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Effect of weed managemant practices and levels of nitrogen on weed dynamics, yield and economics of maize-soybean intercropping system

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ABSTRACT

The field experiment was conducted during Kharif seasons of 2010 and 2011 at Research Farm, R.B.S. College, Bichpuri, Agra (U.P.) to study the effect of weedicides and nitrogen levels on weed dynamics, yield and economics of maize-soybean intercropping system. The treatments consisted of eight weed control in main plots and four nitrogen levels in sub-plots replicated thrice. The lowest weed density, weed dry matter and depletion of N, P and K were noted with Pendimethalin PE @ 1.5 kg ha^{-1}. This treatment resulted in the highest WCE (53.9%) and HEI (0.87). The highest depletion of N, P and K by weeds was noted with the application of 120 kg N ha^{-1} but this was statistically at par with 80 kg N ha^{-1}. Significantly higher bio-mass of maize (100.62 q ha^{-1}), grain (38.93 q ha^{-1}), stover (61.69 q ha^{-1}) and MEY (83.84 q ha^{-1}) were obtained with the application of Pendimethalin PE @ 1.5 kg ha^{-1}. The per cent increases in bio-mass, grain; stover production and MEY by 120 kg N ha^{-1} over control were 96.1, 97.8, 96.2 and 101.0, respectively. The application of Pendimethalin PE @ 1.5 kg ha^{-1} produced significantly higher bio-mass (30.29 q ha^{-1}), grain (12.00 q ha^{-1}) and straw yield (18.29 q ha^{-1}) of soybean over rest of the weed control treatments except Oxyfluorfen pre-em @ 0.150 kg ha^{-1}. Application of 120 kg N ha^{-1} resulted in highest bio-mass, grain and straw yield but this was statistically at par with 40 and 80 kg N ha^{-1} in these respects. The maximum net return (₹ 42810 ha^{-1}) and B:C (3.45) ratio were obtained with Pendimethalin PE @ 1.5 kg ha^{-1}. Application of 120 kg N ha^{-1} gave the highest net return (₹ 44,060) and B:C ratio (3.44).

Keywords: Maize, soybean, weedicides, nitrogen, yield, economics

INTRODUCTION

Maize (*Zea mays*) is one of the most important cereal grown over diverse environments and has varied uses as food, feed and fodder. In maize the wider row spacing and sowing of the crop with the onset of monsoon provide favourable environment for weed growth and help them to absorb more nutrients as compared to crop plants, apart from offering competition for light, space and moisture. Compared to most cereals, maize faces interference of weeds to a greater degree, especially during the rainy season, which is the main growing period in north India. In the absence of appropriate weed management, yield losses may vary from 40-60% (Choudhary *et al.* 2013). Thus, not only numbers of the crops but the type of the crops included in the intercropping system are also important. For this, heavy reliance on cereals need to be shifted to other food like pulses. Maize a widely-spaced crop provides ample opportunity for intercropping short duration varieties of pulses and oilseeds, namely frenchbean, soybean, cowpea and greengram. Intercropping of maize with different legumes improves the fertility status of the soil which is beneficial to succeeding crops (Kaushal *et al.* 2015). The malnutrition caused due to short supply of protein calories is posing a serious threat to be the over growing population of developing countries and India is no exception to this fact. India's population is projected to continue growing for several decades to 1.5 billion in 2030 and 1.7 billion in 2050 (DESA, 2015). The gap between the requirement and supply of protein has to be bridged at an early date particularly through vegetable source because of the dominating religious and social consideration in the country. Soybean (*Glycine max* L. Merrill) has an average protein content of 40% and is more protein-rich than any of the common vegetable or animal food sources. Soybean seeds also contain about 20% oil on a dry matter basis, and this is 85% unsaturated and cholesterol-free (Bekabil, 2015). The most common advantage of intercropping is the production of greater yield on a given piece of land by making more efficient use of the available resources using a mixture of crops of

different rooting ability, canopy structure, height and nutrient requirements based on the complementary utilization of growth resources by the component crops. Moreover, intercropping improves soil fertility through atmosphere nitrogen fixation from atmosphere (150 tons year^{-1}) with the use of legumes, increases soil conservation through greater ground cover than sole cropping (Dwivedi *et al.* 2015). Weed control under such condition is necessary to take full advantage of other technological advancements in crop production. Weed free environment is now a foreseeable reality for most crops including maize planted in rows for full expression of new varieties, added fertility, irrigation etc. required for higher productivity. In Indian soils nitrogen is most important element which needs region wise standardization (Singh, 2017). Maize-soybean intercropping deserves all over wherein both nitrogen and weed management have not studied simultaneously in agro climatic condition of Agra region.

MATERIALS AND METHODS

The field experiment was conducted during kharif seasons of 2010 and 2011 at Agricultural Research Farm, R.B.S. College, Bichpuri, Agra, situated at 27^0 2' N latitude, 77^0 9' E longitude and altitude of 163.4 m above mean sea level. The average annual rainfall of the centre was 665 mm and most of which (84%) is contributed by south west monsoon during July to September. The experimental soil was sandy loam in texture containing organic carbon 3.8 g kg^{-1}, available N 189, P_2O_5 29 and K_2O 313 kg ha^{-1} with pH 8.6 and EC 1.65 dSm^{-1} at 25^{0}C. Thirty two treatment combinations comprising eight weed-control measures were applied (W_0-Weedy check, W_1-Hand weeding at 25 DAS, W_2-Oxyfluorfen PE @ 0.100 kg ha^{-1} , W_3-Oxyfluorfen PE @ 0.150 kg ha^{-1} , W_4-Pendimethalin PE @ 1.000 kg ha^{-1} , W_5-Pendimethalin PE @ 1.500 kg ha^{-1} , W_6-Metribuzin PE @ 0.500 kg ha^{-1} and W_7-Metribuzin PE @ 0.750 kg ha^{-1}) and four nitrogen levels (0, 40, 80 and 120 kg ha^{-1}) were tested in split plot design and replicated thrice with weed-control measures in main plot and levels of nitrogen in sub-plots. The crops were sown in the first week of July during 2009 and in second week of July during 2010. The maize variety 'Megha' and soybean variety PK 472 were used as main and intercrop, respectively. The crop was fertilized with N as per treatment and phosphorus (60 kg), potassium (40 kg) and zinc (30 kg) ha^{-1}. Urea, single super phosphate, muriate of potash and $ZnSO_4$ were used as the source of N, P_2O_5, K_2O and Zn, respectively. Half dose of N as per treatment and full dose of P_2O_5, K_2O and Zn were applied at the time of sowing as basal below the seed. The remaining half dose of N was top dressed at knee high stage of maize crop. Weedicides were sprayed as pre emergence by Knapsack sprayer fitted with flat fan nozzle using 500 litres of water ha^{-1}. Observations on weed density were recorded from 0.25 m quadrate at two places in the net plot and converted in to density m^{-2}. The data were subjected to transformation to normalize their distribution. Later these samples were dried at 70^{0}C till a constant weight. The dry matter was then computed in terms of g m^{-2}. The dried weed and crop grain and stover samples were analyzed for their nitrogen and phosphorus content as per standard procedures (Prasad *et al.*, 2006). The uptake of N, P and K by weed was worked out by multiplying their content values with dry matter. Weedy check plots remained infected with native population of weeds till harvest. The data on weed density and weed dry weight were subjected to transformation $\sqrt{X+1}$ before statistical analysis. Weed control efficiency (WCE) and herbicide efficiency index (HEI) was calculated with the following expression.

$$WCE\ (\%) = \frac{DWC - DWT}{DWC} \times 100$$

Where, WCE, Weed control efficiency; DWT, Dry weight of weed in treated plot; DWC, Dry weight of weed in unweeded control plot.

$$HEI = \frac{\frac{Y_t - Y_c}{Y_c} \times 100}{\frac{DMT}{DMC} \times 100}$$

Where, HEI, Herbicide-efficiency index; Y_t, yield from treated plot; Y_c, yield from unweeded control plot; DMT, dry-matter of weeds in treated plot; DMC, dry matter of weeds from unweeded control plot .

Eight plants (maize + soybean) which were tagged in each net plot pulled out before harvesting and these were utilized for

observations regarding per plant, yield contributing characters. The straw/stover yield was computed by deducting the grain yield from the total biological yield. The economics was work out based on pooled yield data and considering price of inputs and output based on prevailing market price.

RESULT AND DISCUSSION

Effect on weeds

The experimental crops were infested with *Cyperus rotundus*, *Trianthema monogyna*, *Echinochloa colonum*, *Cynodon dectylon* and *Phyllanthus niruri* during the crop seasons. The most dominant weeds were *Cyperus rotundus* and *Trianthema monogyna.* The lowest weed density was noted with Pendimethalin PE @ 1.5 kg ha^{-1} and next best treatment was Oxyfluorfen PE @ 0.15 kg ha^{-1} in this regard and both these treatments were found significantly superior as compared to all other treatments (Table-1). A comparison of hand weeding with chemical method quite clearly indicated that the intensity of weeds in sprayed plots was very much reduced. This may be suppression effect of weeds in the herbicide sprayed plots. Application of Pendimethalin PE @ 1.5 kg ha^{-1} also significantly reduced the weeds dry matter and Oxyfluorfen PE@ 0.150 kg ha^{-1} stood second best in this regard and it was also significantly superior to other treatments expect W_4. With these chemical treatments, the weed population was very much suppressed and hence the dry weight was considerably lower. These results confirm by the findings of Navell *et al.* (2014). The maximum weed control efficiency was found with Pendimethalin PE @ 1.5 kg ha^{-1}. This might be owing to lower weed density and dry-matter production of weed which resulted successful checking of weed growth under this treatment. The higher herbicide efficiency index resulted with Pendimethalin PE @ 1.5 kg ha^{-1} followed by Oxyfluorfen PE@ 0.150 kg ha^{-1} which may be owing to the better control of weeds resulting in higher weed-control efficiency under these treatments. The lowest WCE and HEI were obtained with hand weeding at 25 DAS and metribuzin PE @ 0.5 kg ha^{-1}, respectively. Similar results have also been reported by Yadav *et al.* (2015). The lowest depletion of N, P and K by weeds was obtained with Pendimethalin PE @ 1.5 kg ha^{-1} and the next best treatment was Oxyfluorfen PE @ 0.150 kg ha^{-1} and both the treatments were significantly superior to all other treatments. This happened because of reduction in growth of weeds and lower dry matter accumulation under W_5 treatment which resulted lower depletion of these nutrients as compared to all other treatments.

None of nitrogen level had significant effect reducing weed density and weed dry weight (Table 1). Weed density increased with every increase in the level of nitrogen up to 120 kg N ha^{-1}. However, the dry matter of the total weeds tended to increase with increasing N rates. Thus, the maximum dry weight of total weeds was obtained with 120 kg N ha^{-1} and the lowest with control. Application of 120 kg N ha^{-1} recorded highest depletion of weeds by nitrogen but this level of nitrogen was significantly at par with 80 kg N ha^{-1}. The depletion of P and K by weeds increased significantly with every increase in the level of nitrogen up to 80 kg N ha^{-1}. Although, the highest depletion of P and K by weeds was noted with the application of 120 kg N ha^{-1} but this was statistically at par with 80 kg N ha^{-1}. Manan *et al.* (2013) also reported an increase in nitrogen, phosphorus and potassium uptake in maize.

Yield attributes

The yield attributes differed significantly due to different weedicidal treatments (Table 2). Significantly higher cobs $plant^{-1}$ (1.96) was obtained with the application of Pendimethalin PE @ 1.5 kg ha^{-1} followed by Oxyfluorfen pre-em @ 0.150 kg ha^{-1}. These treatments proved significantly superior to over all other treatments. The maximum weight of cobs $plant^{-1}$ (266.35g) was recorded with Pendimethalin PE @ 1.5 kg ha^{-1} but this was statistically at par with Oxyfluorfen pre-em @ 0.150 kg ha^{-1}. Pendimethalin PE @ 1.5 kg ha^{-1} gave significantly higher seeds cob^{-1} and weight of seeds cob^{-1} as compared to other weedicidal treatments. The maximum shelling percentage (68.01%) was obtained with Pendimethalin PE @ 1.5 kg ha^{-1} and this treatment also proved significant superiority over all to other treatments except Oxyfluorfen pre-em @ 0.150 kg ha^{-1}. Among all the weedicidal treatments, maximum reductions in all yield attributes were recorded in

Table 1: Weed density; weed dry matter, WCE, HEL and nutrients depletion by weeds at 60 DAS as affected by weedicides and nitrogen in maize-soybean intercropping (pooled data of 2 years)

Treatments	Weed density (no m^{-2})	Weed dry matter (g m^{-2})	Weed-control efficiency (%)	Herbicide Efficiency Index	Nutrients depletion by weeds (kg ha^{-1})		
					N	P	K
Weed control measures							
Weedy check	15.3 (234.7)	20.7 (431.1)	00.0	0.00	69.9	25.2	63.5
Hand weeding at 25 DAS	12.6 (159.6)	17.5 (307.6)	28.6	0.33	51.7	20.6	48.9
Oxyfluorfen PE @ 0.10 kg ha^{-1}	10.0 (100.0)	16.2 (264.4)	38.7	0.44	47.6	18.2	42.9
Oxyfluorfen PE @ 0.15 kg ha^{-1}	8.8 (77.3)	14.8 (221.3)	48.7	0.70	41.7	16.6	38.1
Pendimethalin PE @ 1.00 kg ha^{-1}	9.4 (88.9)	15.5 (241.8)	43.9	0.58	44.6	17.7	40.1
Pendimethalin PE @ 1.50 kg ha^{-1}	8.2 (67.6)	14.1 (198.8)	53.9	0.87	38.8	15.7	35.2
Metribuzin PE @ 0.50 kg ha^{-1}	11.4 (131.6)	17.0 (290.3)	32.7	0.18	49.9	18.1	44.3
Metribuzin PE @ 0.75 kg ha^{-1}	10.7 (115.6)	16.5 (271.9)	36.9	0.26	47.8	17.1	42.7
SEm±	0.22	0.25	1.51	0.09	0.89	0.13	0.61
CD (P=0.05)	0.64	0.74	4.56	0.26	2.75	0.42	1.92
Nitrogen (kg ha^{-1})							
0	10.9 (119.3)	16.3 (267.3)	-	-	43.2	15.4	39.6
40	11.0 (121.8)	16.7 (277.9)	-	-	46.9	17.3	42.9
80	11.1 (122.9)	16.8 (283.0)	-	-	51.9	20.3	47.0
120	11.1 (123.6)	16.9 (285.7)	-	-	53.8	21.3	48.4
SEm±	0.18	0.21			0.71	0.43	0.55
CD (P=0.05)	NS	NS			2.10	1.22	1.68

Metribuzin PE @ 0.5 kg ha^{-1} due to more competition effect. It was ascribed due to the vigorous crop growth in the treated plot than the weedy check treatment. The similar results were reported by Bahar and Singh (2013). The number of cobs and weight of cobs per plant increased significantly with every increase in the level of nitrogen up to 80 kg N ha^{-1}(Table 2). Although, the maximum number of cobs and weight of cobs per plant was obtained with 120 kg N ha^{-1} which was statistically at par with 80 kg N ha^{-1}. The seeds cob^{-1}, weight of seeds cob^{-1} and shelling percentage increased significantly with every increasing level of nitrogen up to 120 kg N ha^{-1}. The per cent increase in seeds cob^{-1}, weight of seeds cob^{-1} and shelling percentage under120 kg N ha^{-1} over control were 15.2, 25.4 and 4.9, respectively. Better crop growth and higher nutrient uptake increased the leaf gas exchange parameters like photosynthetic rate, stomatal conductance and better transpiration rate might have influence the yield attributes favourably. Ramachandiran and Pazhanivalan (2016) made similar observations.

Table 2: Yield contributing characters of maize and soybean as affected by weedicides and nitrogen in intercropping (pooled data of 2 years)

Treatments	Maize					Soybean				
	Cobs plant^{-1}	Weight of cobs plant^{-1} (g)	Seeds cob^{-1}	Weight of seeds cob^{-1}	Shelling percentage	Pods plant^{-1}	Weight of pods plant^{-1} (g)	Seeds pod^{-1}	Weight of seeds plant^{-1} (g)	Shelling percentage
Weed control measures										
Weedy check	1.19	218.6	324.3	132.5	60.7	31.9	24.1	2.44	9.6	38.8
Hand weeding at 25 DAS	1.30	241.2	341.2	154.1	63.9	40.5	31.9	2.82	13.7	38.8
Oxyfluorfen PE @ 0.10 kg ha^{-1}	1.46	245.2	345.6	158.4	64.6	44.2	35.2	2.84	15.3	42.1
Oxyfluorfen PE @ 0.15 kg ha^{-1}	1.80	261.2	363.8	173.9	66.8	54.6	44.6	3.11	20.1	42.9
Pendimethalin PE @ 1.00 kg ha^{-1}	1.63	248.9	352.9	164.6	66.2	51.0	40.8	2.93	18.1	44.5
Pendimethalin PE @ 1.50 kg ha^{-1}	1.96	266.4	369.2	181.0	68.0	59.6	48.1	3.15	22.3	43.7
Metribuzin PE @ 0.50 kg ha^{-1}	1.22	232.4	333.6	145.2	62.8	36.7	29.1	2.67	12.1	45.8
Metribuzin PE @ 0.75 kg ha^{-1}	1.29	235.4	338.1	149.6	63.5	38.7	30.7	2.75	13.0	40.9
SEm±	0.05	1.73	0.40	0.89	0.39	0.51	1.07	0.05	1.15	1.00
CD (P=0.05)	0.14	5.15	1.24	2.63	1.24	1.52	3.23	0.17	2.46	2.08
Nitrogen (kg ha^{-1})										
0	1.19	217.4	316.8	136.4	62.7	26.1	18.2	2.27	6.9	38.0
40	1.46	242.1	344.2	156.2	64.4	50.3	39.6	2.95	17.0	43.3
80	1.60	254.5	358.7	166.1	65.3	50.9	41.7	3.04	18.8	44.1
120	1.67	260.7	365.1	171.1	65.8	51.2	42.7	3.10	19.4	44.7
SEm±	0.04	2.11	0.30	0.72	0.14	0.37	1.07	0.07	0.80	0.48
CD (P=0.05)	0.11	6.25	0.89	2.14	0.45	1.12	3.18	0.21	2.43	1.46

PE, Pre emergence; DAS, days after sowing

Application of Pendimethalin PE @ 1.5 kg ha^{-1} produced significantly higher number of pods and weight of pods per plant of soybean over all other treatments (Table 2). The number of seeds per pod, weight of seeds per plant and shelling percentage improved significantly with the application of Pendimethalin PE @ 1.5 kg ha^{-1} as compared to other herbicidal treatments except Oxyfluorfen pre-em @ 0.150 kg ha^{-1}. The increasing number of pods, weight of pods, seeds per pod, weight of seeds per plant and shelling percentage with Pendimethalin PE @ 1.5 kg ha^{-1} was the tune of 87.1, 99.9, 29.1, 135.6 and 17.9 per cent, respectively over weedy check. Such results were also reported by Chander *et al.* (2014). All the yield attributes

Table 3: Yield and economics of maize and soybean as affected by weedicides and nitrogen (pooled data 2 years)

Treatments	Maize			Soybean			Maize equivalent yield (q ha^{-1})	Cost of cultivation (x10^3 ₹ ha^{-1})	Gross return (x10^3 ₹ ha^{-1})	Net return (x10^3 ₹ ha^{-1})	B:C Ratio
	Biological yield (q ha^{-1})	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Biological yield (q ha^{-1})	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})					
Weed control measures											
Weedy check	78.78	27.81	50.97	17.81	5.70	12.11	55.14	16.78	39.51	22.74	2.36
Hand weeding at 25 DAS	92.99	34.28	58.71	22.70	7.98	14.72	69.51	17.98	49.58	31.60	2.76
Oxyfluorfen PE @ 0.10 kg ha^{-1}	94.77	35.29	59.48	23.51	8.41	15.10	71.92	17.12	51.23	34.01	2.99
Oxyfluorfen PE @ 0.15 kg ha^{-1}	99.25	37.79	61.46	30.02	11.84	18.18	81.65	17.19	59.04	41.85	3.44
Pendimethalin PE @ 1.00 kg ha^{-1}	97.66	36.84	60.82	26.82	10.11	16.71	77.22	17.33	55.40	38.07	3.20
Pendimethalin PE @ 1.50 kg ha^{-1}	100.62	38.93	61.69	30.29	12.00	18.29	83.84	17.50	60.32	42.81	3.45
Metribuzin PE @ 0.50 kg ha^{-1}	87.01	31.24	55.77	22.35	7.74	14.61	64.07	17.63	46.19	28.56	2.62
Metribuzin PE @ 0.75 kg ha^{-1}	89.33	32.34	56.99	22.62	7.92	14.70	66.21	17.95	47.64	29.69	2.66
SEm±	0.60	0.50	0.22	0.24	0.10	0.09	0.41	-	-	-	-
CD (P=0.05)	1.28	1.07	0.47	0.73	0.30	0.27	1.24	-	-	-	-
Nitrogen (kg ha^{-1})											
0	58.27	21.52	36.75	14.99	4.84	10.15	43.36	16.78	31.06	14.28	1.86
40	90.59	33.60	56.99	27.59	10.25	17.34	72.15	17.22	52.57	35.35	3.05
80	106.63	39.54	67.09	27.71	10.35	17.36	82.08	17.66	58.84	41.17	3.33
120	114.68	42.56	72.12	27.78	10.41	17.37	87.17	18.10	62.19	44.06	3.44
SEm±	0.37	0.33	0.13	0.12	0.05	0.06	0.33	-	-	-	-
CD (P=0.05)	1.13	0.94	0.42	0.35	0.17	0.19	1.02	-	-	-	-

PE, Pre emergence; DAS, days after sowing

of soybean (number of pods, weight of pods, seeds per pod, weight of seeds per plant and shelling percentage) improved significantly with the application of 40 kg N ha^{-1} over control. Although the highest yield attributes were obtained with 120 kg N ha^{-1} but this was statistically at par with 40 and 80 kg N ha^{-1}. This might be due to enhanced translocation of nutrient at higher levels of nitrogen. Moreover, nitrogen helps in inproving growth and leaf area consequently resulting in more interception of light that aids in increased total photosynthesis and ultimately grain and straw yields (Munirathnam and Kumar, 2015). The per cent increase in these yield attributes due to application of 120 kg N ha^{-1} was 96.4, 134.5, 36.6, 183.5 and 17.5 per cent, respectively over no nitrogen application (control). These results were agreement with the observation reported by Chander *et al.* (2014).

Yield

Maize yield was significantly affected by different weed control measures (Table 3). Pendimethalin PE @ 1.5 kg ha^{-1} was significantly superior over all other weed control treatments with to bio-mass production (100.6 q ha^{-1}) which may be due to beneficial effect of lower weed population. The maximum grain production (38.9 q ha^{-1}) was obtained with Pendimethalin PE @ 1.5 kg ha^{-1} which was significantly higher over rest of the weed control treatments. Uncontrolled weedy check caused 40% reduction in grain yield of maize compared to Pendimethalin PE @ 1.5 kg ha^{-1}. The increase may be ascribed to the vigorous and enhanced plant growth and yield attributes in maize-soybean intercropping (1:1) as a result of reduced inter-row specific competition for solar radiation and plant nutrient. Solanki *et al.* (2011) also reported such effects of inter-row arrangement on yield of maize under maize+legume intercropping system. Among the weed management practices, pre emergence application of Pendimethalin @ 1.5 kg ha^{-1} was most effective in achieving significantly higher stover yield over other treatments except Oxyfluorfen PE @ 0.150 kg ha^{-1} and also obtained higher stover yield by 40% over weedy check. The highest maize-equivalent yield was recorded with Pendimethalin PE @ 1.5 kg ha^{-1} due to superiority in yield attributes of crop components. On the other hand, the lowest maize-equivalent yield was recorded with Metribuzin PE @ 0.5 kg ha^{-1}. On pooled basis, levels of nitrogen increased the bio-mass, grain and stover production significantly up to 120 kg N ha^{-1}. The per cent increase in bio-mass, grain and stover production by 120 kg N ha^{-1} over control were 96.8, 97.8 and 96.2, respectively. Application of 120 kg N ha^{-1} produced the highest maize-equivalent yield and this level was also significantly superior to other levels of nitrogen. Application of 120 kg N ha^{-1} increased the maize-equivalent yield by 101.0% over control. It is well emphasized that increasing rates of nitrogen improved overall growth of the crop in term of dry matter production per plant by virtue of its impact on morphological and photosynthetic components along with accumulation of nutrients. This suggest greater availability of nutrients and metabolite for growth and development of reproductive structure, which ultimately led to realization of higher productivity of individual plant (Singh and Sumeriya, 2012).

A perusal of data (Table 3) reveals positive response of various herbicidal and hand weeding treatments on the yields of soybean. The maximum bio-mass was produced with pre emergence application of Pendimethalin @ 1.5 kg ha^{-1} which was significant superior to other treatments except Oxyfluorfen pre-em @ 0.150 kg ha^{-1}. Application of Pendimethalin PE @ 1.5 kg ha^{-1} produced the significantly higher grain as well as straw over rest of the weed control treatments but this treatment was failed to show its significant superiority over Oxyfluorfen PE @ 0.150 kg ha^{-1}. The increasing bio-mass, grain and straw yield with Pendimethalin PE @ 1.5 kg ha^{-1} was the tune of 70.1, 110.5 and 51.0 per cent, respectively over weedy check. The increase in seed yield with the application of Pendimethalin PE @ 1.5 kg ha^{-1} can be attributed to the fact that the crops were kept free of competition at the early critical stages of growth resulting in the crops using the land and climatic resources more efficiently. These results are in confirmation with the findings of Dhane *et al.* (2011). The highest bio-mass production was obtained with the 120 kg N ha^{-1} which was statistically at par with 40 and 80 kg N ha^{-1}. Application of 120 kg N ha^{-1} resulted in highest seed yield (10.4 q ha^{-1}) and straw yield (17.8 q ha^{-1}) followed by 80 and 40kg N ha^{-1}. It is obviously that dry matter is a net saving of

photosynthesis and essential for the building up of plant organs, which ultimately reflect on bio-mass and straw production. Similar results have been reported by Thenua *et al.* (2010).

Economics

The highest cost of cultivation was involved in hand weeding at 25 DAS because of higher wages of manual labours (Table 3). Pendimethalin PE @ 1.5 kg ha^{-1} was the next costly treatment in this regard mainly because of its higher dose adopted. The highest gross return was obtained with pre emergence application of Pendimethalin @ 1.5 kg ha^{-1} and also gave highest net profit (₹ 42,810). The increase in B:C ratio due to different weed control measures over weedy check was 0.26 to 1.09 and maximum was 3.45 with the application of Pendimethalin PE @ 1.5 kg ha^{-1} closely followed by Oxyfluorfen PE @ 0.150 kg ha^{-1}. Choudhary *et al.* (2013) reported similar variation in net return and B:C ratio among treatments due to variation in yield and expenditure incurred by treatments. The cost of cultivation and gross return increased with every increase in the level of nitrogen up to 120 kg N ha^{-1}. The highest net return (₹ 44,060) and B:C ratio (3.44) was recorded with the 120 kg N ha^{-1}. It was followed by application of 80 kg N ha^{-1} which generated a net income being 7.0 per cent lower than the highest income generator treatment. The highest return under highest doses of N might be owing more MEY which led to proportionally highest gross return than cost of cultivation.

It may be concluded from the results that among the weed control treatments, pre emergence application of Pendimethalin @ 1.5 kg ha^{-1} proved superior for effective control of weeds, improving yield attributes, MEY and economic returns. However, the application of 120 kg N ha^{-1} produced the highest yield attributes, MEY and net returns over lower doses of nitrogen.

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