were recorded 12.68 & 12.54 (groundnut) and 8.21 & 8.13 (soybean) branches plant^{-1} respectively. The minimum branches plant^{-1} was obtained from control plot (T_7). Oxyfluorfen 23.5 EC (T_4) also showed better result in respect of this parameter recorded significantly values against T_2, T_3, T_5 & T_7. POE Quizalofop-ethyl 5 EC (T_2) & Fenoxaprop-p-ethyl 9 EC (T_3) and PE botanicals (T_5) were produced significantly higher branches plant^{-1} over T_7.

4.4.1.2 Pods plant^{-1}

Weed management treatments significantly influenced the number of pods plant^{-1} during both years of experiment and in pooled data has presented in Table 4.83 (groundnut), Table 4.84 (soybean), Table 4.85 (green gram) and Table 4.86 (black gram). Among different weed management practices, Here HW at 20 DAS (T_6) recorded significantly higher number of pods plant^{-1} (13.64 in groundnut, 39.14 in Soybean, 12.62 in green gram, 14.84 in black gram) closely followed by Imazethapyr 10 SL *i.e.* T_1 (13.28 in groundnut, 38.61 in soybean, 12.27 in green gram, 14.70 in black gram) were at par among them. Treatments receiving botanicals in the form of *Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v* (T_5) produced significantly higher number of pods plant^{-1} in respect of control (T_7). Oxyfluorfen 23.5 EC (T_4) recorded higher values in this respect than treatments T_2, T_3, T_5 & T_7 at significant level.

Table 4.79 Phytotoxicity in groundnut crops

Tr.	Treatment Details	2009 (DAS)																				
		Chlorosis			Necrosis			Tip burning			Wilting			Vein clearing			Epinasty			Hyponasty		
		10	20	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_6	Hand Weeding at 20 DAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_7	Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tr.	Treatment Details	2010 (DAS)																				
		Chlorosis			Necrosis			Tip burning			Wilting			Vein clearing			Epinasty			Hyponasty		
		10	20	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_6	Hand Weeding at 20 DAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_7	Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 4.80 Phytotoxicity in soybean crops

Tr.	Treatment Details	2009 (DAS)																				
		Chlorosis			Necrosis			Tip burning			Wilting			Vein clearing			Epinasty			Hyponasty		
		10	20	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_6	Hand Weeding at 20 DAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_7	Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tr.	Treatment Details	2010 (DAS)																				
		Chlorosis			Necrosis			Tip burning			Wilting			Vein clearing			Epinasty			Hyponasty		
		10	20	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_6	Hand Weeding at 20 DAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_7	Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 4.81 Phytotoxicity in green gram crops

Tr.	Treatment Details	2009 (DAS)																				
		Chlorosis			Necrosis			Tip burning			Wilting			Vein clearing			Epinasty			Hyponasty		
		10	20	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_6	Hand Weeding at 20 DAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_7	Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tr.	Treatment Details	2010 (DAS)																				
		Chlorosis			Necrosis			Tip burning			Wilting			Vein clearing			Epinasty			Hyponasty		
		10	20	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_6	Hand Weeding at 20 DAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_7	Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 4.82 Phytotoxicity in black gram crops

Tr.	Treatment Details	2009 (DAS)																				
		Chlorosis			Necrosis			Tip burning			Wilting			Vein clearing			Epinasty			Hyponasty		
		10	20	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_6	Hand Weeding at 20 DAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_7	Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Tr.	Treatment Details	2010 (DAS)																				
		Chlorosis			Necrosis			Tip burning			Wilting			Vein clearing			Epinasty			Hyponasty		
		10	20	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_6	Hand Weeding at 20 DAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_7	Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 4.83 Effect of WM treatments on yield attributing characters of groundnut

Tr.	Treatment Details	Yield attributes of groundnut											
		Branches plant^{-1}			Pod plant^{-1}			Seed pod^{-1}			Test weight		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	12.36	12.71	12.54	13.04	13.52	13.28	2.51	2.58	2.55	39.15	39.26	39.21
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	10.53	10.83	10.68	10.58	10.78	10.68	2.19	2.25	2.22	39.07	39.40	39.24
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	10.24	10.51	10.38	10.14	10.31	10.23	2.13	2.19	2.16	39.11	39.38	39.25
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	11.59	11.89	11.74	10.98	11.58	11.28	2.33	2.37	2.35	39.09	39.31	39.20
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	8.87	9.11	8.99	9.87	10.01	9.94	1.95	2.00	1.98	39.14	39.32	39.23
T_6	Hand Weeding at 20 DAS	12.48	12.87	12.68	13.35	13.92	13.64	2.56	2.61	2.59	39.08	39.24	39.16
T_7	Control	8.05	8.20	8.13	8.91	9.04	8.98	1.82	1.87	1.85	39.12	39.32	39.22
	S.Em (±)	**0.245**	**0.262**	**0.246**	**0.275**	**0.306**	**0.284**	**0.051**	**0.067**	**0.038**	**0.826**	**0.838**	**0.867**
	C.D (P=0.05)	**0.756**	**0.808**	**0.717**	**0.846**	**0.943**	**0.829**	**0.157**	**0.206**	**0.112**	**NS**	**NS**	**NS**

Table 4.84 Effect of WM treatments on yield attributing characters of soybean

Tr.	Treatment Details	Yield attributes of soybean											
		Branches plant^{-1}			Pod plant^{-1}			Seed pod^{-1}			Test weight		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	8.25	8.01	8.13	39.77	37.45	38.61	2.85	2.79	2.82	100.51	100.33	100.42
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	7.46	7.22	7.34	33.12	32.18	32.65	2.55	2.47	2.51	100.32	100.22	100.27
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	7.32	7.14	7.23	32.51	31.33	31.92	2.47	2.41	2.44	100.23	100.01	100.12
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	8.03	7.65	7.84	36.24	33.12	34.68	2.74	2.58	2.66	100.19	100.09	100.14
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	5.91	5.73	5.82	27.01	25.75	26.38	2.27	2.19	2.23	100.86	100.56	100.71
T_6	Hand Weeding at 20 DAS	8.34	8.08	8.21	40.24	38.04	39.14	2.89	2.81	2.85	100.08	100.02	100.05
T_7	Control	5.35	5.29	5.32	22.55	20.19	21.37	2.11	2.03	2.07	100.67	100.55	100.61
	S.Em (±)	**0.069**	**0.080**	**0.071**	**1.033**	**0.879**	**0.827**	**0.032**	**0.065**	**0.028**	**3.439**	**3.185**	**3.130**
	C.D (P=0.05)	**0.213**	**0.248**	**0.206**	**3.182**	**2.708**	**2.413**	**0.098**	**0.201**	**0.083**	**NS**	**NS**	**NS**

Table 4.85 Effect of WM treatments on yield attributing characters of green gram

Tr.	Treatment Details	Yield attributes of green gram								
		Pod plant^{-1}			Seed pod^{-1}			Test weight		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	11.63	12.91	12.27	8.53	8.79	8.66	28.21	28.39	28.30
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	9.27	10.31	9.79	7.49	7.62	7.56	28.13	28.37	28.25
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	8.89	9.87	9.38	7.24	7.45	7.35	28.16	28.35	28.26
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	10.29	11.62	10.96	7.87	8.06	7.97	28.18	28.35	28.27
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	8.51	9.38	8.95	6.73	6.92	6.83	28.17	28.31	28.24
T_6	Hand Weeding at 20 DAS	12.08	13.16	12.62	8.72	8.85	8.79	28.17	28.36	28.27
T_7	Control	7.81	8.64	8.23	6.03	6.25	6.14	28.15	28.31	28.23
	S.Em (±)	**0.218**	**0.231**	**0.227**	**0.167**	**0.210**	**0.174**	**0.678**	**0.702**	**0.679**
	C.D (P=0.05)	**0.672**	**0.713**	**0.663**	**0.513**	**0.648**	**0.509**	**NS**	**NS**	**NS**

Table 4.86 Effect of WM treatments on yield attributing characters of black gram

Tr.	Treatment Details	Yield attributes of black gram								
		Pod plant^{-1}			Seed pod^{-1}			Test weight		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	14.30	15.09	14.70	5.86	5.91	5.89	38.43	38.60	38.52
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	11.87	12.44	12.16	5.19	5.37	5.28	38.38	38.52	38.45
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	11.26	12.41	11.84	5.07	5.25	5.16	38.30	38.49	38.40
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	13.18	13.76	13.47	5.32	5.66	5.49	38.33	38.47	38.40
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	9.46	10.98	10.22	4.49	4.57	4.53	38.51	38.73	38.62
T_6	Hand Weeding at 20 DAS	14.47	15.21	14.84	5.90	5.98	5.94	38.31	38.43	38.37
T_7	Control	8.35	8.52	8.44	4.37	4.44	4.41	38.51	38.66	38.59
	S.Em (±)	**0.355**	**0.415**	**0.357**	**0.167**	**0.076**	**0.078**	**0.464**	**0.508**	**0.473**
	C.D (P=0.05)	**1.095**	**1.278**	**1.041**	**0.513**	**0.234**	**0.229**	**NS**	**NS**	**NS**

4.4.1.3 Kernels/Seeds pod^{-1}

The effect of different weed management methods on number of kernels/seeds pod^{-1} was found significant during both 2009 and 2010 as well as in pooled data (Table 4.83 for groundnut, Table 4.84 for soybean, Table 4.85 for green gram and Table 4.86 for black gram). The highest and lowest number of kernels/seeds pod^{-1} was observed from HW at 20 DAS (T_6) and control (T_7) applied plot respectively. Among the chemical herbicide treatments Imazethapyr 10 SL (T_1) recorded the maximum value and also gave at par result with T_6. The highest kernels/seeds pod^{-1} recorded from the T_6 were 2.59 (groundnut), 2.85 (soybean), 8.79 (green gram) and 5.94 (black gram). The corresponding figures for Imazethapyr 10 SL (T_1) treatment were 2.55 (groundnut), 2.82 (soybean), 8.66 (green gram) and 5.89 (black gram). Oxyfluorfen 23.5 EC (T_4) recorded significantly higher values regarding this parameter against T_2, T_3, T_5 & T_7. Treatments T_2 (Quizalofop-ethyl 5 EC), T_3 (Fenoxaprop-p-ethyl 9 EC) and T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) recorded significantly higher kernels/seeds pod^{-1} against control (T_7).

4.4.1.4 Test weight

All the treatments did not differ significantly among them in respect of test weight in all the four crops and in both years as well as in pooled data.

4.4.2 Effect of weed management methods on yield of crop

Different weed management methods exerted significant effect on increasing the yield of legume crops during both years of experimentation as well as in pooled data (Table 4.87 for groundnut, Table 4.88 for soybean, Table 4.89 for green gram and Table 4.90 for black gram). Among different weed management treatments HW at 20 DAS (T_6) recorded the highest seed yield and the lowest seed yield given by T_7 *i.e* control. The maximum and minimum seed yield (t ha^{-1}) recorded by these two treatments (pooled) were 1.65 & 0.73 (groundnut), 2.53 & 1.27 (soybean), 0.901 & 0.554 (green gram) and 1.008 & 0.575 (black gram) respectively. Among the chemical applied Imazethapyr 10 SL @ 100 g ha^{-1} (T_1) recorded the best result and also found statistically at par with T_6. The corresponding seed yield (t ha^{-1}) for T_1 were 1.59 (groundnut), 2.43 (soybean), 0.870 (green gram) and 0.941 (black gram) as per pooled data. Oxyfluorfen 23.5 EC (T_4) also recorded significantly higher seed yield against T_2, T_3, T_5 & T_7 in case of all legumes and able to hold third position in respect of this parameter in both 2009 & 2010 as well as in pooled.

Table 4.87 Effect of WM treatments on yield of groundnut and WCE

Tr.	Treatment Details	Pod Yield (t ha^{-1})			Kernel/Seed Yield (t ha^{-1})			Shelling %			WCE % 15 DAS			WCE % 30 DAS			WCE % 45 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	2.15	2.18	2.17	1.56	1.61	1.59	74.75	75.78	75.27	-	-	-	82.29	83.28	82.76	68.77	69.83	69.32
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	1.81	1.85	1.83	1.28	1.33	1.31	72.94	74.10	73.52	-	-	-	46.71	47.44	47.09	34.49	34.45	33.69
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	1.79	1.82	1.81	1.26	1.30	1.28	72.58	73.68	73.13	-	-	-	45.02	44.98	45.01	31.94	34.03	31.12
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	1.87	1.95	1.91	1.34	1.42	1.38	73.85	74.93	74.39	73.35	71.37	72.16	65.23	67.03	66.14	50.82	52.78	51.86
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	1.56	1.59	1.58	1.05	1.24	1.15	69.24	70.13	69.69	18.09	15.56	16.68	14.06	13.16	13.60	10.15	8.48	9.25
T_6	Hand Weeding at 20 DAS	2.21	2.27	2.24	1.61	1.68	1.65	74.96	75.92	75.44	-	-	-	86.01	84.86	85.37	72.30	71.75	72.00
T_7	Control	1.11	1.16	1.14	0.71	0.76	0.73	69.13	70.29	69.71	-	-	-	-	-	-	-	-	
	S.Em (±)	**0.080**	**0.069**	**0.072**	**0.067**	**0.072**	**0.067**	**0.275**	**0.264**	**0.224**	-	-	-	-	-	-	-	-	-
	C.D (P=0.05)	**0.247**	**0.212**	**0.209**	**0.207**	**0.223**	**0.195**	**0.846**	**0.812**	**0.653**	-	-	-	-	-	-	-	-	-

Table 4.88 Effect of WM treatments on yield of soybean and WCE

Tr.	Treatment Details	Seed Yield (t ha^{-1})			Stover Yield (t ha^{-1})			WCE % 15 DAS			WCE % 30 DAS			WCE % 45 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	2.48	2.37	2.43	3.58	3.42	3.50	-	-	-	83.80	82.46	83.07	60.61	61.10	60.97
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	1.81	1.73	1.77	2.76	2.61	2.69	-	-	-	40.28	49.42	45.08	33.10	30.52	31.70
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	1.78	1.69	1.74	2.69	2.54	2.62	-	-	-	37.94	46.99	42.68	31.73	27.87	29.66
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	2.31	2.19	2.25	3.41	3.22	3.32	64.22	62.68	63.36	61.17	60.74	61.71	45.00	46.70	45.88
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	1.58	1.52	1.55	2.24	2.11	2.18	17.68	17.70	17.70	12.42	12.97	12.70	11.78	9.59	9.53
T_6	Hand Weeding at 20 DAS	2.56	2.49	2.53	3.77	3.58	3.68	-	-	-	84.87	85.68	85.28	66.74	65.36	65.98
T_7	Control	1.29	1.25	1.27	1.98	1.86	1.92	-	-	-	-	-	-	-	-	-
	S.Em (±)	**0.049**	**0.056**	**0.051**	**0.055**	**0.063**	**0.052**	-	-	-	-	-	-	-	-	-
	C.D (P=0.05)	**0.151**	**0.174**	**0.148**	**0.168**	**0.193**	**0.152**	-	-	-	-	-	-	-	-	-

Table 4.89 Effect of WM treatments on yield of green gram and WCE

Tr.	Treatment Details	Seed Yield (t ha^{-1})			WCE %					
					15 DAS			30 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	0.846	0.892	0.870	-	-	-	82.30	81.94	82.07
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	0.649	0.673	0.662	-	-	-	40.48	42.14	41.38
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	0.631	0.654	0.642	-	-	-	37.93	39.85	38.99
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	0.796	0.826	0.811	69.52	68.58	69.06	64.15	62.08	62.47
T_5	*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*	0.592	0.628	0.611	17.57	19.30	18.53	11.66	14.42	13.17
T_6	Hand Weeding at 20 DAS	0.887	0.915	0.901	-	-	-	84.41	83.69	84.00
T_7	Control	0.524	0.562	0.544	-	-	-	-	-	-
	S.Em (±)	**0.0134**	**0.0205**	**0.0139**	-	-	-	-	-	-
	C.D (P=0.05)	**0.0413**	**0.0632**	**0.0406**	-	-	-	-	-	-

Table 4.90 Effect of WM treatments on yield of black gram and WCE

Tr.	Treatment Details	Seed Yield (t ha^{-1})			WCE %								
					15 DAS			30 DAS			45 DAS		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g a.i. /ha	0.887	0.994	0.941	-	-	-	81.63	81.29	81.39	63.79	64.19	63.99
T_2	Quizalofop-ethyl 5 EC @ 50 g a.i. /ha	0.732	0.801	0.767	-	-	-	42.95	47.47	45.50	35.89	37.14	37.02
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g a.i. /ha	0.725	0.791	0.758	-	-	-	40.72	46.40	43.96	34.16	34.46	32.87
T_4	Oxyfluorfen 23.5 EC @ 200 g a.i. /ha	0.812	0.891	0.852	64.24	66.82	65.51	58.29	60.25	59.37	45.67	43.77	44.66
T_5	*Calotropis* raw leaf extract @ 5% v/v + *Parthenium* raw leaf extract @ 5% v/v	0.673	0.731	0.702	14.54	15.38	14.88	13.28	14.05	13.73	11.29	10.32	10.76
T_6	Hand Weeding at 20 DAS	0.934	1.082	1.008	-	-	-	85.81	84.43	84.97	70.50	69.26	69.82
T_7	Control	0.551	0.599	0.575	-	-	-	-	-	-	-	-	-
	S.Em (±)	**0.0231**	**0.0307**	**0.0241**	-	-	-	-	-	-	-	-	-
	C.D (P=0.05)	**0.0712**	**0.0946**	**0.0703**	-	-	-	-	-	-	-	-	-

Treatments T_2 (Quizalofop-ethyl 5 EC), T_3 (Fenoxaprop-p-ethyl 9 EC) and T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*) recorded higher seed yield in comparison with control (T_7) at significant level.

Almost similar kind of result was also found in case of pod yield of groundnut and stover yield of soybean during both experimental years as well as in pooled data.

4.5 Studies on soil micro flora

Generally, it is found that microbial population was influenced with the application of herbicide chemicals. It is due to creation of favorable environment for microbial growth which ultimately improves soil health.

4.5.1 Effect of weed management methods on total bacteria (CFU x 10^6 g^{-1} of soil)

The soil bacterial population were counted at seven different stages *i.e.* initial, 10, 20, 30, 40, 50 DAS and at the time of harvesting has presented in Table 4.91 (groundnut), Table 4.92 (soybean), Table 4.93 (green gram) and Table 4.94 (black gram).

At initial stage of data recording all the treatments did not show any significant variation among them in both 2009 and 2010.

At 10 DAS marked decrease in bacteria population was recorded by treatment T_4, where Oxyfluorfen 23.5 EC was applied as PE. The minimum total bacteria (CFU x 10^6 g^{-1} of soil) population (pooled) was recorded by treatment T_4 were in groundnut (24.33), soybean (22.67), green gram (19.67) and black gram (20.17) at 10 DAS. Other treatments where botanicals *Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v* (T_5) was applied as PE did not show any variation on total bacteria population in comparison to all other treatments. The corresponding figures (pooled) for T_5 were 53.50 (groundnut), 51.17 (soybean), 44.17 (green gram) and 45.50 (black gram). At this stage of assessment other treatments were significantly similar.

During 20 DAS, reduction on bacteria population was also found in case of POE Imazethapyr 10 SL (T_1), Quizalofop-ethyl 5 EC (T_2) and Fenoxaprop-p-ethyl 9 EC (T_3) applied treatments during both experimental years as well as in pooled data. At this stage the minimum population of total bacteria were 21.83 (groundnut), 21.50 (soybean), 18.00 (green gram) and 18.50 (black gram) recorded by Oxyfluorfen 23.5 EC (T_4) treatment. All the treatments where chemical herbicides were applied for management of weed were recorded significantly lower total bacteria population against T_5, T_6 & T_7.

Table 4.91 Influence of WM treatments on total bacteria (CFU x 10^6 g^{-1} of soil) in groundnut

Tr.	Total bacteria (CFU x 10^6 g^{-1} of soil) in groundnut soil																				
	Initial			10 DAS			20 DAS			30 DAS			40 DAS			50 DAS			Harvest		
	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	50.33	55.33	52.83	51.67	56.33	54.00	22.33	27.67	25.00	19.00	24.33	21.67	18.33	23.33	20.83	29.33	34.67	32.00	72.00	77.00	74.50
T_2	48.67	56.33	52.50	51.33	56.67	54.00	22.00	27.00	24.50	20.33	25.33	22.83	19.33	24.00	21.67	23.33	28	25.67	67.33	72.67	70.00
T_3	49.67	56.33	53.00	51.67	56.67	54.17	22.00	27.33	24.67	20.67	25.67	23.19	19.67	24.33	22.00	23.67	28.67	26.17	68.00	73.67	70.84
T_4	49.33	56.67	53.00	22.33	26.33	24.33	19.33	24.33	21.83	18.46	23.33	20.90	27.67	32.33	30.00	39.33	44	41.67	69.33	74.67	72.00
T_5	50.33	56.00	53.17	50.67	56.33	53.50	51.67	57.67	54.67	52.24	58.00	55.12	52.67	59.33	56.00	53.67	59.67	56.67	55.00	60.00	57.50
T_6	50.33	55.67	53.00	50.33	56.33	53.33	51.33	57.33	54.33	52.05	57.67	54.86	52.67	59.00	55.84	53	58.67	55.84	54.67	60.00	57.34
T_7	49.00	55.67	52.34	48.33	53.33	50.83	48.33	54.67	51.50	49.71	55.67	52.69	50.33	56.67	53.50	50.67	56.33	53.50	52.67	57.33	55.00
S.Em (±)	2.582	3.139	3.102	0.548	0.602	0.512	0.712	0.801	0.722	0.747	0.952	0.785	0.874	1.142	0.878	0.799	0.959	0.760	0.602	0.727	0.576
C.D (P=0.05)	NS	NS	NS	1.689	1.854	1.495	2.195	2.467	2.108	2.301	2.934	2.291	2.694	3.517	2.564	2.461	2.954	2.217	1.854	2.241	1.682

Table 4.92 Influence of WM treatments on total bacteria (CFU x 10^6 g^{-1} of soil) in soybean

Tr.	Total bacteria (CFU x 10^6 g^{-1} of soil) in soybean soil																				
	Initial			10 DAS			20 DAS			30 DAS			40 DAS			50 DAS			Harvest		
	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	48.67	53.00	50.83	48.67	54.00	51.33	21.67	26.33	24.00	18.33	23.00	20.67	17.67	22.33	20.00	28.33	33.00	30.67	69.00	73.67	71.33
T_2	46.67	54.00	50.33	49.00	54.67	51.83	21.00	26.00	23.50	19.33	24.33	21.83	19.00	24.00	21.50	22.67	26.33	24.50	64.33	70.00	67.17
T_3	47.67	53.33	50.50	49.67	54.00	51.83	21.00	25.67	23.33	19.67	24.00	21.83	18.67	23.33	21.00	22.67	27.33	25.00	65.33	69.67	67.50
T_4	47.33	54.33	50.83	20.33	25.00	22.67	18.67	24.33	21.50	18.00	22.33	20.17	26.33	32.33	29.33	37.67	42.67	40.17	66.00	71.33	68.67
T_5	48.67	53.67	51.17	48.33	54.00	51.17	49.67	55.33	52.50	50.33	55.67	53.00	51.00	56.33	53.67	52.00	57.00	54.50	53.00	57.33	55.17
T_6	48.00	53.67	50.83	48.00	54.33	51.17	49.00	55.33	52.17	49.67	55.67	52.67	50.33	57.00	53.67	50.67	56.67	53.67	52.33	58.00	55.17
T_7	47.33	53.33	50.33	49.33	51.33	50.33	46.67	53.00	49.83	48.33	54.00	51.17	48.33	55.33	51.83	48.67	54.33	51.50	51.33	55.00	53.17
S.Em (±)	1.184	1.758	1.171	0.873	0.991	0.876	1.156	0.849	0.888	0.548	0.666	0.533	0.638	0.799	0.607	0.653	0.748	0.670	0.927	0.718	0.722
C.D (P=0.05)	NS	NS	NS	2.689	3.052	2.557	3.561	2.616	2.591	1.689	2.051	1.557	1.965	2.463	1.772	2.013	2.303	1.956	2.856	2.211	2.107

Table 4.93 Influence of WM treatments on total bacteria (CFU x 10^6 g^{-1} of soil) in green gram

Tr.	Total bacteria (CFU x 10^6 g^{-1} of soil) in green gram soil																				
	Initial			10 DAS			20 DAS			30 DAS			40 DAS			50 DAS			Harvest		
	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	41.67	46.00	43.83	42.00	46.67	44.33	18.33	23.00	20.67	16.00	20.00	18.00	15.33	19.33	17.33	24.33	28.67	26.50	61.00	65.67	63.33
T_2	40.00	46.67	43.33	42.00	47.33	44.67	17.67	22.00	19.83	16.67	21.00	18.83	16.33	20.67	18.50	19.00	23.33	21.17	55.33	60.67	58.00
T_3	41.00	46.33	43.67	42.33	46.67	44.50	18.00	22.33	20.17	16.67	20.67	18.67	16.00	20.33	18.17	19.33	24.00	21.67	56.00	60.33	58.17
T_4	40.33	47.00	43.67	17.67	21.67	19.67	16.00	20.00	18.00	15.00	19.67	17.33	22.67	27.00	24.83	33.00	36.00	34.50	57.00	62.33	59.67
T_5	41.67	46.33	44.00	41.67	46.67	44.17	42.67	48.00	45.33	43.33	48.00	45.67	43.67	49.00	46.33	44.33	49.33	46.83	45.33	49.67	47.50
T_6	41.33	46.67	44.00	41.33	47.00	44.17	42.00	48.00	45.00	42.67	48.33	45.50	43.33	49.33	46.33	43.33	49.00	46.17	45.00	50.00	47.50
T_7	40.33	46.33	43.33	40.00	44.33	42.17	40.00	45.67	42.83	41.00	46.33	43.67	41.67	47.33	44.50	41.67	47.00	44.33	42.67	49.00	45.83
S.Em (±)	**0.863**	**1.263**	**0.887**	**0.712**	**1.164**	**0.689**	**1.263**	**1.545**	**1.286**	**1.125**	**1.282**	**1.106**	**1.168**	**1.354**	**1.132**	**1.231**	**1.415**	**1.217**	**1.236**	**1.023**	**1.059**
C.D (P=0.05)	NS	NS	NS	**2.195**	**3.587**	**2.012**	**3.892**	**4.761**	**3.753**	**3.467**	**3.951**	**3.228**	**3.598**	**4.171**	**3.305**	**3.792**	**4.358**	**3.551**	**3.809**	**3.152**	**3.091**

Table 4.94 Influence of WM treatments on total bacteria (CFU x 10^6 g^{-1} of soil) in black gram

Tr.	Total bacteria (CFU x 10^6 g^{-1} of soil) in black gram soil																				
	Initial			10 DAS			20 DAS			30 DAS			40 DAS			50 DAS			Harvest		
	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	42.67	47.67	45.17	42.67	48.33	45.50	18.67	23.67	21.17	16.33	21.00	18.67	15.67	20.00	17.83	25.00	29.67	27.33	62.67	68.00	65.33
T_2	41.00	48.33	44.67	43.00	49.00	46.00	18.00	22.67	20.33	16.67	21.67	19.17	16.67	21.33	19.00	19.00	24.33	21.67	56.67	63.00	59.83
T_3	42.33	48.00	45.17	43.67	48.33	46.00	18.33	23.33	20.83	17.00	21.33	19.17	16.33	21.00	18.67	20.00	25.00	22.50	57.67	62.67	60.17
T_4	41.33	48.67	45.00	18.00	22.33	20.17	16.33	20.67	18.50	15.33	20.33	17.83	22.67	28.33	25.50	33.67	37.33	35.50	58.33	64.33	61.33
T_5	42.67	48.00	45.33	42.67	48.33	45.50	43.67	49.67	46.67	44.33	49.67	47.00	45.00	50.67	47.83	45.67	51.00	48.33	46.67	51.67	49.17
T_6	42.67	48.33	45.50	42.67	48.67	45.67	43.33	50.00	46.67	44.00	50.33	47.17	44.67	51.33	48.00	44.67	51.00	47.83	46.33	52.00	49.17
T_7	41.33	48.00	44.67	43.67	46.00	44.83	42.00	48.33	45.17	42.67	49.33	46.00	43.00	50.00	46.50	43.00	48.67	45.83	44.00	51.33	47.67
S.Em (±)	**1.497**	**1.629**	**1.549**	**1.044**	**1.251**	**1.031**	**1.617**	**1.830**	**1.469**	**1.786**	**1.876**	**1.810**	**1.919**	**2.017**	**1.863**	**2.258**	**2.559**	**2.334**	**1.383**	**1.142**	**1.142**
C.D (P=0.05)	NS	NS	NS	**3.216**	**3.854**	**3.009**	**4.982**	**5.637**	**4.288**	**5.501**	**5.779**	**5.283**	**5.912**	**6.214**	**5.437**	**6.958**	**7.883**	**6.812**	**4.261**	**3.519**	**3.332**

The population of total bacteria in case of Oxyfluorfen 23.5 EC (T_4) treatment decreased up to 30 DAS, after that it has increased and at the time of harvesting its value was significantly higher than T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*), T_6 (HW at 20 DAS) and T_7 (control) treatments. Similar result was also found in case of POE herbicide applied treatments. In case of Imazethapyr 10 SL (T_1) progressive increase in the population of total bacteria was found at 50 DAS whereas Quizalofop-ethyl 5 EC (T_2) and Fenoxaprop-p-ethyl 9 EC (T_3) increase bacteria population after 50 DAS. At the time of harvesting Imazethapyr 10 SL (T_1) recorded the highest significant total bacteria population over other treatment followed by Oxyfluorfen 23.5 EC (T_4). The higher total bacteria (CFU x 10^6 g^{-1} of soil) populations (pooled) were 74.50 & 72.00 (groundnut), 71.33 & 68.67 (soybean), 63.33 & 59.67 (green gram) and 65.33 & 61.33 (black gram) recorded by T_1 & T_4 respectively. Control (T_7) treatment produced the lowest population (55.00 in groundnut, 53.17 in soybean, 45.83 in green gram, 47.67 in black gram) at the time of harvesting as per pooled data. The total bacteria population recorded by botanicals (T_5) and HW (T_6) treatments were also found significantly lower than the population recorded by chemical herbicide treatments (T_1, T_2, T_3 and T_4) at harvesting during both 2009 & 2010.

4.5.2 Effect of weed management methods on Fungi (CFU x 10^4 g^{-1} of soil)

Population of fungi (CFU x 10^4 g^{-1} of soil) was assessed at different dates has been presented on Table 4.95 (groundnut), Table 4.96 (soybean), Table 4.97 (green gram) and Table 4.98 (black gram). Chemical herbicides initially reduce the fungi population but at harvesting stage they were found better as compared with control, HW and botanical herbicide treated plot.

The population of fungi (CFU x 10^4 g^{-1} of soil) at initial observation stage recorded non significant result but at 10 DAS, after application of Oxyfluorfen 23.5 EC (T_4) and *Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v* (T_5) showed significant variation in the *rhizosphere* soil. The fungi population of Oxyfluorfen 23.5 EC (T_4) applied plot was decreased from 10 DAS to 30 DAS and after that it has increased and at harvest stage recorded second highest value regarding this parameter. The population of fungi (CFU x 10^4 g^{-1} of soil) obtained from T_4 (pooled) were 21.83, 20.83, 23.33 & 24.17 (initial), 9.84, 8.67, 9.67 & 9.83 (10 DAS), 8.83, 8.50, 9.00 & 9.33 (20 DAS), 8.83, 7.83, 8.83 & 9.00 (30 DAS), 17.00, 15.83, 17.67 & 18.17 (40 DAS), 23.17, 21.50, 24.00 & 24.83 (50 DAS) and 39.84, 36.17, 41.50 & 42.67 (Harvesting) in groundnut, soybean, green gram and black gram respectively.

Treatments where POE chemical herbicides were applied *i.e.* Imazethapyr 10 SL (T_1), Quizalofop-ethyl 5 EC (T_2) and Fenoxaprop-p-ethyl 9 EC (T_3) also showed decreasing trend according to their persistency. At the time of harvest Imazethapyr 10 SL (T_1) resulted in a significant enhancement in the population of fungi in the *rhizosphere* soil over other treatments in both 2009 & 2010 in other hand lowest was obtained from T_7 (control) treatment. The population of fungi (CFU x 10^4 g^{-1} of soil) obtained from T_1 (pooled) were 22.00, 20.33, 22.83 & 23.67 (initial), 22.00, 20.50, 23.00 & 23.83 (10 DAS), 8.83, 8.17, 9.17 & 9.50 (20 DAS), 8.67, 8.00, 8.67 & 8.83 (30 DAS), 8.17, 7.67, 8.83 & 9.00 (40 DAS), 17.67, 16.67, 18.67 & 19.33 (50 DAS) and 41.33, 38.50, 43.17 & 45.33 (Harvesting) in groundnut, soybean, green gram and black gram respectively.

At harvesting the chemical weed management treatments (T_1, T_2, T_3 and T_4) recorded the higher population of fungi (CFU x 10^4 g^{-1} of soil) than rest of the non chemical applied treatments (T_5, T_6 and T_7) at significant level in both 2009 & 2010.

4.5.3 Effect of weed management methods on Actinomycetes (CFU x 10^5 g^{-1} of soil)

The population of Actinomycetes (CFU x 10^5 g^{-1} of soil) at *rhizosphere* soil as presented in Table 4.99 (groundnut), Table 4.100 (soybean), Table 4.101 (green gram) and Table 4.102 (black gram) revealed that at initial stage all the treatments did not differ significantly among them. At 10 DAS of population counting the PE Oxyfluorfen 23.5 EC (T_4) treatment was recorded reduced value and continued up to 30 DAS. At that time other treatments were did not differ significantly (T_1, T_2, T_3, T_5, T_6 and T_7).

During 20 DAS, POE chemical herbicide treatments *i.e.* Imazethapyr 10 SL (T_1), Quizalofop-ethyl 5 EC (T_2) and Fenoxaprop-p-ethyl 9 EC (T_3) also recorded in decreased actinomycetes population trend which continued up to 50 DAS. During 20, 30, 40 & 50 DAS, the actinomycetes population showed by the T_5 (*Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v*), T_6 (HW at 20 DAS) and T_7 (control) were almost similar in respect of initial reading and found statistically at per among them throughout the observation period.

Chemicals for soil micro flora analysis

Total bacteria population (CFU x 10^6 g^{-1} of soil)

Actinomycetes population (CFU x 10^5 g^{-1} of soil)

Fungi population (CFU x 10^4 g^{-1} of soil)

Plate 4.3 Analysis of soil micro flora

Table 4.95 Influence of WM treatments on Fungi (CFU x 10^4 g^{-1} of soil) in groundnut

Tr.	Fungi (CFU x 10^4 g^{-1} of soil) in groundnut soil																				
	Initial			10 DAS			20 DAS			30 DAS			40 DAS			50 DAS			Harvest		
	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	20.33	23.67	22.00	20.67	23.33	22.00	8.33	9.33	8.83	8.00	9.33	8.67	7.67	8.67	8.17	16.67	18.67	17.67	40.33	42.33	41.33
T_2	21.00	23.33	22.17	20.67	23.67	22.17	8.67	9.33	9.00	8.33	9.33	8.83	7.67	9.00	8.34	13.00	16.00	14.50	35.67	36.67	36.17
T_3	20.67	23.67	22.17	20.33	23.33	21.83	8.67	9.67	9.17	8.67	9.67	9.17	8.00	9.33	8.67	13.67	16.33	15.00	35.67	37.00	36.34
T_4	20.33	23.33	21.83	9.00	10.67	9.84	8.33	9.33	8.83	8.33	9.33	8.83	15.33	18.67	17.00	21.67	24.67	23.17	38.67	41.00	39.84
T_5	20.67	23.67	22.17	20.67	23.67	22.17	21.00	24.67	22.84	21.67	25.00	23.34	21.67	25.33	23.50	22.33	25.67	24.00	26.00	27.67	26.84
T_6	20.77	23.00	21.89	20.33	23.33	21.83	21.00	24.33	22.67	21.33	24.67	23.00	22.00	25.00	23.50	22.33	25.33	23.83	24.00	27.33	25.67
T_7	20.33	23.00	21.67	20.67	23.00	21.84	21.33	24.33	22.83	21.33	24.67	23.00	21.00	25.00	23.00	22.00	25.33	23.67	23.33	26.00	24.67
S.Em (±)	0.435	0.516	0.577	0.184	0.309	0.176	0.233	0.200	0.199	0.170	0.254	0.170	0.250	0.424	0.256	0.452	0.546	0.401	0.523	0.420	0.407
C.D (P=0.05)	NS	NS	NS	0.568	0.951	0.514	0.719	0.615	0.581	0.524	0.781	0.497	0.769	1.305	0.747	1.391	1.682	1.169	1.611	1.294	1.187

Table 4.96 Influence of WM treatments on Fungi (CFU x 10^4 g^{-1} of soil) in soybean

Tr.	Fungi (CFU x 10^4 g^{-1} of soil) in soybean soil																				
	Initial			10 DAS			20 DAS			30 DAS			40 DAS			50 DAS			Harvest		
	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	19.00	21.67	20.33	19.00	22.00	20.50	7.67	8.67	8.17	7.67	8.33	8.00	7.33	8.00	7.67	15.67	17.67	16.67	37.33	39.67	38.50
T_2	19.67	21.67	20.67	19.00	22.33	20.67	8.00	8.67	8.33	7.67	8.67	8.17	7.67	8.67	8.17	12.00	15.00	13.50	33.00	34.33	33.67
T_3	19.00	22.00	20.50	18.67	22.00	20.33	8.00	9.00	8.50	7.67	8.67	8.17	7.67	8.67	8.17	12.67	15.00	13.83	33.00	34.67	33.83
T_4	19.33	22.33	20.83	8.33	9.00	8.67	7.67	9.33	8.50	7.33	8.33	7.83	14.33	17.33	15.83	20.00	23.00	21.50	34.67	37.67	36.17
T_5	19.00	22.33	20.67	19.00	22.00	20.50	19.33	23.00	21.17	20.67	24.00	22.33	21.67	24.33	23.00	22.33	24.67	23.50	23.00	26.00	24.50
T_6	19.00	22.33	20.67	19.33	22.00	20.67	19.67	22.67	21.17	20.33	23.33	21.83	21.33	23.67	22.50	22.33	24.33	23.33	23.00	26.00	24.50
T_7	18.67	22.00	20.33	19.00	21.67	20.33	19.67	23.00	21.33	20.00	23.00	21.50	20.67	23.33	22.00	21.00	24.33	22.67	21.33	25.00	23.17
S.Em (±)	0.508	0.439	0.379	0.546	0.630	0.521	0.535	0.602	0.527	0.461	0.450	0.434	0.527	0.565	0.535	0.591	0.634	0.601	0.729	0.615	0.597
C.D (P=0.05)	NS	NS	NS	1.682	1.941	1.521	1.647	1.854	1.539	1.421	1.386	1.267	1.623	1.741	1.563	1.821	1.953	1.755	2.247	1.896	1.743

Table 4.97 Influence of WM treatments on Fungi (CFU x 10^4 g^{-1} of soil) in green gram

Tr.	Fungi (CFU x 10^4 g^{-1} of soil) in green gram soil																				
	Initial			10 DAS			20 DAS			30 DAS			40 DAS			50 DAS			Harvest		
	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	21.33	24.33	22.83	21.33	24.67	23.00	8.67	9.67	9.17	8.00	9.33	8.67	8.33	9.33	8.83	17.67	19.67	18.67	42.00	44.33	43.17
T_2	22.00	24.00	23.00	21.33	24.33	22.83	8.67	10.00	9.33	8.67	9.67	9.17	8.67	9.33	9.00	13.67	16.67	15.17	37.00	38.33	37.67
T_3	21.33	24.67	23.00	21.00	24.33	22.67	9.00	10.00	9.50	8.67	9.67	9.17	8.67	9.67	9.17	14.00	17.00	15.50	37.00	38.67	37.83
T_4	21.67	25.00	23.33	9.33	10.00	9.67	8.67	9.33	9.00	8.33	9.33	8.83	16.00	19.33	17.67	22.33	25.67	24.00	40.00	43.00	41.50
T_5	21.33	24.67	23.00	21.33	24.67	23.00	22.00	25.67	23.83	22.33	26.00	24.17	22.67	26.33	24.50	23.33	26.67	25.00	26.00	29.00	27.50
T_6	21.33	24.67	23.00	21.67	24.67	23.17	22.00	25.33	23.67	22.33	25.67	24.00	22.67	26.33	24.50	23.33	26.67	25.00	26.00	29.00	27.50
T_7	20.67	24.33	22.50	21.67	24.67	23.17	22.00	25.67	23.83	22.00	26.00	24.00	23.00	25.67	24.33	23.00	26.00	24.50	25.00	26.67	25.83
S.Em (±)	0.643	0.667	0.636	0.523	0.597	0.522	0.635	0.653	0.599	0.535	0.643	0.468	0.547	0.636	0.516	0.556	0.448	0.443	0.617	0.367	0.345
C.D (P=0.05)	NS	NS	NS	1.612	1.839	1.524	1.956	2.013	1.749	1.649	1.981	1.367	1.684	1.959	1.507	1.713	1.381	1.293	1.902	1.131	1.006

Table 4.98 Influence of WM treatments on Fungi (CFU x 10^4 g^{-1} of soil) in black gram

Tr.	Fungi (CFU x 10^4 g^{-1} of soil) in black gram soil																				
	Initial			10 DAS			20 DAS			30 DAS			40 DAS			50 DAS			Harvest		
	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	22.00	25.33	23.67	22.33	25.33	23.83	9.00	10.00	9.50	8.33	9.33	8.83	8.33	9.67	9.00	18.33	20.33	19.33	43.00	47.67	45.33
T_2	22.67	25.00	23.83	22.00	25.33	23.67	8.67	10.33	9.50	9.00	9.67	9.33	9.00	9.67	9.33	14.00	17.33	15.67	38.00	39.67	38.83
T_3	22.00	25.67	23.83	21.67	25.33	23.50	9.33	10.33	9.83	9.00	10.00	9.50	9.00	10.00	9.50	14.33	17.67	16.00	38.00	40.00	39.00
T_4	22.33	26.00	24.17	9.33	10.33	9.83	9.00	9.67	9.33	8.67	9.33	9.00	16.33	20.00	18.17	23.00	26.67	24.83	41.00	44.33	42.67
T_5	22.00	25.67	23.83	22.00	25.67	23.83	22.67	26.67	24.67	23.00	27.00	25.00	23.33	27.33	25.33	24.00	27.67	25.83	26.67	30.00	28.33
T_6	22.00	25.67	23.83	22.33	25.67	24.00	22.67	26.33	24.50	23.00	26.67	24.83	23.33	27.33	25.33	23.67	27.33	25.50	26.67	30.00	28.33
T_7	21.33	25.33	23.33	22.33	25.67	24.00	22.33	26.33	24.33	22.33	27.00	24.67	23.67	26.67	25.17	23.67	27.00	25.33	25.67	28.33	27.00
S.Em (±)	0.982	1.250	1.009	0.871	0.959	0.720	0.756	0.958	0.732	0.876	1.023	0.857	1.185	1.052	1.027	0.936	0.816	0.824	0.945	1.090	0.945
C.D (P=0.05)	NS	NS	NS	2.682	2.953	2.101	2.328	2.951	2.138	2.699	3.152	2.501	3.652	3.241	2.998	2.883	2.514	2.406	2.912	3.358	2.759

Table 4.99 Influence of WM treatments on Actinomycetes (CFU x 10^5 g^{-1} of soil) in groundnut

Tr.	Actinomycetes (CFU x 10^5 g^{-1}) in groundnut soil																				
	Initial			10 DAS			20 DAS			30 DAS			40 DAS			50 DAS			Harvest		
	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	75.33	78.00	76.67	75.67	78.33	77.00	38.33	40.00	39.17	37.67	38.67	38.17	37.33	37.67	37.50	52.33	53.33	52.83	113.33	115.00	114.17
T_2	76.33	77.67	77.00	76.33	78.33	77.33	39.00	41.00	40.00	38.00	39.33	38.67	37.67	38.67	38.17	47.67	48.00	47.84	105.00	106.00	105.50
T_3	75.67	77.67	76.67	75.67	78.00	76.84	38.67	40.33	39.50	38.33	39.33	38.83	37.67	39.33	38.50	47.33	49.00	48.17	106.33	108.67	107.50
T_4	76.00	78.33	77.17	38.67	39.33	39.00	37.67	39.00	38.34	37.33	38.00	37.67	51.33	53.00	52.17	60.00	61.67	60.84	109.67	111.00	110.34
T_5	76.33	78.00	77.17	76.33	77.67	77.00	77.00	79.33	78.17	77.33	79.67	78.50	77.67	80.67	79.17	78.00	81.00	79.50	81.67	82.67	82.17
T_6	75.67	78.00	76.84	76.00	78.00	77.00	76.67	79.00	77.84	77.00	79.67	78.34	77.33	80.33	78.83	77.67	80.67	79.17	81.00	82.33	81.67
T_7	75.00	78.33	76.67	75.67	78.67	77.17	76.33	79.00	77.67	77.00	79.33	78.17	77.33	79.67	78.50	77.67	80.33	79.00	79.33	81.67	80.50
S.Em (±)	**1.143**	**1.607**	**1.428**	**1.110**	**1.725**	**1.148**	**1.022**	**1.576**	**0.999**	**0.842**	**1.033**	**0.784**	**0.947**	**1.144**	**0.929**	**1.023**	**1.205**	**1.046**	**1.124**	**1.238**	**1.100**
C.D (P=0.05)	**NS**	**NS**	**NS**	**3.419**	**5.314**	**3.352**	**3.149**	**4.854**	**2.917**	**2.594**	**3.182**	**2.289**	**2.917**	**3.526**	**2.713**	**3.152**	**3.711**	**3.052**	**3.462**	**3.814**	**3.211**

Table 4.100 Influence of WM treatments on Actinomycetes (CFU x 10^5 g^{-1} of soil) in soybean

Tr.	Actinomycetes (CFU x 10^5 g^{-1}) in soybean soil																				
	Initial			10 DAS			20 DAS			30 DAS			40 DAS			50 DAS			Harvest		
	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	68.33	72.33	70.33	68.67	71.67	70.17	33.67	37.00	35.33	34.33	35.67	35.00	34.00	34.67	34.33	47.33	49.33	48.33	102.67	106.33	104.50
T_2	69.33	71.67	70.50	69.33	71.67	70.50	35.33	36.67	36.00	34.67	35.67	35.17	34.33	35.33	34.83	43.00	44.33	43.67	95.67	97.67	96.67
T_3	68.33	71.67	70.00	68.00	71.67	69.83	35.00	36.33	35.67	34.33	36.00	35.17	34.00	36.00	35.00	42.67	44.67	43.67	95.67	99.33	97.50
T_4	68.33	72.67	70.50	35.00	35.67	35.33	34.33	34.67	34.50	33.67	34.67	34.17	46.67	48.33	47.50	55.67	57.00	56.33	99.67	101.33	100.50
T_5	69.00	71.67	70.33	69.33	71.33	70.33	69.67	72.67	71.17	69.67	73.00	71.33	70.00	73.67	71.83	70.67	74.00	72.33	73.33	75.33	74.33
T_6	68.67	71.00	69.83	69.00	71.33	70.17	69.67	72.33	71.00	70.00	73.00	71.50	70.33	73.00	71.67	70.67	73.67	72.17	74.00	75.67	74.83
T_7	69.00	72.33	70.67	68.33	72.00	70.17	69.33	71.67	70.50	69.67	72.33	71.00	69.67	72.67	71.17	70.00	73.33	71.67	71.67	74.33	73.00
S.Em (±)	**0.870**	**1.293**	**0.872**	**1.252**	**1.523**	**1.261**	**1.133**	**1.294**	**1.141**	**0.987**	**1.028**	**0.945**	**0.891**	**0.913**	**0.888**	**0.871**	**0.946**	**0.887**	**0.968**	**1.544**	**0.984**
C.D (P=0.05)	**NS**	**NS**	**NS**	**3.856**	**4.691**	**3.681**	**3.492**	**3.988**	**3.329**	**3.041**	**3.167**	**2.759**	**2.746**	**2.813**	**2.591**	**2.682**	**2.914**	**2.588**	**2.981**	**4.756**	**2.871**

Table 4.101 Influence of WM treatments on Actinomycetes (CFU x 10^5 g^{-1} of soil) in green gram

Tr.	Actinomycetes (CFU x 10^5 g^{-1}) in green gram soil																				
	Initial			10 DAS			20 DAS			30 DAS			40 DAS			50 DAS			Harvest		
	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	72.00	75.00	73.50	72.33	75.33	73.83	37.00	38.67	37.83	36.00	40.67	38.33	35.67	36.33	36.00	50.00	51.67	50.83	108.00	110.67	109.33
T_2	73.00	74.67	73.83	73.00	75.00	74.00	37.33	38.67	38.00	36.33	40.67	38.50	36.00	37.33	36.67	45.33	46.67	46.00	100.67	102.67	101.67
T_3	72.00	75.00	73.50	71.67	75.00	73.33	37.00	39.00	38.00	36.33	41.33	38.83	36.00	37.67	36.83	45.00	47.00	46.00	100.67	104.33	102.50
T_4	72.33	74.67	73.50	37.00	37.33	37.17	36.00	37.33	36.67	35.67	39.67	37.67	49.00	50.67	49.83	58.00	58.33	58.17	104.67	106.00	105.33
T_5	73.00	75.00	74.00	73.00	74.67	73.83	73.33	76.00	74.67	73.33	80.00	76.67	73.67	77.00	75.33	74.33	77.67	76.00	77.33	79.00	78.17
T_6	72.33	74.67	73.50	72.67	74.67	73.67	73.33	76.00	74.67	73.67	79.67	76.67	74.00	76.67	75.33	74.33	77.00	75.67	77.67	79.33	78.50
T_7	72.00	74.33	73.17	72.67	75.00	73.83	72.67	75.67	74.17	73.33	79.33	76.33	73.67	76.33	75.00	73.67	76.67	75.17	75.33	77.67	76.50
S.Em (±)	1.588	2.216	1.575	1.483	1.921	1.424	1.240	1.465	1.216	1.075	1.280	0.993	1.498	1.624	1.473	1.586	1.432	1.388	1.033	1.484	1.022
C.D (P=0.05)	NS	NS	NS	4.568	5.918	4.157	3.821	4.512	3.548	3.311	3.942	2.899	4.615	5.002	4.298	4.886	4.413	4.051	3.182	4.571	2.983

Table 4.102 Influence of WM treatments on Actinomycetes (CFU x 10^5 g^{-1} of soil) in black gram

Tr.	Actinomycetes (CFU x 10^5 g^{-1}) in black gram soil																				
	Initial			10 DAS			20 DAS			30 DAS			40 DAS			50 DAS			Harvest		
	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	74.00	78.00	76.00	74.00	78.00	76.00	37.67	40.00	38.83	37.33	42.00	39.67	36.67	37.67	37.17	51.33	53.67	52.50	111.67	115.33	113.50
T_2	75.00	77.33	76.17	75.00	77.67	76.33	38.33	40.00	39.17	37.33	42.33	39.83	36.67	38.67	37.67	46.67	48.33	47.50	103.33	106.33	104.83
T_3	74.00	78.00	76.00	73.67	78.00	75.83	38.00	40.67	39.33	37.33	43.00	40.17	37.00	39.00	38.00	46.33	48.67	47.50	103.67	108.33	106.00
T_4	74.00	77.33	75.67	38.00	38.67	38.33	37.00	38.67	37.83	36.67	41.00	38.83	50.33	52.33	51.33	59.33	60.33	59.83	107.33	109.67	108.50
T_5	75.00	78.00	76.50	75.00	77.33	76.17	75.33	78.67	77.00	75.67	83.00	79.33	75.67	79.33	77.50	76.33	80.67	78.50	79.33	82.00	80.67
T_6	74.33	77.67	76.00	74.67	77.67	76.17	75.00	79.00	77.00	75.67	82.67	79.17	76.00	79.67	77.83	75.67	80.00	77.83	80.00	82.33	81.17
T_7	74.00	77.33	75.67	74.67	77.33	76.00	74.67	79.00	76.83	75.33	82.33	78.83	76.00	79.33	77.67	75.67	79.67	77.67	77.67	81.67	79.67
S.Em (±)	2.270	2.355	2.230	1.650	1.935	1.652	1.827	1.937	1.717	1.951	2.215	1.874	1.637	1.888	1.606	1.600	1.825	1.461	1.361	1.726	1.374
C.D (P=0.05)	NS	NS	NS	5.082	5.961	4.821	5.628	5.968	5.013	6.011	6.825	5.469	5.042	5.817	4.689	4.929	5.621	4.263	4.193	5.318	4.011

At the last stage of population counting it has observed that treatments receiving chemical herbicides recorded higher value as compared with others even from the initial stage. Imazethapyr 10 SL (T_1) treatment gave significantly highest actinomycetes population followed by Oxyfluorfen 23.5 EC (T_4) applied plot at harvest stage and lowest obtained from T_7 (control) treatment. The higher actinomycetes (CFU x 10^5 g^{-1} of soil) populations (pooled) were 114.17 & 110.34 (groundnut), 104.50 & 100.50 (soybean), 109.33 & 105.33 (green gram) and 113.50 & 108.50 (black gram) recorded by T_1 & T_4 respectively at harvesting.

4.6 Studies on residual effect in succeeding direct seeded rice crop

The population of direct seeded rice crop recorded at 15 DAS showed the range of 50.28 to 51.33 (groundnut, Table 4.103), 50.50 to 51.83 (soybean, Table 4.104), 49.56 to 50.78 (green gram Table 4.105) and 50.06 to 50.45 (black gram Table 4.106) as per pooled. The population density did not show any significant variation among the different treatments used in the previous groundnut, soybean, green gram and black gram crop grown during summer season.

The grain yield (t ha^{-1}) data ranges from (pooled) 3.55 to 3.82 (groundnut, Table 4.103), 3.41to 3.61 (soybean, Table 4.104), 3.81 to 3.98 (green gram Table 4.105) and 3.75 to 3.95 (black gram Table 4.106) also did not differ significantly among the treatments where the different weed management methods were applied in previous experiments. Similar kind of results was also found in straw yield of direct seeded rice.

4.6 Studies on economics

Data pertaining to economics of weed management during 2009 and 2010 and also their mean data has been presented in Table 4.107 (groundnut), Table 4.108 (soybean), Table 4.109 (green gram) and Table 4.110 (black gram). The maximum net return (mean) of Rs. 53584 ha^{-1} (groundnut), Rs. 41925 ha^{-1} (soybean), Rs. 18185 ha^{-1} (green gram) and Rs. 21300 ha^{-1} (black gram) was recorded in POE application of Imazethapyr 10 SL (T_1) treatment followed by T_6 (HW at 20 DAS). The corresponding figures for T_6 were Rs. 51619 ha^{-1} (groundnut), Rs. 39660 ha^{-1} (soybean), Rs. 14660 ha^{-1} (green gram) and Rs. 19215 ha^{-1} (black gram). Oxyfluorfen 23.5 EC (T_4) also recorded higher net return in comparison with other weed management treatments; there was mean Rs. 41694, Rs. 35935, Rs. 14335 and Rs. 16250 were found in groundnut, soybean, green gram and black gram respectively.

Table 4.103 Population and yield of follow up DS Rice in groundnut experiment

Tr.	Treatment Details	Population m^{-2} at 15 DAS			Grain Yield ($t\ ha^{-1}$)			Straw Yield ($t\ ha^{-1}$)		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	50.67	49.89	50.28	3.89	3.68	3.79	5.91	5.47	5.69
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	51.44	50.11	50.78	3.69	3.49	3.59	5.79	5.28	5.54
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	50.89	50.33	50.61	3.71	3.52	3.62	5.82	5.32	5.57
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	50.56	50.78	50.67	3.78	3.54	3.66	5.85	5.34	5.60
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	51.44	51.22	51.33	3.67	3.51	3.59	5.76	5.16	5.46
T_6	Hand Weeding at 20 DAS	50.78	51.11	50.95	4.06	3.57	3.82	6.14	5.29	5.72
T_7	Control	51.33	49.89	50.61	3.64	3.45	3.55	5.73	5.19	5.46
	S.Em (±)	**1.142**	**1.284**	**1.091**	**0.457**	**0.398**	**0.361**	**0.648**	**0.689**	**0.582**
	C.D (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 4.104 Population and yield of follow up DS Rice in soybean experiment

Tr.	Treatment Details	Population m^{-2} at 15 DAS			Grain Yield ($t\ ha^{-1}$)			Straw Yield ($t\ ha^{-1}$)		
		2009	**2010**	**Pooled**	**2009**	**2010**	**Pooled**	**2009**	**2010**	**Pooled**
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	51.78	50.33	51.06	3.79	3.38	3.59	5.89	5.31	5.60
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	52.22	51.44	51.83	3.81	3.41	3.61	5.46	5.42	5.44
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	49.89	51.11	50.50	3.56	3.36	3.46	5.76	5.16	5.46
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	50.44	51.56	51.00	3.75	3.42	3.59	5.61	5.34	5.48
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	51.56	50.78	51.17	3.61	3.29	3.45	5.69	5.41	5.55
T_6	Hand Weeding at 20 DAS	50.89	51.33	51.11	3.68	3.21	3.45	5.62	5.72	5.67
T_7	Control	51.11	51.89	51.50	3.58	3.24	3.41	5.58	5.39	5.49
	S.Em (±)	**1.214**	**1.367**	**1.105**	**0.521**	**0.486**	**0.451**	**0.682**	**0.575**	**0.543**
	C.D (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 4.105 Population and yield of follow up DS Rice in green gram experiment

Tr.	Treatment Details	Population m^{-2} at 15 DAS			Grain Yield ($t\ ha^{-1}$)			Straw Yield ($t\ ha^{-1}$)		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	50.33	48.78	49.56	4.05	3.76	3.91	5.66	5.25	5.46
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	51.67	48.89	50.28	3.79	3.89	3.84	5.30	5.48	5.39
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	51.44	49.22	50.33	3.95	3.71	3.83	5.62	5.27	5.45
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	51.22	49.44	50.33	4.02	3.67	3.85	5.58	5.16	5.37
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	51.89	49.67	50.78	3.89	3.72	3.81	5.47	5.13	5.30
T_6	Hand Weeding at 20 DAS	50.89	48.78	49.84	4.11	3.84	3.98	5.82	5.33	5.58
T_7	Control	50.78	48.89	49.84	3.84	3.78	3.81	5.39	5.35	5.37
	S.Em (±)	**1.351**	**1.227**	**1.119**	**0.428**	**0.479**	**0.413**	**0.574**	**0.561**	**0.486**
	C.D (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 4.106 Population and yield of follow up DS Rice in black gram experiment

Tr.	Treatment Details	Population m^{-2} at 15 DAS			Grain Yield ($t\ ha^{-1}$)			Straw Yield ($t\ ha^{-1}$)		
		2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
T_1	Imazethapyr 10 SL @ 100 g ha^{-1}	51.22	49.33	50.28	4.13	3.76	3.95	5.81	5.19	5.50
T_2	Quizalofop-ethyl 5 EC @ 50 g ha^{-1}	50.89	49.44	50.17	4.01	3.61	3.81	5.61	5.04	5.33
T_3	Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}	51.11	49.78	50.45	3.98	3.67	3.83	5.58	5.20	5.39
T_4	Oxyfluorfen 23.5 EC @ 200 g ha^{-1}	50.78	49.89	50.34	4.02	3.71	3.87	5.72	5.27	5.50
T_5	*Calotropis* raw leaf extract @ 5% *v*/v + *Parthenium* raw leaf extract @ 5% *v/v*	51.22	48.89	50.06	3.76	3.79	3.78	5.26	5.34	5.30
T_6	Hand Weeding at 20 DAS	51.56	49.11	50.34	4.05	3.84	3.95	5.73	5.33	5.53
T_7	Control	51.11	49.56	50.34	3.86	3.63	3.75	5.36	5.11	5.24
	S.Em (±)	**1.105**	**1.524**	**0.997**	**0.389**	**0.462**	**0.357**	**0.689**	**0.743**	**0.619**
	C.D (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 4.107 Economics of weed management in groundnut

Tr.	2009 (Rs ha^{-1})						2010 (Rs ha^{-1})						Mean (Rs ha^{-1})					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
T_1	32382	1080	33462	86000	52538	2.57	31890	1080	32970	87200	54230	2.64	32136	1080	33216	86800	53584	2.61
T_2	32382	1870	34252	72400	38148	2.11	31890	1870	33760	74000	40240	2.19	32136	1870	34006	73200	39194	2.15
T_3	32382	1216	33598	71600	38002	2.13	31890	1216	33106	72800	39694	2.20	32136	1216	33352	72400	39048	2.17
T_4	32382	2570	34952	74800	39848	2.14	31890	2570	34460	78000	43540	2.26	32136	2570	34706	76400	41694	2.20
T_5	32382	1854	34236	62400	28164	1.82	31890	1854	33744	63600	29856	1.88	32136	1854	33990	63200	29210	1.86
T_6	32382	5845	38227	88400	50173	2.31	31890	5845	37735	90800	53065	2.41	32136	5845	37981	89600	51619	2.36
T_7	32382	0	32382	44400	12018	1.37	31890	0	31890	46400	14510	1.46	32136	0	32136	45600	13464	1.42

1= Common cost of cultivation; 2= Treatment cost; 3= Total cost of cultivation; 4= Produce Value; 5= Net Return; 6= Benefit Cost ratio

Table 4.108 Economics of weed management in soybean

Tr.	2009 (Rs ha^{-1})						2010 (Rs ha^{-1})						Mean (Rs ha^{-1})					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
T_1	17950	1080	19030	62000	42970	3.26	17540	1080	18620	59250	40630	3.18	17745	1080	18825	60750	41925	3.23
T_2	17950	1870	19820	45250	25430	2.28	17540	1870	19410	43250	23840	2.23	17745	1870	19615	44250	24635	2.26
T_3	17950	1216	19166	44500	25334	2.32	17540	1216	18756	42250	23494	2.25	17745	1216	18961	43500	24539	2.29
T_4	17950	2570	20520	57750	37230	2.81	17540	2570	20110	54750	34640	2.72	17745	2570	20315	56250	35935	2.77
T_5	17950	1854	19804	39500	19696	1.99	17540	1854	19394	38000	18606	1.96	17745	1854	19599	38750	19151	1.98
T_6	17950	5845	23795	64000	40205	2.69	17540	5845	23385	62250	38865	2.66	17745	5845	23590	63250	39660	2.68
T_7	17950	0	17950	32250	14300	1.80	17540	0	17540	31250	13710	1.78	17745	0	17745	31750	14005	1.79

1= Common cost of cultivation; 2= Treatment cost; 3= Total cost of cultivation; 4= Produce Value; 5= Net Return; 6= Benefit Cost ratio

Table 4.109 Economics of weed management in green gram

Tr.	2009 (Rs ha^{-1})						2010 (Rs ha^{-1})						Mean (Rs ha^{-1})					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
T_1	15400	1080	16480	33840	17360	2.05	15670	1080	16750	35680	18930	2.13	15535	1080	16615	34800	18185	2.09
T_2	15400	1870	17270	25960	8690	1.50	15670	1870	17540	26920	9380	1.53	15535	1870	17405	26480	9075	1.52
T_3	15400	1216	16616	25240	8624	1.52	15670	1216	16886	26160	9274	1.55	15535	1216	16751	25680	8929	1.53
T_4	15400	2570	17970	31840	13870	1.77	15670	2570	18240	33040	14800	1.81	15535	2570	18105	32440	14335	1.79
T_5	15400	1854	17254	23680	6426	1.37	15670	1854	17524	25120	7596	1.43	15535	1854	17389	24440	7051	1.41
T_6	15400	5845	21245	35480	14235	1.67	15670	5845	21515	36600	15085	1.70	15535	5845	21380	36040	14660	1.69
T_7	15400	0	15400	20960	5560	1.36	15670	0	15670	22480	6810	1.43	15535	0	15535	21760	6225	1.40

1= Common cost of cultivation; 2= Treatment cost; 3= Total cost of cultivation; 4= Produce Value; 5= Net Return; 6= Benefit Cost ratio

Table 4.110 Economics of weed management in black gram

Tr.	2009 (Rs ha^{-1})						2010 (Rs ha^{-1})						Mean (Rs ha^{-1})					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
T_1	15130	1080	16210	35480	19270	2.19	15390	1080	16470	39760	23290	2.41	15260	1080	16340	37640	21300	2.30
T_2	15130	1870	17000	29280	12280	1.72	15390	1870	17260	32040	14780	1.86	15260	1870	17130	30680	13550	1.79
T_3	15130	1216	16346	29000	12654	1.77	15390	1216	16606	31640	15034	1.91	15260	1216	16476	30320	13844	1.84
T_4	15130	2570	17700	32480	14780	1.84	15390	2570	17960	35640	17680	1.98	15260	2570	17830	34080	16250	1.91
T_5	15130	1854	16984	26920	9936	1.59	15390	1854	17244	29240	11996	1.70	15260	1854	17114	28080	10966	1.64
T_6	15130	5845	20975	37360	16385	1.78	15390	5845	21235	43280	22045	2.04	15260	5845	21105	40320	19215	1.91
T_7	15130	0	15130	22040	6910	1.46	15390	0	15390	23960	8570	1.56	15260	0	15260	23000	7740	1.51

1= Common cost of cultivation; 2= Treatment cost; 3= Total cost of cultivation; 4= Produce Value; 5= Net Return; 6= Benefit Cost ratio

The maximum benefit: cost of 2.61 (groundnut), 3.23 (soybean), 2.09 (green gram) and 2.30 (black gram) were recorded by Imazethapyr 10 SL (T_1). Treatment T_6 (HW at 20 DAS) recorded the next highest value in this respect was 2.36 in groundnut but in case of soybean, green gram and black gram Oxyfluorfen 23.5 EC (T_4) hold the second position recorded benefit: cost of 2.77, 1.79 & 1.91 respectively. Treatments where natural botanicals was applied as *Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v* (T_5) recorded higher benefit: cost ratio than control (T_7). The minimum benefit: cost was obtained from control (T_7) treatment were 1.42 (groundnut), 1.79 (soybean), 1.40 (green gram) and 1.51 (black gram). Treatments T_2 and T_3 also recorded higher value regarding this parameter against T_7 (control).

Chapter-5

Discussions

DISCUSSIONS

The findings of the present investigation on effect of different weed management treatments on existing weed flora of groundnut, soybean, green gram and black gram crop field, various growth and yield attributing characters of crops, nodulation and soil micro flora population as presented in the previous chapter are discussed below to assign the possible reasons for variations of the treatment effect.

5.1 Effect of weed management methods on population and dry weight of dominant weeds

From the results, it is very clear that the sedge *Cyperus rotundus* was the most dominant throughout the experimental period in all leguminous crop fields. This may be due to potentiality of the mutha grass to survive in the worst situation, networking ability of tubers under the soil surface and rapid spreading ability during summer season in aerobic ecosystem. The highest and lowest density and dry weight of weed flora were different at different observation dates. Different herbicides and botanicals were applied either as pre-emergence (Oxyflourfen 23.5 EC and *Calotropis* raw leaf extract + *Parthenium* raw leaf extract) or as post-emergence (Imazethapyr 10S L, Quizalofop-ethyl 5 EC and Fenoxaprop-p-ethyl 9 EC) on the four legume crops groundnut, soybean, green gram and black gram may be the reason for the dis similar time of application of the chemicals along with their different mode of action.

Imazethapyr 10 SL @ 100 g ha^{-1} was applied in the experiment as post-emergence at 20 DAS so its effect was not found in first date of observation at 15 DAS. This chemical has an ability to kill both monocot and dicot weeds thus it effectively reduced both monocot and dicot weed density and dry weight up the third observation at 45 DAS created a situation of lesser crop-weed. It has found that Imazethapyr 10 SL recorded 54.78, 50.03, 66.78 and 51.04 % decrease in weed dry mass over average dry weight throughout the investigation period of groundnut, soybean, green gram and black gram respectively. Similar kinds of findings were also reported by Vouzounis (2006) in groundnut and Shete *et al.* (2007 and 2008), Girothia and Thakur (2006), Kushwah and Vyas (2005), Kalpana and Velayutham (2004), Bhattacharya *et al.* (1998), Skrzypczak and Blecharczyk (1994) in soybean.

Quizalofop-ethyl 5 EC @ 50 g ha^{-1} and Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1} also applied as post-emergence at 20 DAS were only able to knock down annual and perennial monocot weeds but did not show any response found on dicot weeds.

Ability of Quizalofop-ethyl and Fenoxaprop-p-ethyl to control the monocot weeds were also observed by Pandey *et al.* (2007), Singh (2005), Kushwah and Vyas (2005), Idapuganti *et al.* (2005), Tiwari and Mathew (2002) in legume crops. At later stage of crop growth, in these two treated plots dicot weed infestation were increased and thus created higher competition to crops unlike the 30 DAS observation.

Ability of Oxyfluorfen 23.5 EC to control all types of weed flora for longer period is mainly due to its more persistence in soil and irrigation before flowering also helps to increase its activity in all four crops. The pre-emergence application of Oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} ensured the population and dry mass reduction of both monocot and dicot to 45 DAS. This kind of weed control ability was also noticed by Nejad *et al.* (2010), Patra (1999) in legume crops. HW at 20 DAS made the plot almost free on 30 DAS observation, but in later stage of observation (45 DAS) infestation on all categories of weed gradually increased as normally happens.

Calotropis + *Parthenium* raw leaf extract also effective on monocot weed management and were unable to show any remarkable performance on reduction of dicot weed population in any of the experiments. Because of the chemicals calotropin in *Calotropis* and sesquitarpene lacutone & phenols in *Parthenium* this treatment has allelopathic effect on monocot weeds and not on dicot weeds as found in many experiments (Ghosh 2006, Kole *et al.* 2011, Ghosh *et al.* 2012). In a lab experiment, Al-Taisan (2010) reported same kind of efficacy by *Calotropis*. There was no response was found by *Parthenium* raw leaf extract @ 5% *v/v* at all dates of observation recorded 60.64, 49.04, 49.79 and 55.14 % increase of weed dry weight over average in groundnut, soybean, greengram and blackgram experiments respectively.

From the correlation matrix Table 5.1 – 5.4 it has been found that the total bio mass of weed is negatively correlated with dry matter accumulation, root volume, number of pod $plant^{-1}$, number of seed $plant^{-1}$ and yield of the all legume crops. Dry weight weeds had no influence on the nodulation characteristics of the legume crops and also in soil micro flora.

Table 5.1 Correlations matrix among dry matter accumulation, root volume, nodule plant^{-1}, dry weight of nodule, leghemoglobin content of nodule, no. of pod plant^{-1}, no. of seed pod^{-1}, soil micro flora, weed dry mass and pod yield of groundnut

	Dry matter accumulation	Root Volume	Nodule Plant^{-1}	Dry weight of nodule	Leghemoglobin content	No. of pod plant^{-1}	No. of seed pod^{-1}	Soil micro flora	Weed dry mass	Pod Yield
Dry matter accumulation	1.000									
Root Volume	.958**	1.000								
Nodule Plant^{-1}	-.247	-.408	1.000							
Dry weight of nodule	-.168	-.338	.995**	1.000						
Leghemoglobin content	-.461	-.507	.895**	.868*	1.000					
No. of pod plant^{-1}	.975**	.924**	-.125	-.046	-.314	1.000				
No. of seed pod^{-1}	.995**	.959**	-.219	-.142	-.414	.989**	1.000			
Soil micro flora	.452	.531	-.936**	-.907	-.985**	.307	.404	1.000		
Weed dry mass	-.995**	-.971**	.317	.241	.521	-.950**	-.984**	-.514	1.000	
Pod Yield	.984**	.986**	-.288	-.211	-.428	.974**	.989**	.442	-.980**	1.000

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 5.2 Correlations matrix among dry matter accumulation, root volume, nodule plant^{-1}, dry weight of nodule, leghemoglobin content of nodule, no. of pod plant^{-1}, no. of seed pod^{-1}, soil micro flora, weed dry mass and seed yield of soybean

	Dry matter accumulation	Root Volume	Nodule Plant^{-1}	Dry weight of nodule	Leghemoglobin content	No. of pod plant^{-1}	No. of seed pod^{-1}	Soil micro flora	Weed dry mass	Seed Yield
Dry matter accumulation	1.000									
Root Volume	.976**	1.000								
Nodule Plant^{-1}	-.320	-.203	1.000							
Dry weight of nodule	-.282	-.139	.983**	1.000						
Leghemoglobin content	-.500	-.373	.909**	.925**	1.000					
No. of pod plant^{-1}	.979**	.947**	-.442	-.387	-.546	1.000				
No. of seed pod^{-1}	.995**	.973**	-.362	-.310	-.512	.992**	1.000			
Soil micro flora	.519	.395	-.939**	-.949**	-.984**	.586	.537	1.000		
Weed dry mass	-.997**	-.963**	.323	.292	.512	-.975**	-.991**	-.531	1.000	
Seed Yield	.976**	.981**	-.134	-.100	-.367	.917**	.958**	.373	-.972**	1.000

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 5.3 Correlations matrix among dry matter accumulation, root volume, nodule plant^{-1}, dry weight of nodule, leghemoglobin content of nodule, No. of pod plant^{-1}, no. of seed pod^{-1}, soil micro flora, weed dry mass and seed yield of green gram

	Dry matter accumulation	Root Volume	Nodule Plant^{-1}	Dry weight of nodule	Leghemoglobin content	No. of pod plant^{-1}	No. of seed pod^{-1}	Soil micro flora	Weed dry mass	Seed Yield
Dry matter accumulation	1.000									
Root Volume	.991**	1.000								
Nodule Plant^{-1}	-.253	-.200	1.000							
Dry weight of nodule	-.214	-.162	.990**	1.000						
Leghemoglobin content	-.455	-.402	.885**	.819*	1.000					
No. of pod plant^{-1}	.991**	.993**	-.146	-.107	-.372	1.000				
No. of seed pod^{-1}	.995**	.996**	-.228	-.195	-.417	.994**	1.000			
Soil micro flora	.464	.409	-.947**	-.909**	-.974**	.371	.430	1.000		
Weed dry mass	-.944**	-.914**	.327	.251	.605	-.918**	-.916**	-.561	1.000	
Seed Yield	.975**	.982**	-.099	-.043	-.377	.989**	.973**	.347	-.937**	1.000

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Table 5.3 Correlations matrix among dry matter accumulation, root volume, nodule plant^{-1}, dry weight of nodule, leghemoglobin content of nodule, no. of pod plant^{-1}, no. of seed pod^{-1}, soil micro flora, weed dry mass and seed yield of black gram

	Dry matter accumulation	Root Volume	Nodule Plant^{-1}	Dry weight of nodule	Leghemoglobin content	No. of pod plant^{-1}	No. of seed pod^{-1}	Soil micro flora	Weed dry mass	Seed Yield
Dry matter accumulation	1.000									
Root Volume	.184	1.000								
Nodule Plant^{-1}	-.162	-.106	1.000							
Dry weight of nodule	.032	-.017	.971**	1.000						
Leghemoglobin content	-.391	-.127	.862*	.764*	1.000					
No. of pod plant^{-1}	.970**	.286	-.327	-.119	-.514	1.000				
No. of seed pod^{-1}	.991**	.193	-.272	-.075	-.464	.990**	1.000			
Soil micro flora	.454	.133	-.916**	-.829*	-.971**	.573	.534	1.000		
Weed dry mass	-.985**	-.164	.246	.039	.495	-.984**	-.990**	-.535	1.000	
Seed Yield	.967**	.261	.039	.240	-.273	.913**	.931**	.299	-.944**	1.000

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).00

5.2 Effect of weed management methods on nodulation of legume crops

Biological nitrogen fixation is a process that can only be performed by certain prokaryotes. In some cases, such bacteria are able to fix nitrogen in a symbiotic relationship with plants. Bacteria of the genera *Azorhizobium*, *Bradyrhizobium*, *Mesorhizobium*, *Rhizobium*, and *Sinorhizobium* (collectively referred to as *Rhizobium* or rhizobia) are able to establish an endosymbiotic association with legumes. Under nitrogen-limiting conditions, the leguminous plants can form root nodules, in which the rhizobia are hosted intracellularly. There they find the proper conditions for reducing atmospheric nitrogen into ammonia. The formation of a nodule requires the reprogramming of differentiated root cells to form a primordium, from which a nodule can develop. Furthermore, the bacteria must infect the root before the nitrogen-fixing root nodule can be formed. These steps in nodule formation involve changes in three root tissues, namely epidermis, cortex and pericycle.

When *rhizobia* have colonized the root surface of their host, they induce morphological changes by inducing certain genes at broad region of the epidermis. The transition from nodule primordium to young developing nodule occurs after infection of primordial cells. During this transition, cells at the base of the primordium establish a radial pattern consisting of a central tissue surrounded by peripheral tissues (Pawlowski and Bisseling, 1996). Concomitantly, cells at the apex of the primordium form a meristem that, by division, maintains itself and adds new cells to the different tissues according to the pattern established at the base of the primordium. But a meristematic cell is never infected by rhizobia, and genes that are activated in the primordium and are not transcribed in the nodule meristem (Scheres *et al.* 1990).

5.2.1 Nodule number and dry weight

Nodulation in most legumes was started at 20 DAS. From the results, it cleared that the number of nodules in groundnut, soybean, green gram and black gram roots were influenced by different weed management treatments. Plots treated with both PE Oxyfluorfen 23.5 EC and POE Imazethapyr 10 SL, Quizalofop-ethyl 5 EC and Fenoxaprop-p-ethyl 9 EC herbicides recorded a decrease in the crop nodulation at immediately after application but in later all the four legume crops in respect of number of effective nodules showed almost similar to the hand weeded plot (Fig. 5.1 – 5.8). The reason behind the decrease of number of nodules in all four crops immediately after application of synthetic chemical herbicides, may be as PE or POE, is the toxic effect of these chemicals that affect the *rhizobium* bacteria, as a result nodules were not formed properly. Anikwe *et al.* (2003) reported that both post-emergence and a combination of pre and post-emergence herbicide treatments applied reduced the nodulation of legumes. Significant reductions on nodule number in legume crop were also found by Rafia *et al.* (2007) and (Khan *et al.*, 2006) with Atrazine. Botanicals, on other hand did not show as much as detrimental effect that of the synthetic chemicals in respect of number of nodules in all four legume crops. This may be due to the reason that natural organo-chemicals had lesser effect on the *rhizobium* bacteria particularly 3 weeks after application.

For the formation of nodule, symbiotic association of *rhizobium* bacteria with crop roots is mandatory. So, at initial stage of nodule formation lesser *rhizobium* population may cause lesser number of nodules in all the four legume crops. Arias and Peretti (1993) also found that growth of *rhizobium* restricted by application of 2, 4-D. At later stages of observation on nodule numbers in these four crops revealed that neither synthetic chemicals nor botanicals show any detrimental effect on nodule numbers.

The hand weeded plots and unweeded check also showed no detrimental effect on the number and dry weight of nodules though because of some toxic allelochemicals from the roots of the weed plants, unweeded plot may cause the lesser nodule number in comparison to hand weeded plot. Sandhu *et al.* (1991) reported that average number of nodules and dry weight plant $^{-1}$ were highest in hand hoeing treatment as compared with terbutryn, oxyfluorfen, linuron, metribuzin, methabenzthiazuron and oxadiazon applied plotfrom at Ludhiana with legume crops.

Dry weight of nodule was also differed due to same reason.

From the correlation matrix Table 5.1 – 5.4 it has been found that the nodule plant^{-1} is correlated with its dry weight. This parameter has negative correlation with population of soil micro flora. Nodulation of legumes had no influence on the yield of legume crops.

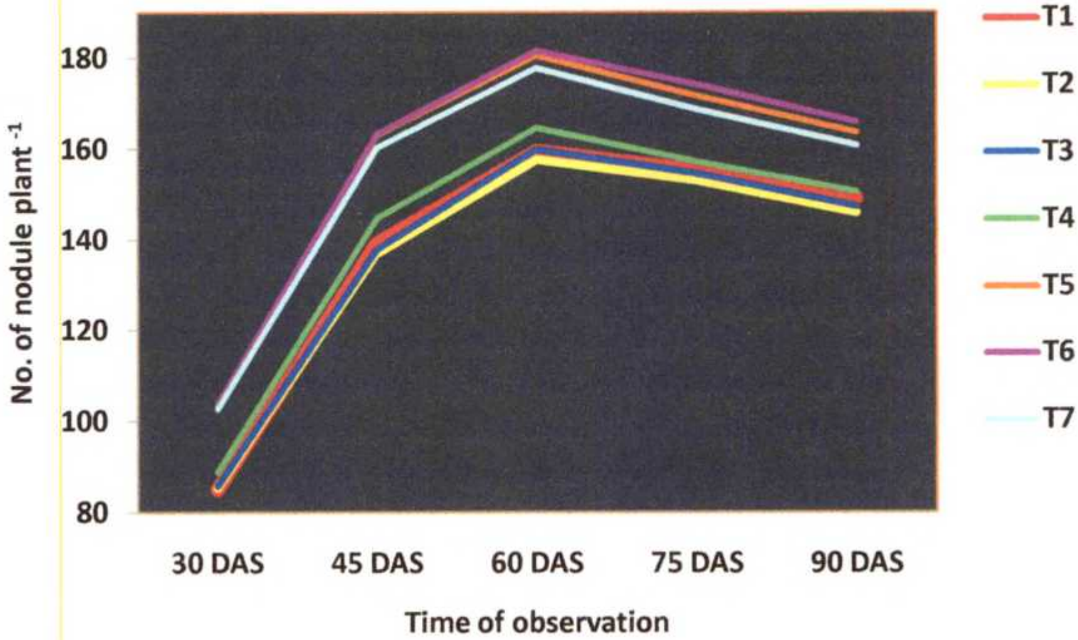


Fig. 5.1 No. of nodule plant $^{-1}$ in groundnut

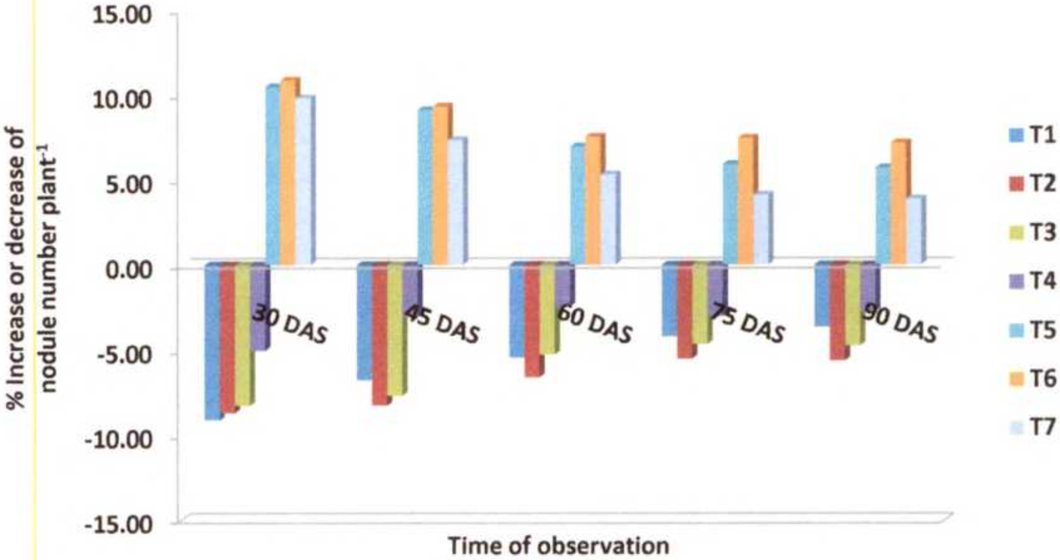


Fig. 5.2 Percentage (%) increase or decrease over average nodule number plant^{-1} in groundnut

T_1 - Imazethapyr 10 SL @100 g ha^{-1}, T_2 - Quizalofop-ethyl 5 EC @ 50 g ha^{-1},
T_3 - Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}, T_4 - Oxyfluorfen 23.5 EC @ 200 g ha^{-1},
T_5 - Tank mixture of *Calotropis* & *Parthenium* raw leaf extract 5% v/v ,
T_6 - Hand Weeding at 20 DAS and T_7 - control

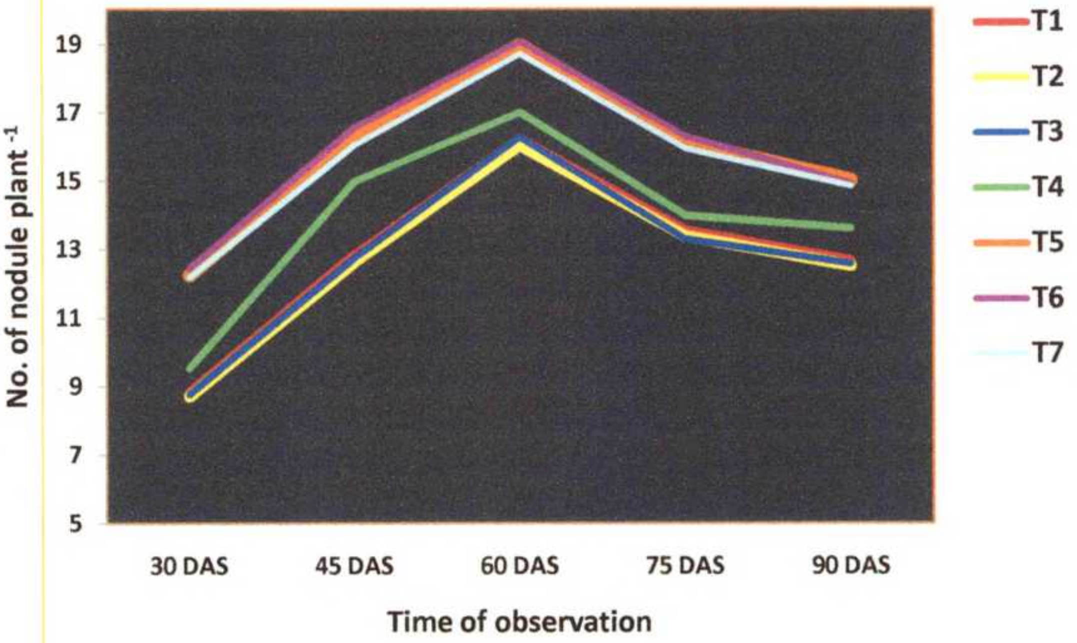


Fig. 5.3 No. of nodule plant $^{-1}$ in soybean

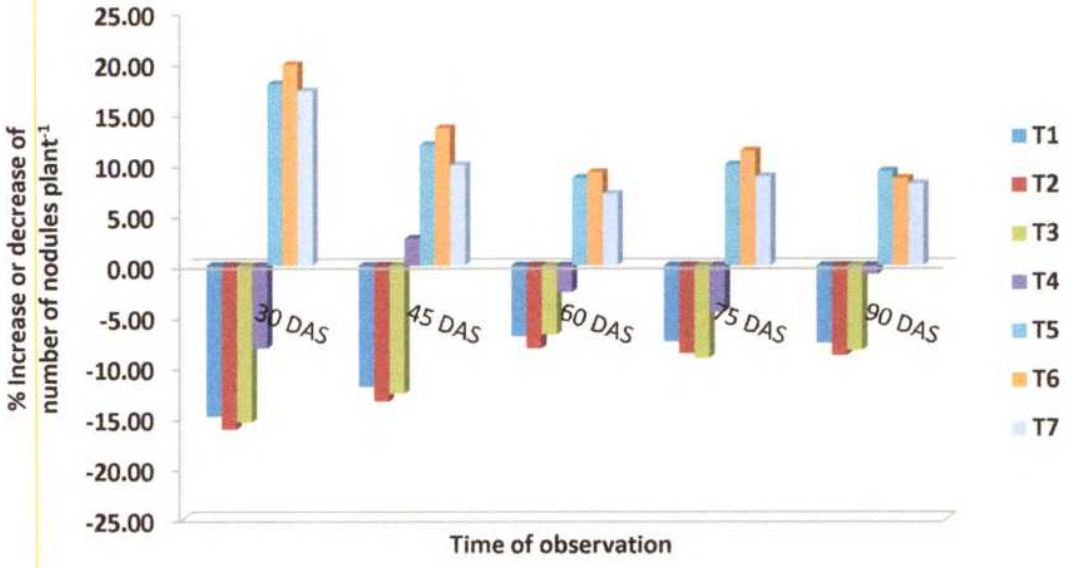


Fig. 5.4 Percentage (%) increase or decrease over average nodule number plant^{-1} in soybean

T_1 - Imazethapyr 10 SL @100 g ha^{-1}, T_2 - Quizalofop-ethyl 5 EC @ 50 g ha^{-1},
T_3 - Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}, T_4 - Oxyfluorfen 23.5 EC @ 200 g ha^{-1},
T_5 - Tank mixture of *Calotropis* & *Parthenium* raw leaf extract 5% v/v,
T_6 - Hand Weeding at 20 DAS and T_7 - control

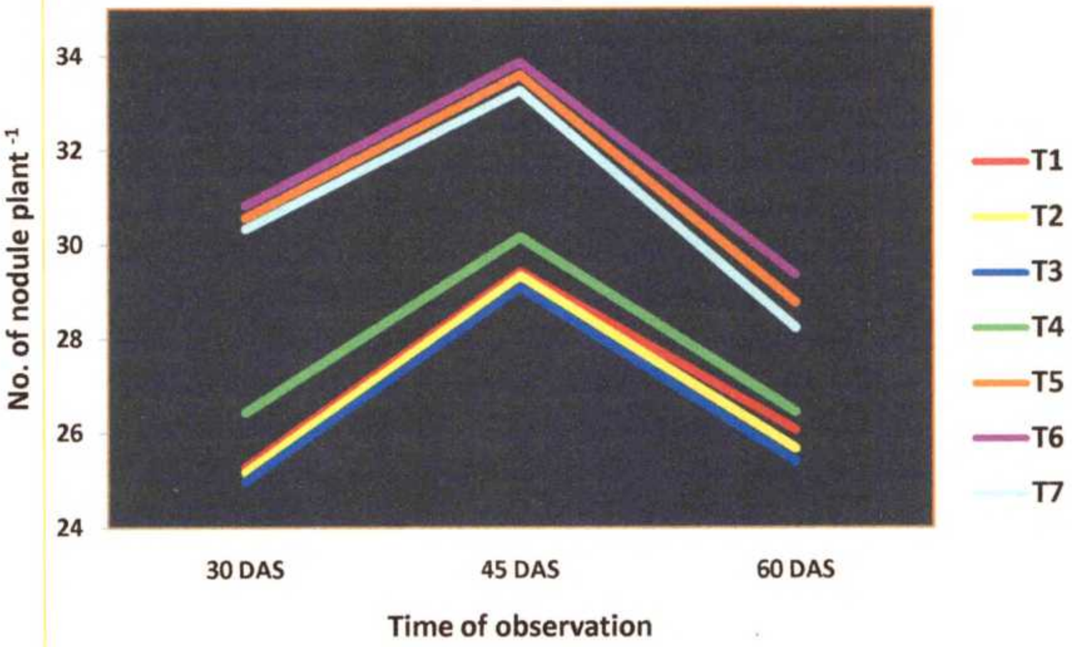


Fig. 5.5 No. of nodule plant $^{-1}$ in green gram

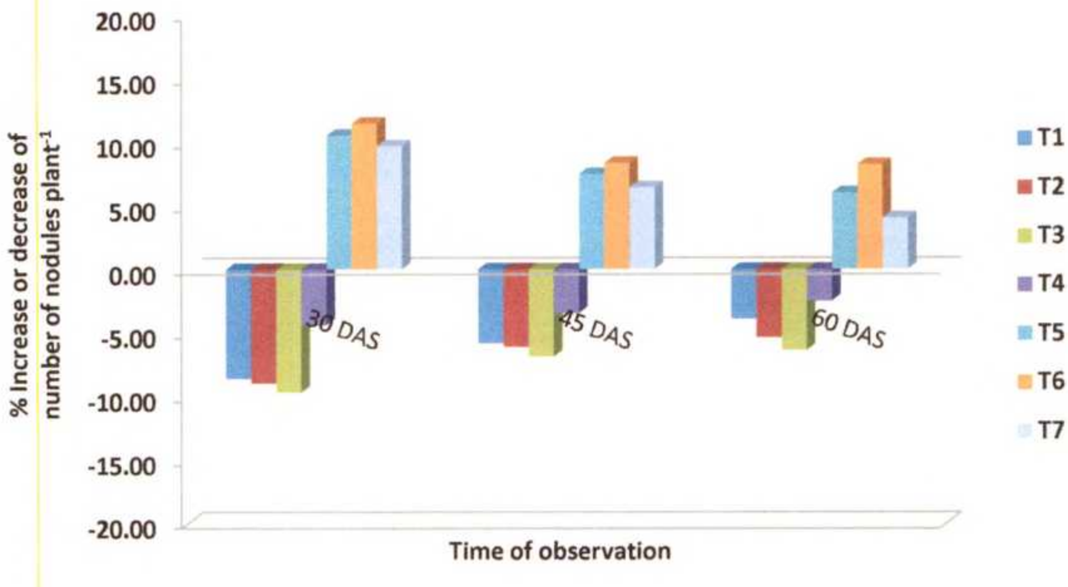


Fig. 5.6 Percentage (%) increase or decrease over average nodule number plant^{-1} in green gram

T_1 - Imazethapyr 10 SL @100 g ha^{-1}, T_2 - Quizalofop-ethyl 5 EC @ 50 g ha^{-1},
T_3 - Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}, T_4 - Oxyfluorfen 23.5 EC @ 200 g ha^{-1},
T_5 - Tank mixture of *Calotropis* & *Parthenium* raw leaf extract 5% v/v ,
T_6 - Hand Weeding at 20 DAS and T_7 - control

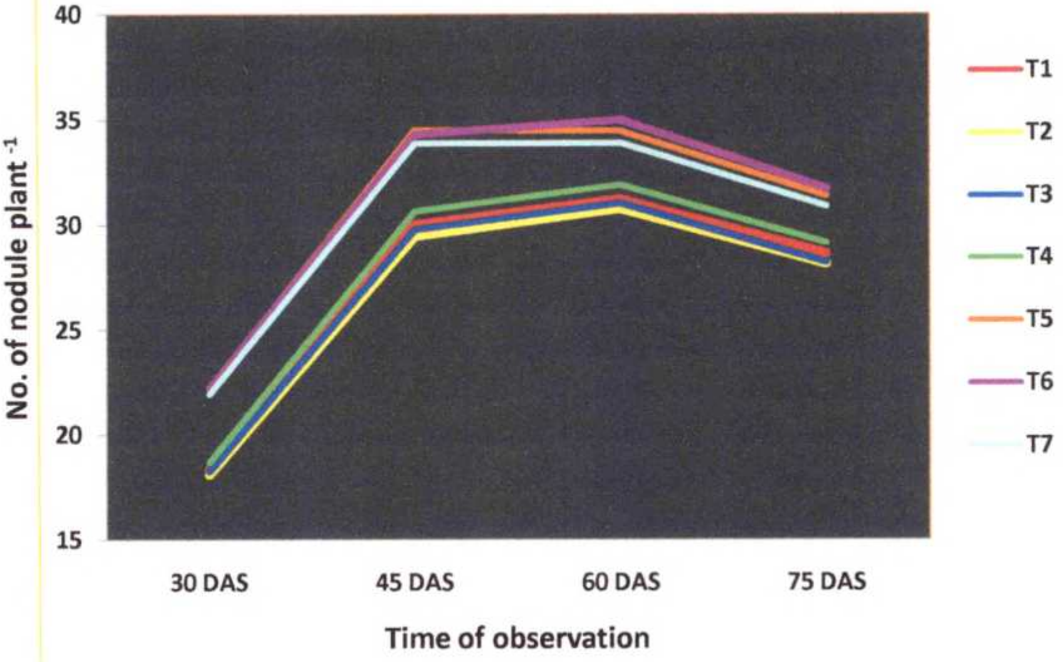


Fig. 5.7 No. of nodule plant $^{-1}$ in black gram

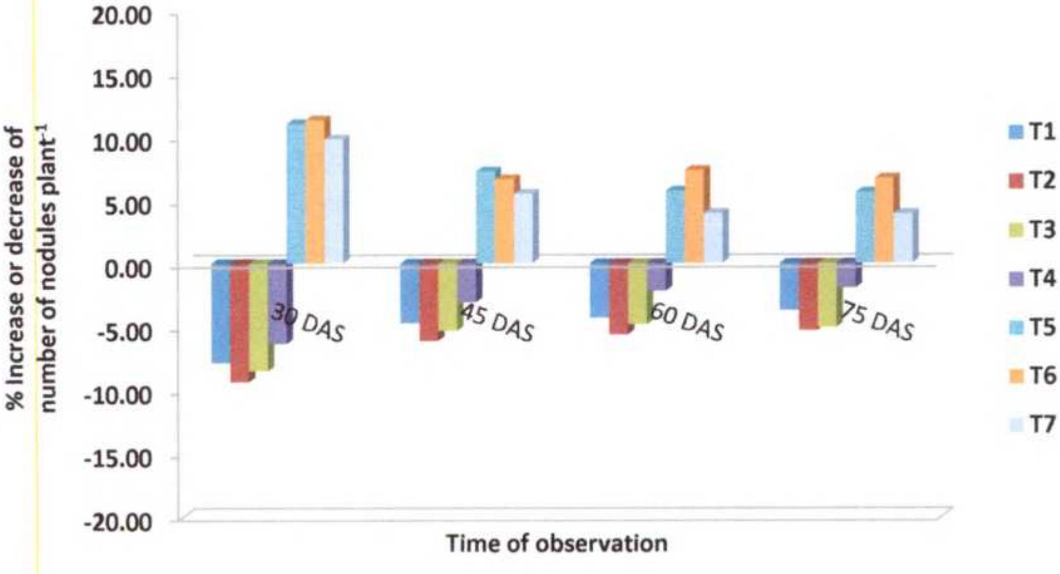


Fig. 5.8 Percentage (%) increase or decrease over average nodule number plant^{-1} in black gram

T_1 - Imazethapyr 10 SL @100 g ha^{-1}, T_2 - Quizalofop-ethyl 5 EC @ 50 g ha^{-1},
T_3 - Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}, T_4 - Oxyfluorfen 23.5 EC @ 200 g ha^{-1},
T_5 - Tank mixture of *Calotropis* & *Parthenium* raw leaf extract 5% v/v ,
T_6 - Hand Weeding at 20 DAS and T_7 - control

5.2.2 Leghemoglobin content of nodule

Leghemoglobin is a nitrogen or oxygen carrier, because naturally occurring oxygen and nitrogen interact similarly with this protein; and a hemoprotein found in the nitrogen-fixing root nodules of leguminous plants. It is produced by legumes in response to the roots being infected by nitrogen-fixing bacteria, termed *rhizobia*, as part of the symbiotic interaction between plant and bacterium: roots uninfected with *Rhizobium* do not synthesise leghemoglobin. In plants infected with *Rhizobium*, the presence of oxygen in the root nodules would reduce the activity of the oxygen-sensitive nitrogenase - an enzyme responsible for the fixation of atmospheric nitrogen. Leghemoglobin buffers the concentration of free oxygen in the cytoplasm of infected plant cells to ensure the proper function of root nodules. Leghemoglobin has a high affinity for oxygen (a K_m of about 0.01 μM), about ten times higher than the β chain of human hemoglobin. This allows an oxygen concentration that is low enough to allow nitrogenase to function but high enough so that it can provide the bacteria with oxygen for respiration.

Chemical herbicide treated legume crops recorded lower content of leghemoglobin in all observation stages. The percentage of reduction was higher in case of initial stage, but later stages it has recovered to some extent but not same as compared with nonchemical treatment. From the Fig. 5.9 – 5.16 it is cleared that nodule leghemoglobin content of legumes was closer to average value in advancement of the crop growth. The probable reasons behind that, application of chemical herbicides because of its toxic effect initially hampered the *rhizobium* population as a result lesser number of root nodule was formed which ultimately affects the nodule leghemoglobin content. But at later stages of crop growth the toxicity level of chemical herbicides was reduced which promote the legume nodulation. So, because of increasing nodule-*rhizobium* symbiotic association the nodule leghemoglobin content was also increased. Similar kind of findings regarding reduction of leghemoglobin content has also found by Reddy and Zablotowicz (2003) from a field study with ITD, and ADT salt formulations of glyphosate in legumes. Glyphosate levels in nodules from treated plants ranged from 39 to 147 and leghemoglobin content was reduced by as much as 10%.

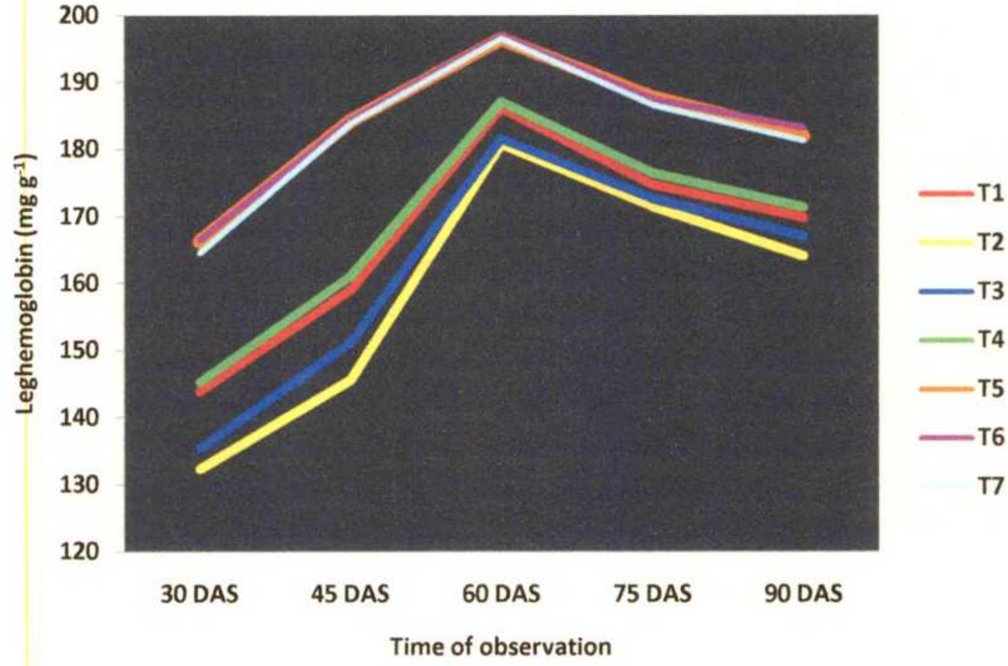


Fig. 5.9 Leghemoglobin content (mg g^{-1}) in groundnut nodule

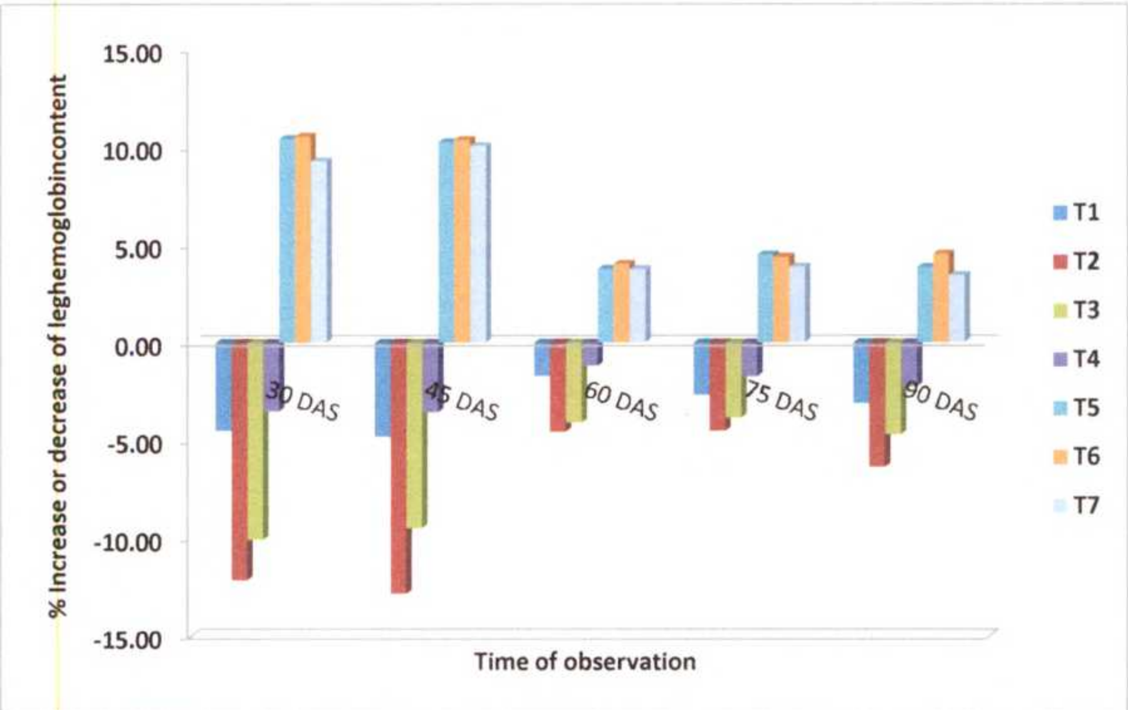


Fig. 5.10 Percentage (%) increase or decrease over average Leghemoglobin content in groundnut

T_1 - Imazethapyr 10 SL @100 g ha^{-1}, T_2 - Quizalofop-ethyl 5 EC @ 50 g ha^{-1},
T_3 - Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}, T_4 - Oxyfluorfen 23.5 EC @ 200 g ha^{-1},
T_5 - Tank mixture of *Calotropis* & *Parthenium* raw leaf extract 5% v/v ,
T_6 - Hand Weeding at 20 DAS and T_7 - control

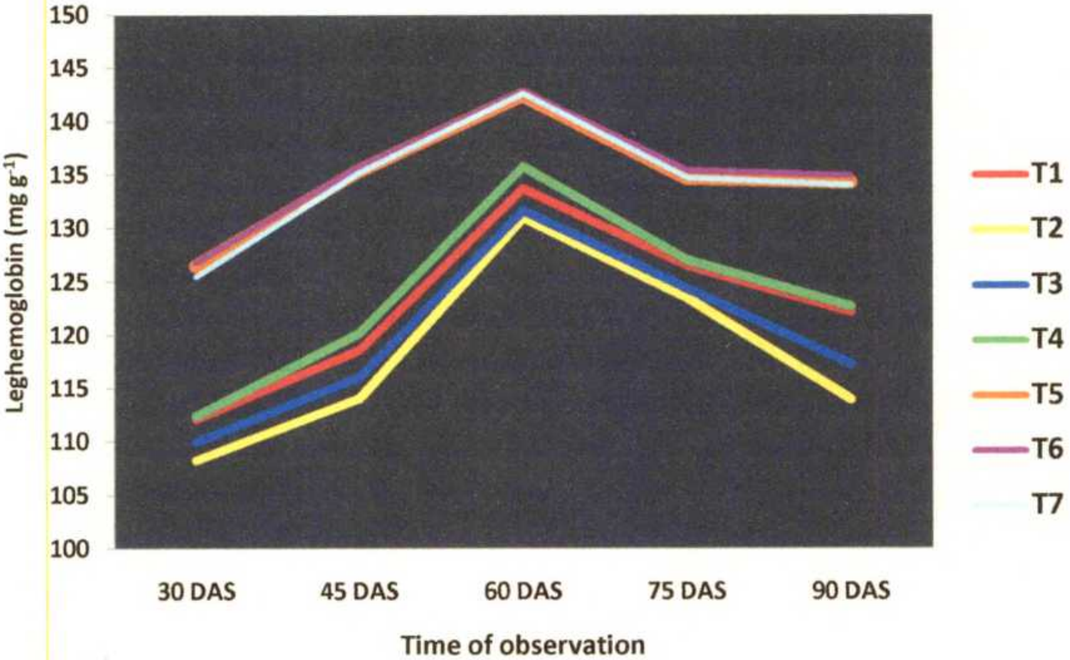


Fig. 5.11 Leghemoglobin content (mg g^{-1}) in soybean nodule

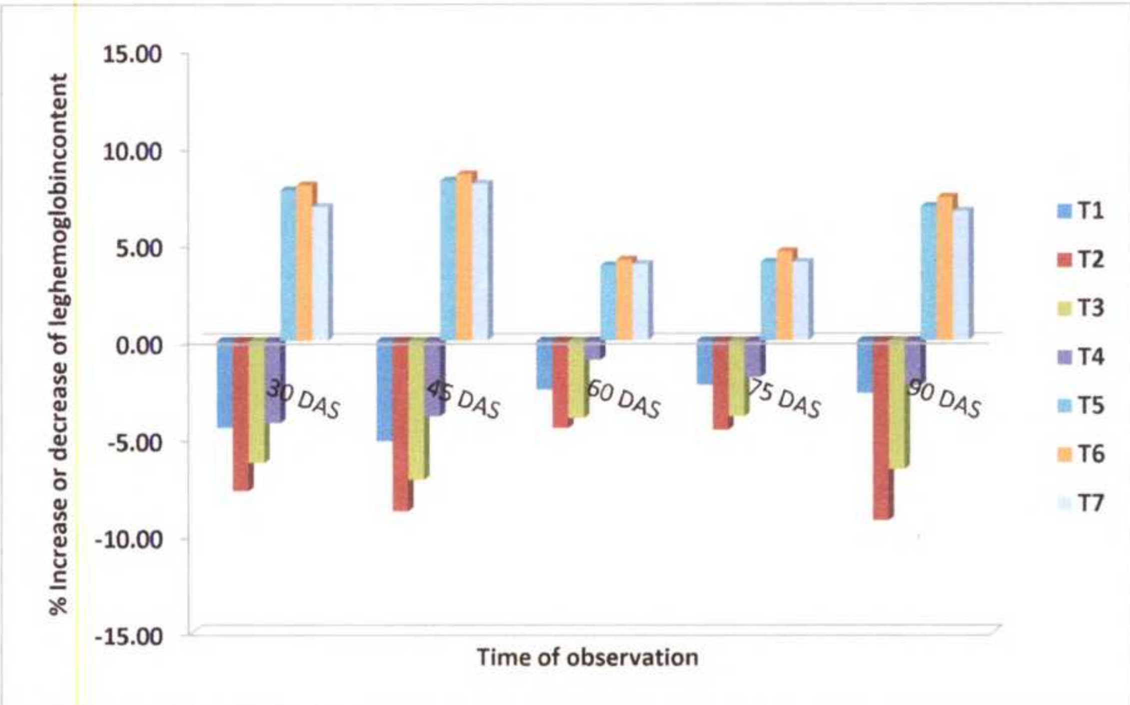


Fig. 5.12 Percentage (%) increase or decrease over average Leghemoglobin content in soybean

T_1 - Imazethapyr 10 SL @100 g ha^{-1}, T_2 - Quizalofop-ethyl 5 EC @ 50 g ha^{-1},
T_3 - Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}, T_4 - Oxyfluorfen 23.5 EC @ 200 g ha^{-1},
T_5 - Tank mixture of *Calotropis* & *Parthenium* raw leaf extract 5% v/v ,
T_6 - Hand Weeding at 20 DAS and T_7 - control

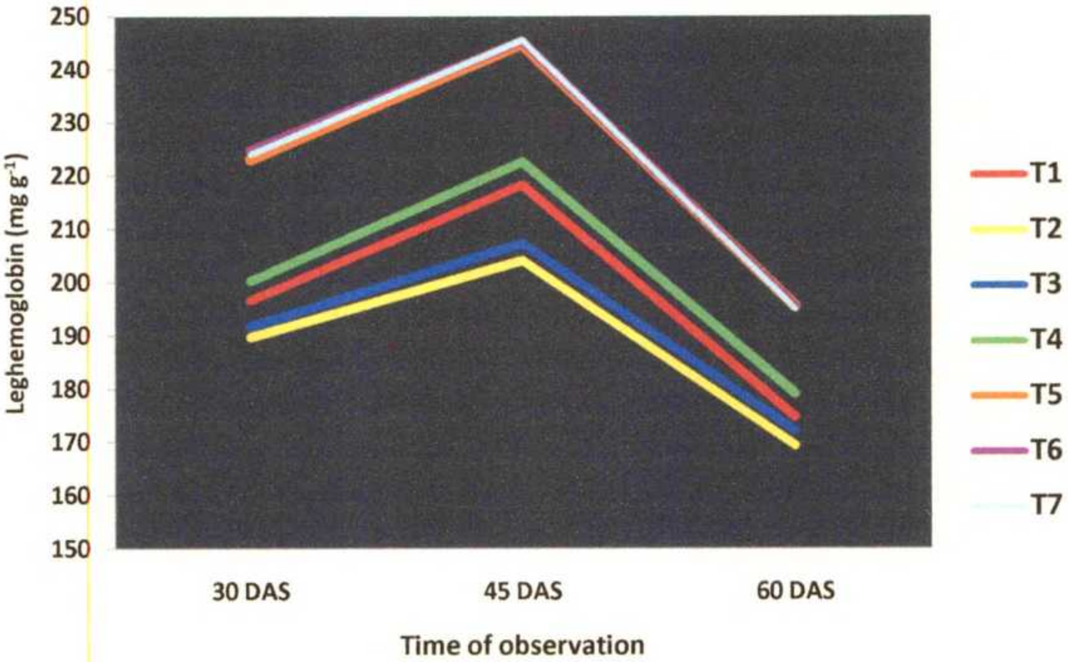


Fig. 5.13 Leghemoglobin content (mg g^{-1}) in green gram nodule

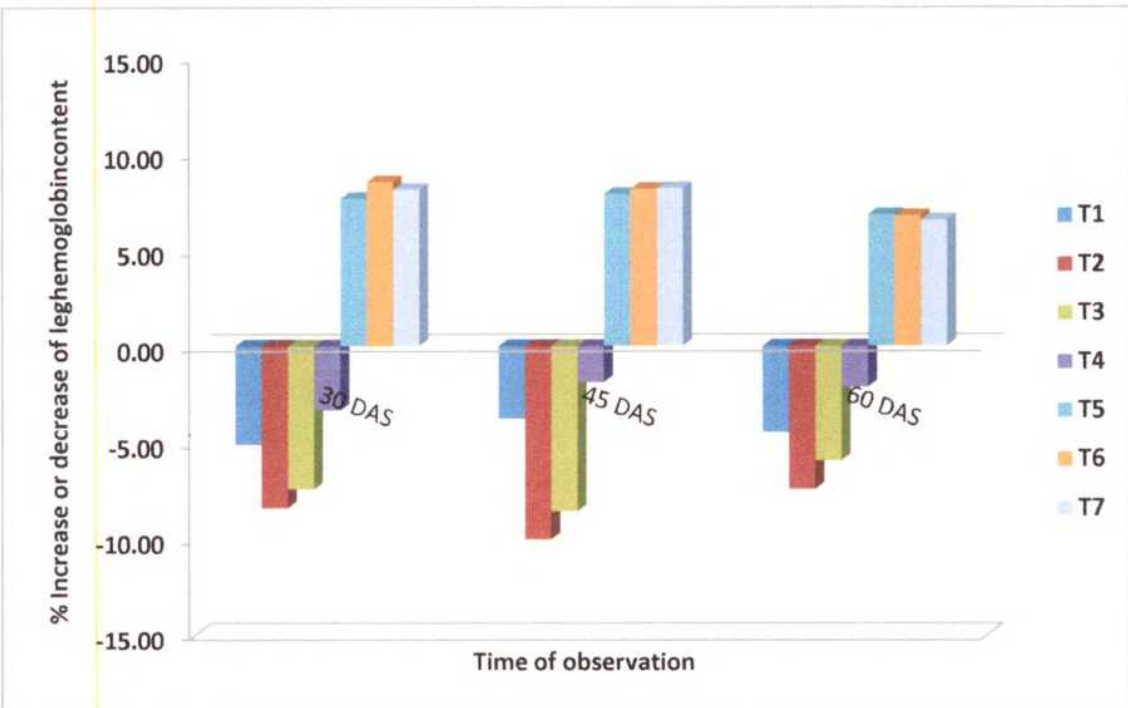


Fig. 5.14 Percentage (%) increase or decrease over average Leghemoglobin content in green gram

T_1 - Imazethapyr 10 SL @100 g ha^{-1}, T_2 - Quizalofop-ethyl 5 EC @ 50 g ha^{-1},
T_3 - Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}, T_4 - Oxyfluorfen 23.5 EC @ 200 g ha^{-1},
T_5 - Tank mixture of *Calotropis* & *Parthenium* raw leaf extract 5% v/v ,
T_6 - Hand Weeding at 20 DAS and T_7 - control

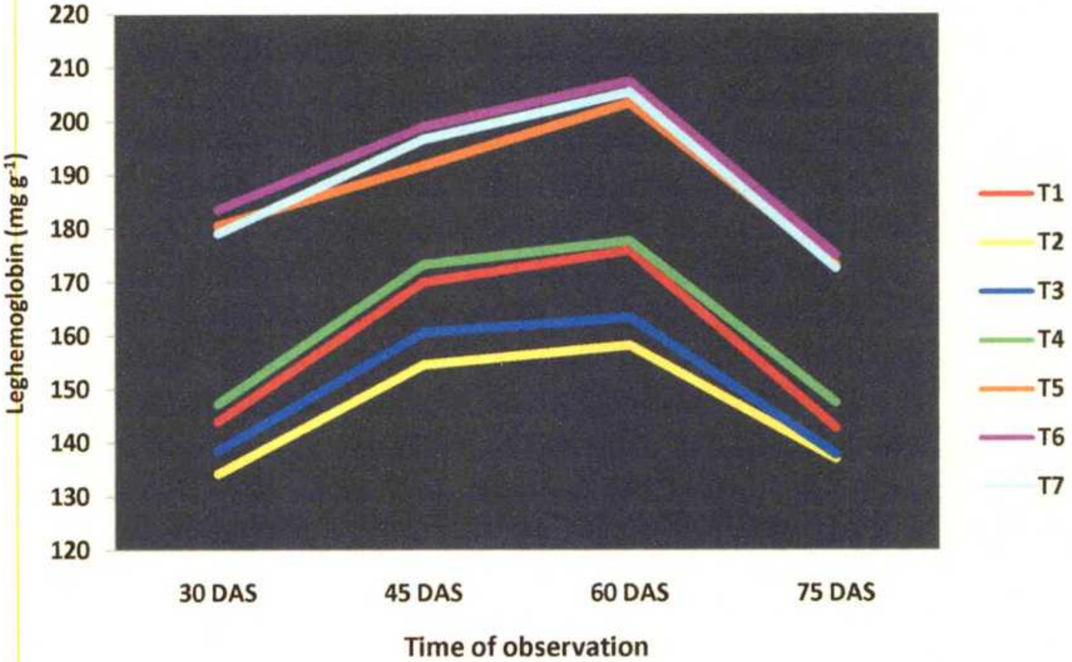


Fig. 5.9 Leghemoglobin content (mg g^{-1}) in black gram nodule

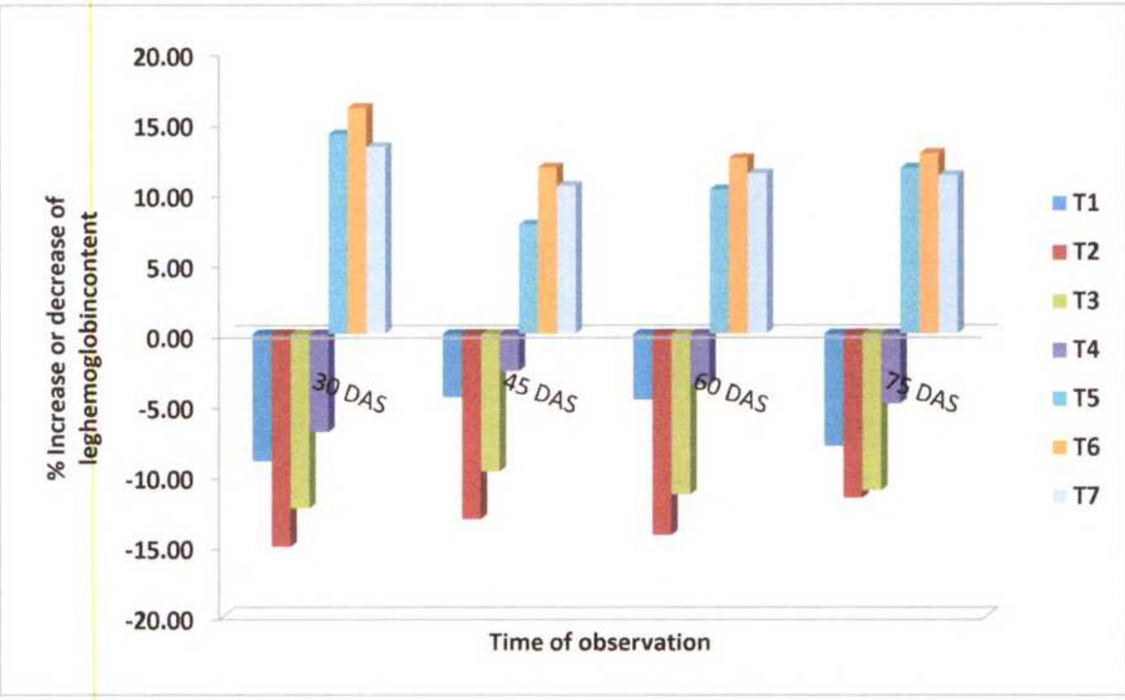


Fig. 5.16 Percentage (%) increase or decrease over average Leghemoglobin content in black gram

T_1 - Imazethapyr 10 SL @100 g ha^{-1}, T_2 - Quizalofop-ethyl 5 EC @ 50 g ha^{-1},
T_3 - Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1}, T_4 - Oxyfluorfen 23.5 EC @ 200 g ha^{-1},
T_5 - Tank mixture of *Calotropis* & *Parthenium* raw leaf extract 5% v/v ,
T_6 - Hand Weeding at 20 DAS and T_7 - control

Application of botanicals *i.e.* *Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v* , hand weeding and untreated control has no detrimental effect on leghemoglobin content of legumes.

From the correlation matrix table 5.1 – 5.4 it has been cleared that nodule leghemoglobin content has no significant correlation on the yield attributing characters and yield. Shveta and Dhingra (2003) also reported that application of pendimethalin @1.0 kg ha^{-1} recorded significant decline in nodule number (24.5%) and nodule dry weight (14.8%) but did not show any effect on seed yield of legume crop. Significant negative correlations were found in case of soil micro flora and leghemoglobin content.

5.3 Effect of weed management methods on crop growth

In case of all experiments minimum growth parameter *i.e.* plant height, LAI, dry matter, CGR, root volume was found in untreated control throughout crop growth and the possible reason behind this phenomenon was the early shading of crop by weeds, which could not make up at later stages of crop growth. HW at 20 DAS kept the plot almost weeds free throughout season and provide suitable situation for better crop growth. As result maximum growth parameters were found from HW treatment in case of all four legumes. HW recorded 15.13, 16.74, 16.67 and 17.46 % increase over average dry matter accumulation in groundnut, soybean, green gram and black gram experiments respectively.

Among the chemical herbicide treatments in contrast of plant height, LAI, dry matter accumulation, crop growth rate and root volume of crops were greatly influenced by Imazethapyr 10 SL treatment at harvest, this was probably due to the long time weed control in crop field which resulted in minimum competition to crop. The available situation helped the crop plant for optimum utilization of growth resources that was reflected in physiological index. Imazethapyr 10 SL showed 13.86, 15.09, 14.92 and 15.51 % increase over average dry matter accumulation in groundnut, soybean, green gram and black gram experiments respectively. Similar kind of observation was also reported by Velu *et al.* (1994) and Deore *et al.* (2008) in legume crops.

Application of Oxyfluorfen 23.5 EC @ 200 g ha^{-1} also kept the plots free from monocot and dicot weeds during the entire growth period of all crops, which was ultimately, reflected higher growth parameters of legume crops as compared with rest of the treatments. Widaryanto (1994) observed same kind of results. Quizalofop-ethyl 5 EC @ 50 g a.i. ha^{-1} and Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1} ensured only monocot weed control in the fields so dominant dicot weeds present in the crop field offered slightly higher competition as compared with other chemical herbicide treated plots.

Ability of botanicals *i.e. Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v* to manage monocot weeds provide lesser competition to crop in comparison to weedy check and showed 9.39, 7.83, 9.82 and 11.54 % higher dry matter accumulation in groundnut, soybean, green gram and black gram experiments respectively.

Correlation matrix table 5.1-5.4 showed that crop biomass and root volume was positively correlated in case of all legumes. Positive correlations were also found with yield attributing characters and yield. Jain *et al.* (1996) reported that all growth parameters of legume gave higher values with herbicides Oxadiazon, oxyfluorfen, fluchloralin and metribuzin. CGR was positively correlated with seed yield (r = 0.4568) and crop biomass (r = 0.4597), and was described by the regression equation (Y = 1281.04 + 48.761X). Regarding dry mass of the weed negative significant relationship was noticed.

5.4 Effect of weed management methods on yield attributing characters and yield

The data on different yield attributes and yield clearly indicate that all weed management treatments significantly improve the pod $plant^{-1}$ and seed pod^{-1} that was ultimately reflected in higher yield values. HW at 20 DAS showed higher yield attributes and yield of all four legumes. This was mainly due to good control of weeds, better crop establishment and growth, maximum utilization of growth resources and proper diversification of photosynthate. The yield attributes like pod $plant^{-1}$ and seed pod^{-1} were greatly influenced by Imazethapyr 10 SL. The reason for higher yield attributing characters was that Imazethapyr 10 SL provide better aeration and minimum competition to crop throughout the growth period. These two treatments recorded 51.89 & 47.88 % (groundnut), 83.15 & 78.17 % (soybean), 53.34 & 49.09 % (green gram) and 75.83 & 74.17 % (black gram) higher pod $plant^{-1}$ and 40.00 & 37.84 % (groundnut), 37.68 & 36.23 % (soybean), 43.16 & 41.04 % (green gram) and 34.69 & 33.56 % (black gram) higher seed pod^{-1} over weedy check where maximum crop-weed competition was noted throughout the crop growth period. Regarding yield they showed 26.92 & 22.31 % (groundnut), 31.09 & 25.91 %

(soybean), 25.14 & 20.83 % (green gram) and 26.00 & 17.63 % (black gram) increased value over average seed yield. Similar kind of observations was also reported by Bhattacharya *et al.* (1996), Singh *et al.* (2002 and 2004), Chandel and Saxena (2001), Rani *et al.* (2004) and Veeraputhiran *et al.* (2008) in legume crops.

Similarly, PE application of Oxyfluorfen 23.5 EC @ 200 g ha^{-1} recorded higher number of pod plant^{-1} and seed pod^{-1} as compared with rest of treatments due to its higher weed control ability that create conductive environment for crop growth and more competitiveness to crop. Hiremath *et al.* (1997) Kumar (1993) Rafey and Prasad (1995) Velu *et al.* (1994), Jain *et al.* (1996), Thakare *et al.* (1998), Singh *et al.* (2003), Shaikh *et al.* (2002) also reported same findings. POE application of Quizalofop-ethyl 5 EC and Fenoxaprop-p-ethyl 9 EC increased yields according to their merit of weed controlling ability.

PE application of *Calotropis* raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v* attributed 10.69 & 7.03 % (groundnut), 23.44 & 7.73 % (soybean), 8.75 & 11.24 % (green gram) and 21.09 & 2.72 % (black gram) higher pod plant^{-1} and seed pod^{-1} and ultimately provide 57.53 % (groundnut), 22.05 % (soybean), 12.32 % (green gram) and 22.09 % (black gram) higher seed yield due to the initial checked monocot weed growth. Under untreated control plot minimum seed yield was obtained mainly due to heavy weed pressure and poor initial crop growth.

Significant positive correlations were also found in case of yield attributing characters with yield of groundnut, soybean, green gram and black gram. Yield of these crops was negatively correlated with total weed dry mass. Similar kind of result was also found by Jhala *et al.* (2005).

5.5 Effect of weed management methods on soil micro flora

Data on soil micro flora population revealed that application of chemical herbicides initially hampered the microbial population of soil at *rhizosphere* region. The reason behind the decreased micro flora population immediately after application of synthetic chemical herbicides, may be as PE or POE, is the toxic effect of these chemicals that affect the microbes, as a result they were not multiplied normally. But at harvest the microbe population showed higher in number in respect of the initial. This kind of results happened because all the herbicides used in this experiment having low persistency so they degraded in soil shortly ; as a result they released

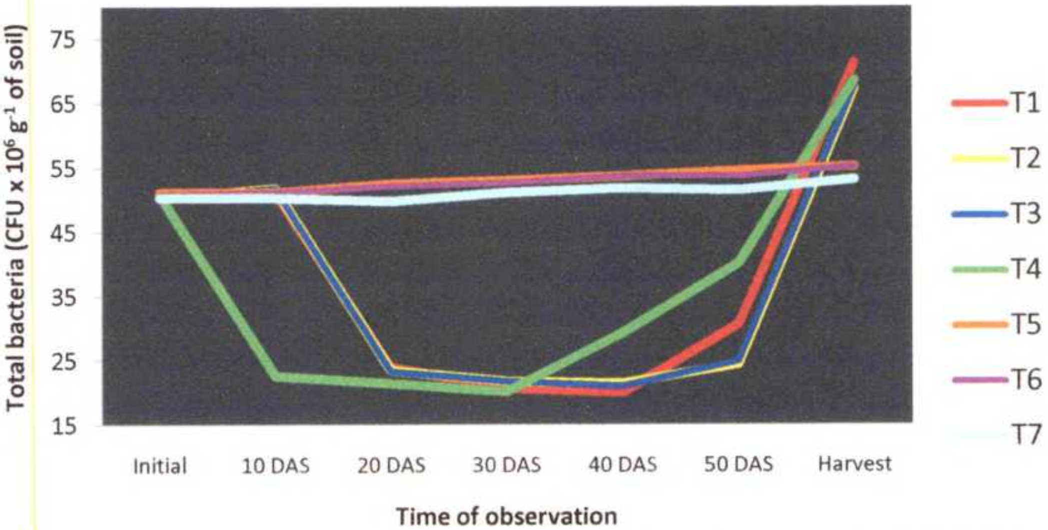


Fig. 5.17 Influence of treatments on population (mean) of total bacteria (CFU x 10^6 g^{-1} of soil)

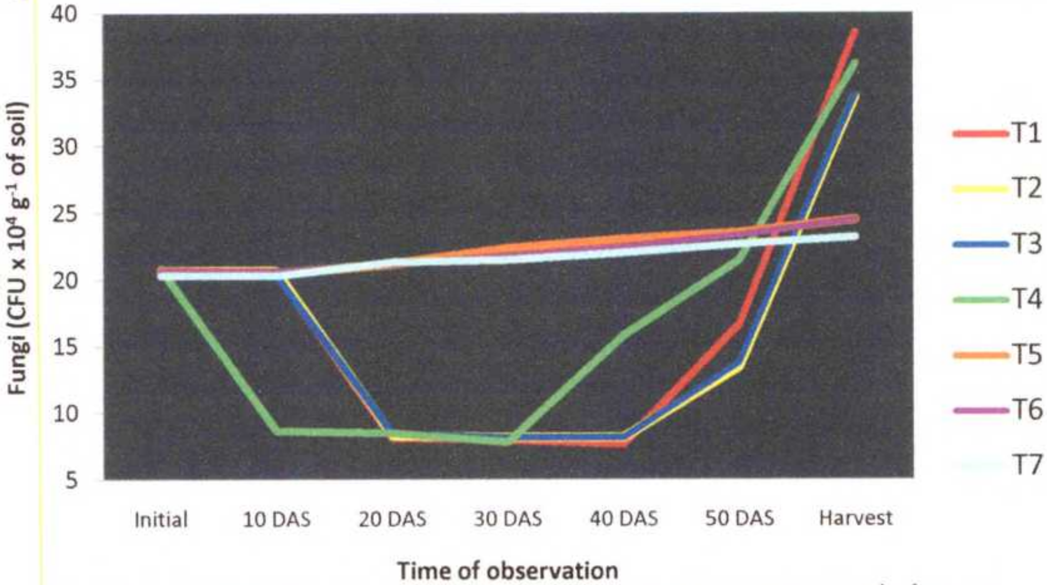


Fig. 5.18 Influence of treatments on population (mean) of Fungi CFU x 10^4 g^{-1} of soil)

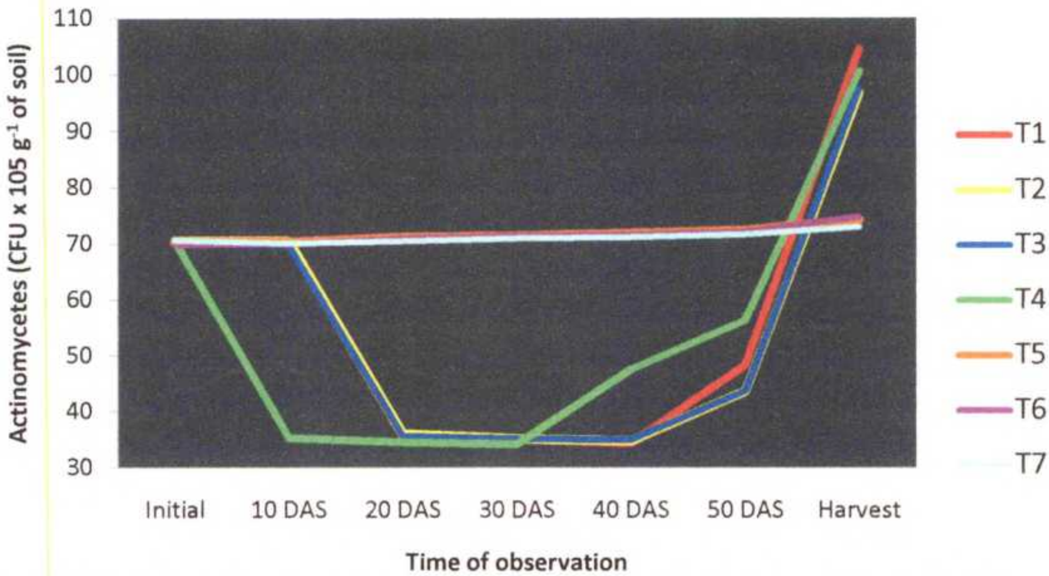


Fig. 5.19 Influence of treatments on population (mean) of Actinomycetes (CFU x 10^5 $g^{-1}$of soil)

organic carbon in the soil, which is the main nutrient of soil microbs. It is evident that Oxyfluorfen 23.5 EC and Imazethapyr 10 SL treated plot started in population increasing almost after 30 days of application where as Quizalofop-p-ethyl 5 EC and Fenoxaprop-p-ethyl 9 EC after 45-50 days. At harvest maximum population of all microbes *i.e.* total bacteria, fungi and actinomycetes found in Imazethapyr 10 SL applied plot this was due to addition of higher carbone in the soil, showed 17.53, 17.78, 18.69 and 19.19 % increased soil micro flora over average population in groundnut, soybean, green gram and black gram experiments respectively.

Calotropis raw leaf extract @ 5% *v/v* + *Parthenium* raw leaf extract @ 5% *v/v* on other hand did not show any detrimental effect that of the synthetic chemicals in respect of population of total bacteria, fungi and actinomycetes of *rhizosphere* soil in all four legume crop field. This may be due to the reason that natural allelochemicals derived from botanicals had lesser effect on the soil microbes. Plots where untreated control was adopted gave lowest reading of micro flora population at harvest. Choudhari *et al.* (2009) also reported same kind of result.

Regarding soil micro flora population significant negative correlations were found with nodulation characters of crops (Table 5.1 to 5.4)

5.6 Effect of weed management methods on follow up crop

No phytotoxic effect was found in the follow up crops of all four experiments because all the synthetic chemical herbicides and natural botanicals used in this experiment were degraded shortly and also having low persistency in the soil. Similar kind of findings was also found by Tiwari and Kurchania (2007) when pre-emergence herbicides used in legume crops.

5.7 Economics of weed management

The highest benefit : cost (2.61 for groundnut, 3.23 for soybean, 2.09 for green gram and 2.30 for black gram) with a net profit (Rs. 53584 ha^{-1} for groundnut, Rs. 41925 ha^{-1} for soybean, Rs. 18185 ha^{-1} for green gram and Rs. 21300 ha^{-1} for black gram) was recorded by POE application of Imazethapyr 10 SL treatment. Hand weeding recorded maximum value of produce due to highest yield but the maximum additional investment was also incurred because of more labour requirement for removal of weeds at 20 DAS. Similar kind of result was also found by Sasikala *et al.* (2004), Deore *et al.* (2007) and Kundu *et al.* (2009) by herbicide weed management of legumes. In case of untreated control plot minimum produce was obtained as a result net return was also became minimum finally recorded lowest benefit : cost.

Chapter-6

Summary & Conclusion

SUMMARY AND CONCLUSION

Field experiment conducted at Instructional Farm (Jaguli), Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia during pre-*kharif* (summer) 2009 and 2010 on groundnut, soybean, green gram and black gram with the objectives to study the effect of both synthetic herbicides and natural botanicals on nodulation, yield and bio-efficacy & phytotoxicity on both weeds and crops and also their effect on soil micro flora. Four separate experiments were carried out with oilseed legumes (groundnut & soybean), pulse legumes (green gram and black gram) in randomized block design with three replications and seven treatments *viz.* POE application of herbicides Imazethapyr 10 SL @100 g ha^{-1} (T_1), Quizalofop-ethyl 5 EC @ 50 g ha^{-1} (T_2) and Fenoxaprop-p-ethyl 9 EC @ 50 g ha^{-1} (T_3); PE application of Oxyfluorfen 23.5 EC @ 200 g ha^{-1} (T_4) and tank mixture of botanicals *Calotropis* & *Parthenium* raw leaf extract 5% *v/v* (T_5) besides hand weeding at 20 DAS (T_6) and control (T_7).

The dominant weed flora in all these four summer legume crops were *Echinochloa colona* , *Digitaria sanguinalis* , *Dactyloctenium aegyptium* (grass monocot) , *Cyperus rotundus* that only sedge monocot and *Digera arvensis* , *Physalis minima* , *Trianthema portulecastrum* were among dicot weeds. Due to potentiality of the *Cyperus rotundus* to survive in the worst situation, networking ability of tubers under the soil surface and rapid spreading during summer season in aerobic ecosystem found most dominant weed throughout the experimental period in all up land crops including these leguminous crop fields. Different herbicides and botanicals were applied either as PE or POE resulted different density or dry weight of weed flora was at different observation dates. The ability of Imazethapyr 10 SL to control both grassy monocots and dicot categories of weeds could effectively reduce the total weed density and dry weight up the third observation at 45 DAS and therefore created a situation favourable crop growth due to lesser competition of weed followed by PE Oxyfluorfen 23.5 EC. Quizalofop-ethyl 5 EC and Fenoxaprop-p-ethyl 9 EC also applied as POE but were only able to manage the monocot weeds and did not show any response on dicot weeds. Botanicals applied in the form of *Calotropis* + *Parthenium* raw leaf extract @ 5% *v/v* were effective only against annual monocot weed flora and unable to show any efficacy neither on perennial monocots nor on dicot weeds in any of the experiments. Lowest monocot and dicot weed flora population and dry weight was observed in HW at 20 DAS treatment because it can able to manage all type of weed flora, the monocot grass, sedge and dicot broad leaves. Correlation matrix showed that the total bio mass of weed is negatively correlated with growth and yield characters of legumes.

The nodulation results from the pooled data of 2009 & 2010 revealed that in all four crops in terms of number of nodules plant^{-1} has reduced by 5.45 % in goundnut, 7.34 % in soybean, 6.27 % in green gram and 4.93 % in black gram as against application of three POE chemicals at flowering stage. The corresponding figures were 2.47 %, 2.63 %, 3.46 % & 2.18 % decreased in PE herbicides and 6.96 %, 8.65 %, 7.52 % & 5.70 % increased for PE botanicals respectively. The dry weight of nodules were also followed the same trend of variations. The leghemoglobin contents were also recorded similar variations with reduction of 3.45 % in goundnut, 3.67 % in soybean, 7.46 % in green gram and 10.11 % in black gram as against application of three POE chemicals. The corresponding figures were 1.19 %, 1.00 %, 1.88 % & 3.65 % decreased for PE chemicals and 3.78 %, 3.89 %, 7.90 % & 10.22 % increased for natural botanicals.

All the four chemical herbicides applied on legumes showed an adverse affect on the *rhizobium* population, as a result, symbiotic association of root nodule-*rhizobium* were also reduced at least up to 15 DAA. Thereafter when the herbicides were degraded the multiplication of *rhizobium* bacteria again reinitiated and as a result due to symbiotic association of *rhizobium* with newly emerged root could able to produced higher nodule number at later stage. With increase of the nodule-*rhizobium* symbiotic association in all four legumes along with progress of the crop growth the leghemoglobin content was also increased. This may be due to the reason that nodules are generally formed when a single bacterium infects a root hair and subsequently bacterial infection can only occur with the bacteria and root hairs association. Therefore, at later stage of the crop when chemicals were degraded, in the newly appeared root hairs of fresh roots the nodule-*rhizobium* symbiotic association was reinitiated.

The observations on micro flora population of the soil showed almost similar to that of nodulation – an initial decrease followed by increase up to harvest. The natural allelochemicals derived from the botanicals are not so toxic and therefore, did affect neither the nodulation nor the process of production of the microflora in soil. Hand weeding also did not show any adverse effect either on nodulation or on micro flora population of the experimental soil.

As expected the growth and yield parameters of all four legumes were significantly lower in weedy check than rest of the weed management treatments. Hand weeding as recorded lowest weed dry matter in all observation excepting in first observation at 15 DAS, offered lesser competition to crop which ultimately reflected on the growth and yield of all legume crops followed by Imazethapyr 10 SL. These two treatments recorded 26.92 & 22.31 % (groundnut), 31.09 & 25.91 % (soybean), 25.14 & 20.83 % (green gram) and 26.00 & 17.63 % (black gram) higher yield over the average yield value of each four crops. The corresponding figures for the treatment Oxyflourfen was 6.15 %, 16.58 %, 12.64 % and 6.50 % respectively.

No phytotoxic effect was found in the follow up crops of all four experiments because all the synthetic chemical herbicides and botanicals used in this experiment were degraded shortly and also having low persistency in the soil.

The highest benefit: cost ratio with a net profit was recorded by POE application of Imazethapyr 10 SL treatment. Hand weeding recorded maximum value of produce due to highest yield but the additional investment incurred because of more labour requirement for removal of weeds was also maximum, thus benefit : cost ratio is lowered.

Therefore, from this experiment considering the benefit: cost ratio it can be recommended that for increasing the productivity by managing weed flora in legume oilseed and pulse crops, the safer chemicals or botanicals with proper doses and time of application, may be an alternative of the traditional hand weeding and these chemicals or botanicals also had no such detrimental effect on nodulation of these crops in this inceptisol.

Chapter-7

Future Scope of Research

FUTURE SCOPE OF RESEARCH

The present investigation is a modest agronomic trial with limited facilities to add some knowledge on the effect of herbicides on nodulation and yield of groundnut, soybean, green gram and black gram during the year 2009 and 2010 at Instructional Farm (Jaguli), Bidhan Chandra Krishi Viswavidyalaya, Mohanpur. The effect of different weed management approaches like chemical (both PE and POE), botanical, physical and ecological were evaluated in all four legumes. In addition to these, an attempt has been made to find out the effect of both synthetic herbicides and botanicals on nodulation characteristics of legumes, bio-efficacy & phytotoxicity on both weeds and crops and also their effect on soil micro flora.

As the result from the experiment showed positive response of chemicals and botanicals there are some tremendous future scope of works which may initiate in different agro-climatic conditions in systematic manner.

- Observation towards development of resistance on weeds with herbicides is to be kept under clear consideration.
- The experiments may be conducted with other legume crops with different types of herbicides.
- Future experiments on different concentrations of different botanicals to study their effect on weeds.
- The botanicals may be tried with some more formulations adding with different adjuvant.
- For better understanding of legume nodulation it may be important to undertake future studies on the nitrogenese enzyme activity.
- Effect of botanicals on the absorption and transformation pattern by soil and crops, its effect on plant enzymatic systems.
- The study on physico-chemical changes in soil due to different herbicide application is necessary.
- Instead of Randomized Block Design (R.B.D.), the experiment can be fitted in a Split Plot Design through investigation of different interaction.
- The similar experiments may be conducted in other agro-climatic zones like RLZ, HZ, TZ, C & S Zones.

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Appendices

Appendix -I

Cost of different materials and man units associated with these experiments,

Sl. No.	Particulars	Price (Rs.)
1.	Seed	
	i) Groundnut	80 kg^{-1}
	ii) Soybean	60 kg^{-1}
	iii) Green gram	40 kg^{-1}
	iv) Black gram	40 kg^{-1}
2.	Fertilizer	
	i) Urea	6 kg^{-1}
	ii) SSP	4.5 kg^{-1}
	iii) MOP	5.5 kg^{-1}
	iv) *Rhizobium* culture	70 per pack (200 g)
	v) *Trichoderma viride*	200 kg^{-1}
3.	Chemicals	
	i) Imazethapyr	175 (250 ml)
	ii) Quizalofop-ethyl	376 (250 ml)
	iii) Fenoxaprop-p-ethyl	160 (100 ml)
	iv) Oxyflourfen	650 (250 ml)
	v) Immidachlorprit	130 (50 ml)
4.	Machinery and man power	
	i) Irrigation	80 hr^{-1}
	ii) Ploughing	150 per ploughing
	iii) Man unit	167 $ManUnit^{-1}$
5.	Value of produce	
	i) Groundnut pod	40000 t^{-1}
	ii) Soybean seed	25000 t^{-1}
	iii) Green gram seed	40000 t^{-1}
	iv) Black gram seed	40000 t^{-1}