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RESEARCH ARTICLE :

Effect of different weed management methods on growth and yield of irrigated sorghum

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SUMMARY : A field experiment was conducted at Department of Millets,Tamil Nadu Agricultural University, Coimbatore during *Kharif*, 2011to study integrated weed management practices on growth and yield of irrigated sorghum. The experiment was laid out in a Randomized Block Design with three replications. Plant growth parameters like plant height, dry matter production, leaf area index and yield parameters *viz*., earhead length, ear head weight, 1000 grain weight and grain and stover yields of sorghum were recorded to assess the crop productivity. The economic parameters like cost of cultivation, gross and net returns, benefit cost ratio were also estimated to assess the influence of different weed control methods. Higher grain yield of 1847 kg ha^{-1} was recorded in PE Atrazine 0.25 kg ha^{-1} + HW at 30 and 45 DAS. Higher net return of Rs.32,014 ha^{-1} and B:C ratio of 3.02 was registered in PE Atrazine 0.25 kg ha^{-1} + Pendimethalin 0.50 kg ha^{-1} at 30 DAS (Layby application).

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BACKGROUND AND OBJECTIVES

Sorghum [*Sorghum bicolor* (L.) Moench] is the fifth most important cereal crop in the world.In India, this crop was one of the major cereal staple diets during 1950's and occupied an area of more than 18 mha but has come down to 7.69 mha in 2010. The decline has serious concern on the cropping systems and the food security of dry land regions of the country.Maximum damage to sorghum is caused by weeds and about 33 per cent of the potential production is lost due to weed competition, besides taking away as much as 30 to 45 per cent of the plant nutrients from the soil.Besides quantitative effect on yield, weeds deteriorate the quality of produce through physical presence of the weed seeds and debris. Timely and effective weed control will go a long way in gaining crop yields.

Hence, various components of integrated weed management are to be blended in a systematic way to achieve the acceptable level of weed control. So there is a need to make a comparative study of different weed management techniques in sorghum and to develop an integrated weed management approach, which should be efficient, cost effective and environmentally safe. Keeping these facts in view, a comprehensive study was planned to study the influence of

integrated weed management on growth and yield of sorghum.

RESOURCES AND METHODS

Field investigations were carried out at, Department of Millets, Tamil Nadu Agricultural University, Coimbatore during *Kharif,* 2011 to evaluate integrated weed management methods on growth and yield of irrigated sorghum.The treatments tested were as follows;T_1 - PEAtrazine 0.50 kg ha^{-1} + HW at 30 DAS, T_2 - PE Atrazine 0.25 kg ha^{-1} + HW at 30 DAS and 45 DAS, T_3 - PE Pendimethalin 0.50 kg ha^{-1} + HW at 30 DAS, T_4 - PE Oxyfluorfen 0.15 kg ha^{-1} + HW at 30 DAS, T_5 - PE Atrazine 0.25 kg ha^{-1} + Pendimethalin 0.25 kg ha^{-1}as (Tank mix - TM), T_6- PE Atrazine 0.25 kg ha^{-1}+ Pendimethalin 0.50 kg ha^{-1} (TM), T_7 - PE Atrazine 0.25kg ha^{-1}+ Oxyfluorfen 0.15 kg ha^{-1} as (TM),T_8- PE Atrazine 0.25 kg ha^{-1}+ Oxyfluorfen 0.15 kg ha^{-1}as (TM) + 2, 4-D 0.50 kgha-1as POE,T_9 - PE Atrazine 0.25 kg ha^{-1}+ Pendimethalin 0.50 kg ha^{-1}as (TM) + 2,4-D 0.50 kg ha^{-1}as POE, T_{10} - PE Atrazine 0.25 kg ha^{-1}+ 2,4-D 0.50 kg ha^{-1} as POE, T_{11} -PE Atrazine 0.25 kg ha^{-1} + Pendimethalin 0.50 kg ha^{-1}at 30 DAS (Lay-by application), T_{12} - HW on 25 and 45 DAS, T_{13} - PE Atrazine 0.25 kg ha^{-1} + Power weeder on 30 DAS,T_{14} - PE Atrazine 0.25 kg ha^{-1}+Twin wheel hoe on 30 DAS,T_{15}- Unweeded control. The treatments were laid in Randomized Block Design with three replications.The soil of the experiment field was sandy clay loam in texture, lowin available nitrogen (135.2 kg ha^{-1}), high in available phosphorus (38.0 kg ha^{-1}) and available potassium (687.0 kg ha^{-1}).

Weeding was done as per the treatment schedule. For manual weeding treatment, two hand weedings were given on 30 and 45 DAS. Herbicide treatment plots were applied with, Atrazine 50% WP at 0.25 kg ha^{-1} and 0.50 kg ha^{-1} Pendimethalin 30% EC at 0.25 kg ha^{-1} and 0.50 kg ha^{-1} Oxyfluorfen 23.5% EC at 0.15 kg ha^{-1} as pre-emergence spray on 3 DAS andfollowed by 2,4-D0.50 kg ha^{-1} as post-emergenceas per-treatment schedule. Calculated quantity of herbicide with a spray fluid of 500 lit ha^{-1} was sprayed uniformly over the plots using battery operated sprayer fitted with fan type WFN 40 nozzle. For mechanically weeded plots, same pre emergence herbicides as per treatment schedule were applied followed by twin wheel hoe and power weeder weeding on 30 DAS in between the rows. The weeds that were present within the rows were removed manually.

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Effect of integrated weed management methods on weeds :

Weed flora of the experimental field during the cropping period primarily composed of grasses and broad leaved weeds. The grasses constituted the major proportion of the weed flora accounting 28.87 per cent of the total weed density at 60 DAS. Among the individual weed species *Rottboellia cochinchinensis* (27.27%) *Cynodon dactylon* (14.21%) *Digera arvensis* (19.58%) *and Parthenium hysterophorus* (21.78%) were predominant in irrigated sorghum at 60 DAS. Dominance of such weeds in sorghum crop on sandy clay loam soils of Coimbatore was earlier reported by Ponnusamy (2002).

The predominant occurrence of these weed species in sorghum could probably be attributed to the ecological adaptation and dominance of the above listed weeds in black clay loam soils of Coimbatore region. Such dominant occurrence of *Cynodon dactylon*, *Digera arvensis* and *Parthenium hysterophorus* was reported by Sharma *et al.* (2000) in sorghum fields of clay loam soils under Coimbatore conditions.

Chemical and mechanical methods of weed control significantly reduced the weed density over unweeded control. At 60DAS, total weed density was observed withpre-emergence application of atrazine 0.25 kg ha^{-1} followed by two hand weedings at 30 DAS and 45 DAS registered lower weed density by control of weeds at the germination phase by the pre-emergence application of herbicide and significant reduction at later growth stages as late germinating weeds were removed by hand weeding. Application of atrazine 0.25 kg ha^{-1} followed by pendimethalin 0.50 kg ha^{-1} at 30 DAS as layby application and hand weeding twice at 25 DAS and 45 DAS were also found to be significantly superior over the unweeded control. The results are in support with the findings of Rathod *et al.* (2010). Either hand weeding twice at 30 DAS and 45 DAS (or) PE atrazine followed by mechanical weeding with twin wheel hoe weeder and power weeder reduced the total weed density, since hand weeding or mechanical weeding could reduce the weeds at early stages of crop growth as earlier reportedby Leela

(2002). Tank mix application of atrazine + pendimethalin and atrazine + oxyfluorfen also reduced the weed density over unweeded control.

Considerable reduction in grass and broad leaved weed density was observed with pre-emergence application of atrazine 0.25 kg ha^{-1} followed by two hand weedings at 30DAS and 45 DAS. Application of herbicide at pre-emergence as well as at early establishment of weeds in the crop was found to control the germinating weeds. Degradation of the chloroplasts and swelling followed by disruption of granal discs of the emerging weed seedlings by atrazine (Hill *et al*., 1968) eventually causing the death of tissueand whole plant could be attributed to the reduction of weed density. Jaykumar *et al.* (1987) had also made similar observations with reduction of weed density in sorghum due to application of atrazine. Obviously unweeded control resulted in higher grasses and broad leaved weed density due to unchecked weed growth at all growth stages of the crop.

Weed dry weight is the most important parameter to assess the weed competitiveness for the crop growth and productivity. Sparse weeds with high biomass might be more competitive for crops than dense weeds with lesser dry matter. Considerable reduction in weed dry weight was observed at 60 DAS with two hand weedings at 25 DAS and 45 DAS which might be due to presence of lesser number of total weeds during crop growth. At 60 DAS significantly reduction in weed dry weight was observed with application of atrazine 0.25 kg ha^{-1} as pre-emergence followed by two hand weedings at 30 DAS and 45 DAS and this might be due to effective control of weeds by atrazine followed by manual weedings. It is in conformity with the experimental results of Kaushik and Shaktawat (2005) who have recorded lower weed dry weight with pre-emergence application of atrazine followed by hand weeding in sorghum.

Similarly, weed control efficiency was highly influenced by different weed control practices. Two hand weedings at 25 DAS and 45 DAS recorded higher WCE of 82.21 per cent, followed by pre-emergence application of atrazine 0.25 kg ha^{-1} + pendimethalin at 0.50 kg ha^{-1} as layby application. This might be due to reduced weed dry weight and weed density resulting in higher WCE in 60 DAS.

Table 1: Effect of integrated weed management practices onand growth parametersin irrigated sorghum

Treatments	Total weed density (No.m^{2})	Total weed dry wt (kg ha^{-1})	Weed control efficiency (%)	Plant Height (cm)	DMP (kg.ha^{-1})	LAI
T_1 - PE Atr 0.50 kg ha^{-1} + HW at 30 DAS (Pre emergence-PE)	8.39 (68.41)	10.76(113.69)	54.89	154.2	5150	12.9
T_2 - PE Atr 0.25 kg ha^{-1} + HW at 30 and 45 DAS	5.56 (28.91)	7.09 (48.21)	80.87	170.6	5946	14.3
T_3 - PE Pendi 0.50 kg ha^{-1} + HW at 30 DAS	7.24 (50.49)	8.64 (72.73)	71.14	151.6	4730	10.3
T_4 - PE Oxy 0.15 kg ha^{-1} + HW at 30 DAS	7.14 (48.95)	8.60 (71.94)	71.46	130.4	4615	9.7
T_5 - PE Atr 0.25 kg ha^{-1} + Pendi 0.25 kg ha^{-1} as (Tank mix - TM)	7.39 (52.62)	8.43 (69.06)	72.60	148.9	5109	11.3
T_6 - PE Atr 0.25 kg ha^{-1} + Pendi 0.50 kg ha^{-1} (TM)	8.15 (64.37)	11.06(120.36)	52.24	145.3	5130	10.6
T_7 -PE Atr 0.25 kg ha^{-1} + Oxy 0.15 kg ha^{-1} as (TM)	7.84 (59.41)	9.62 (90.58)	64.06	127.2	4580	10.6
T_8 -PE Atr 0.25 kg ha^{-1} + Oxy 0.15 kg^{-1} as (TM) + POE 2,4-D 0.50 kg ha^{-1}	7.10 (48.42)	8.92 (77.65)	69.19	127.0	4484	11.7
T_9-PE Atr 0.25 kg ha^{-1} + Pendi 0.50 kg ha as (TM) + POE 2,4-D, 0.50 kg ha^{-1}	6.54 (40.77)	7.88 (60.11)	76.15	142.3	4980	11.5
T_{10} -PE Atr 0.25 kg ha^{-1} + POE 2,4-D 0.50 kg ha^{-1}(Post emergence-POE)	7.21 (50.06)	9.12 (81.11)	67.82	141.6	4950	11.4
T_{11}-PE Atr 0.25 kg ha^{-1} + Pendi 0.50 kg ha^{-1} at 30 DAS (Layby application)	5.83 (31.95)	6.99 (46.86)	81.40	167.2	5785	13.7
T_{12} -HW on 25 and 45 DAS	5.85 (32.17)	6.84 (44.82)	82.21	171.4	5941	13.1
T_{13} -PE Atr 0.25 kg ha^{-1} + PW on 30DAS	8.10 (63.61)	9.92 (96.36)	61.76	138.2	4930	12.7
T_{14} -PE Atr 0.25 kg ha^{-1} + TWH on 30DAS	8.61 (72.12)	10.65(111.44)	55.78	133.5	4885	11.8
T_{15} - Unweeded control	12.53(155.12)	15.94(252.02)	0.00	101.2	3319	6.7
S.E.±	0.78	0.98	-	13.8	427.6	1.1
C.D.(P=0.05)	1.61	2.01	-	28.3	876.0	2.2

Figures in parenthesis are original values

Effect of integrated weed management methods on sorghum growth attributes :

At 60 DAS, significantly higher plant height was recorded with PE Atrazine0.25 kg ha^{-1} + HW at 30 DAS and 45 DAS and was on par with HW on 25 and 45 DAS, PE Atrazine 0.25 kg ha^{-1} + Pendimethalin 0.50 kg ha^{-1} at 30 DAS (Layby application)and PE Atrazine 0.50 kg ha^{-1} + HW at 30 DAS. This was followed by PE Atrazine 0.25 kg ha^{-1}+ Pendimethalin 0.50 kg ha^{-1} (TM), PE Atrazine 0.25 kg ha^{-1} + Pendimethalin 0.50 kg ha^{-1} as (TM) + 2, 4-D 0.50 kg ha^{-1}as POE, PE Atrazine 0.25 kg ha^{-1}+ 2, 4-D 0.50 kg ha^{-1} as POE and PE Atrazine 0.25 kg ha^{-1} + PW on 30 DAS.

Dry matter production :

At 60 DAS, PE Atrazine 0.25 kg ha^{-1} + HW at 30 DAS and 45 DAS recorded significantly higher dry matter production which was on par with HW on 25 and 45 DAS, PE Atrazine 0.25 kg ha^{-1}+ Pendimethalin 0.50 kg ha^{-1} at 30 DAS (Layby application) and PE Atrazine 0.50 kg ha^{-1} + HW at 30 DAS. However, this was closely followed by PE Atrazine 0.25 kg ha^{-1} + Pendimethalin 0.50 kg ha^{-1}as (TM) + 2, 4- D 0.50 kg ha^{-1} as POE, PE Atrazine 0.25 kg ha^{-1} + 2, 4-D 0.50 kg ha^{-1} as POE and PE Atrazine 0.25 kg ha^{-1}+ PW on 30 DAS.This might be due to better weed control with favourable soil environment resulting in reduced crop-weed competition for growth factors such as light, space and nutrients which in turn helped in efficient photosynthetic activity recording taller plants. The result is in line with the findings of Kumar (1987).

Inspite of better weed control efficiency by tank mix application of atrazine + oxyfluorfen, it was observed with lower plant height due to early crop growth stunting and leaf scorching. Mechanical weeding with power weeder and twin wheel hoe weeding combined with application of pre-emergence herbicides recorded higher plant height due to effective weed control efficiency over unweeded control. Unweeded control showed significant reduction of plant height at all the growth stages of the crop. Whereas, herbicidal treatments combined with manual or mechanical method of weeding resulted in higher plant height at all stages of crop growth in sorghum crop which might be the reason for better utilization of growth factors.

Leaf area index :

This was observed with pre-emergence application of atrazine 0.25 kg ha^{-1} followed by two hand weeding at 30 DAS and 45 DAS at all stages of crop growth. Hand weeding twice at 25 DAS and 45 DAS and pre-emergence application of atrazine 0.25 kg ha^{-1} +

Table 2 : Effect of integrated weed management practices onyield and yield parameters of in irrigated sorghum

Treatments	Yield (kg ha^{-1})	St.yield (kg ha^{-1})	Earhead length (cm)	Earhead weight (g)	1000 grain weight (g)
T_1 - PE Atr 0.50 kg ha^{-1} + HW at 30 DAS (Pre-emergence-PE)	1573	10640	18.0	34.6	31.3
T_2 - PE Atr 0.25 kg ha^{-1} + HW at 30 and 45 DAS	1847	13981	20.4	53.0	40.3
T_3 - PE Pendi 0.50 kg ha^{-1} + HW at 30 DAS	1564	10634	17.8	43.2	29.8
T_4 - PE Oxy 0.15 kg ha^{-1} + HW at 30 DAS	1024	9134	12.0	33.2	22.3
T_5 - PE Atr 0.25 kg ha^{-1} + Pendi 0.25 kg ha^{-1} as (Tank mix - TM)	1560	10629	17.4	40.5	29.3
T_6 - PE Atr 0.25 kg ha^{-1} + Pendi 0.50 kg ha^{-1} (TM)	1552	10625	16.0	38.4	28.2
T_7 -PE Atr 0.25 kg ha^{-1} + Oxy 0.15 kg ha^{-1} as (TM)	852	7924	10.8	31.2	22.0
T_8 -PE Atr 0.25 kg ha^{-1} + Oxy 0.15 kg $^{-1}$ as (TM) + POE 2,4-D 0.50 kg ha^{-1}	845	7919	10.6	27.5	21.8
T_9-PE Atr 0.25 kg ha^{-1} + Pendi 0.50 kg ha as (TM) + POE 2,4-D, 0.50 kg ha^{-1}	1544	10617	15.7	38.2	27.9
T_{10} -PE Atr 0.25 kg ha^{-1} + POE 2,4-D 0.50 kg ha^{-1}(Post-emergence-POE)	1541	10610	15.3	36.6	27.4
T_{11}-PE Atr 0.25 kg ha^{-1} + Pendi 0.50 kg ha^{-1} at 30 DAS (Layby application)	1823	13950	18.4	51.9	38.1
T_{12} -HW on 25 and 45 DAS	1722	11645	18.2	37.5	31.9
T_{13} -PE Atr 0.25 kg ha^{-1} + PW on 30DAS	1533	10608	12.8	35.2	25.8
T_{14} -PE Atr 0.25 kg ha^{-1} + TWH on 30DAS	1526	10603	12.3	34.3	25.1
T_{15} - Unweeded control	565	5985	8.0	15.7	15.3
S.E.±	117	902	1.4	3.0	2.6
C.D. (P=0.05)	239	1847	2.9	6.2	5.3

pendimethalin at 0.50 kg ha^{-1} as layby application was superior over unwedded control. In conformity with this, Zanin *et al*. (1984) found that higher growth parameters were achieved through effective weed control with application of pre-emergence herbicide along with manual weeding. This results are significantly higher leaf area index was recorded with PE Atrazine 0.25 kg ha^{-1} + HW at 30 DAS and 45 DAS (T_2) which was on par with PE Atrazine 0.25 kg ha^{-1}+ Pendimethalin 0.50 kg ha^{-1} at 30 DAS (Layby application) (T_{11}), HW on 25 and 45 DAS (T_{12}) PE Atrazine 0.50 kg ha^{-1} + HW at 30 DAS (T_1).and PE Atrazine 0.25 kg ha^{-1} + PW on 30 DAS (T_{13}) at all the growth stages. However, this was closely followed byPE Atrazine 0.25 kg ha^{-1} + TWH on 30 DAS (T_{14}), PE Atrazine 0 .25 kg ha^{-1} + Oxyfluorfen 0.15 kg ha^{-1} as (TM)+2,4-D 0.50 kg ha^{-1} as POE (T_8) and PE Atrazine 0.25 kg ha^{-1} + Pendimethalin 0.50 kg ha^{-1} as (TM) + 2,4-D 0.50 kg ha^{-1} as POE (T_9). Lower leaf area index was recorded in unweeded control (T_{15}) at 60 DAS.

Effect of integrated weed management methods on yield attributes and yield :

PE Atrazine 0.25 kg ha^{-1} + HW at 30 DAS and 45 DAS registered significantly higher ear head length which was on par with PE Atrazine 0.25 kg ha^{-1} + Pendimethalin 0.50 kg ha^{-1} at 30 DAS (Layby application), HW on 25 and 45 DAS and PE Atrazine 0.50 kg ha^{-1} + HW at 30 DAS. This was closely followed by PE Atrazine 0.25 kg ha^{-1} + Pendimethalin 0.50 kg ha^{-1} as (TM) + 2, 4- D 0.50 kg ha^{-1}as POE, PE Atrazine 0.25 kg ha^{-1} + 2, 4-D 0.50 kg ha^{-1} as POE and PE Atrazine 0.25 kg ha^{-1} + PW on 30 DAS However, the lower ear head length was recorded in unweeded control.

PE Atrazine 0.25 kg ha^{-1} + HW at 30 DAS and 45 DAS (T_2) registered significantly higher ear head weight and it was on par with PE Atrazine 0.25 kg ha^{-1} Pendimethalin 0.50 kg ha^{-1} at 30 DAS (Layby application) (T_{11}). This was closely followed by PE Pendimethalin 0.50 kg ha^{-1} + HW at 30 DAS (T_3), PE Atrazine 0.25 kg ha^{-1} + Pendimethalin 0.25 kg ha^{-1} as (TM) (T_5) and PE Atrazine 0.25 kg ha^{-1} + Pendimethalin 0.50 kg ha^{-1} (TM) (T_6). Significantly lower ear head weight was observed in unweeded control (T_{15}).

PE Atrazine 0.25 kg ha^{-1} + HW at 30 DAS and 45 DAS (T_2) registered significantly higher 1000 grain weight and it was on par with PE Atrazine 0.25 kg ha^{-1} +Pendimethalin 0.50 kg ha^{-1} at 30 DAS (Layby application).

Larger and longer sorghum ear head with more number of grains and higher test weight were obtained with pre-emergence application of atrazine 0.25 kg ha^{-1} followed by two hand weeding at 30 DAS and 45 DAS. This might be due to better control of weeds at all growth stages of sorghum plant. Atrazine 0.25 kg ha^{-1} followed by 0.50 kg ha^{-1} of pendimethalin as lay by application and other herbicidal treatments combined with manual

Table 3 : Effect of integrated weed management practices on the economics in irrigated sorghum

Treatments	CoC. (Rs.ha^{-1})	Gr.ret (Rs.ha^{-1})	Net.ret (Rs.ha^{-1})	B:C ratio
T_1 - PE Atr 0.50 kg ha^{-1} + HW at 30 DAS (Pre emergence-PE)	15469	42003	26534	2.72
T_2 - PE Atr 0.25 kg ha^{-1} + HW at 30 and 45 DAS	16304	48118	31814	2.95
T_3 - PE Pendi 0.50 kg ha^{-1} + HW at 30 DAS	15907	41134	25227	2.59
T_4 - PE Oxy 0.15 kg ha^{-1} + HW at 30 DAS	15151	24601	9449	1.62
T_5 - PE Atr 0.25 kg ha^{-1} + Pendi 0.25 kg ha^{-1} as (Tank mix - TM)	14880	40983	26103	2.75
T_6 - PE Atr 0.25 kg ha^{-1} + Pendi 0.50 kg ha^{-1} (TM)	15072	40900	25828	2.71
T_7 -PE Atr 0.25 kg ha^{-1} + Oxy 0.15 kg ha^{-1} as (TM)	15024	23473	8449	1.56
T_8 -PE Atr 0.25 kg ha^{-1} + Oxy 0.15 kg $^{-1}$ as (TM) + POE 2,4-D 0.50 kg ha^{-1}	15585	23422	7837	1.50
T_9 - PE Atr 0.25 kg ha^{-1} + Pendi 0.50 kg ha as (TM) + POE 2,4-D, 0.50 kg ha^{-1}	15441	40807	25366	2.64
T_{10} -PE Atr 0.25 kg ha^{-1} + POE 2,4-D 0.50 kg ha^{-1}(Post emergence-POE)	14865	40668	25803	2.74
T_{11}-PE Atr 0.25 kg ha^{-1} + Pendi 0.50 kg ha^{-1} at 30 DAS (Layby application)	15880	47894	32014	3.02
T_{12} -HW on 25 and 45 DAS	15939	42135	26196	2.64
T_{13} -PE Atr 0.25 kg ha^{-1} + PW on 30DAS	14704	40433	25729	2.75
T_{14} -PE Atr 0.25 kg ha^{-1} + TWH on 30DAS	14404	40369	25965	2.80
T_{15} - Unweeded control	11884	14912	3028	1.25

or mechanical weeding provided favourable environment for recording higher yield attributes of sorghum against unweeded control. Similarly, higher earhead length and test weight was obtained by Hennigh *et al*. (2010) due to application of atrazine combined with manual weeding.

Yield :

The perusal of yield data clearly indicated that different weed management practices positively influenced the grain yield of sorghum. PE Atrazine 0.25 kg ha^{-1} + HW at 30 DAS and 45 DAS recorded higher grain and stover yield which was on par with PE Atrazine 0.25 kg ha^{-1}+ Pendimethalin 0.50 kg ha^{-1} at 30 DAS (Layby application). However, this was closely followed by HW on 25 and 45 DAS, PE Atrazine 0.50 kg ha^{-1} + HW at 30 DAS and PE Pendimethalin 0.50 kg ha^{-1} + HW at 30 DAS. Invariably unweeded control registered lower grain and stover yield.

In irrigated sorghum, among the weed control methods, pre-emergence application of atrazine 0.25 kg ha^{-1} followed by two hand weedings at 30 DAS and 45 DAS recorded higher grain yield (1847 kg ha^{-1}). Other herbicidal treatments combined with manual or mechanical weedings registered higher grain yield over unweeded control.

These results are in conformity with the findings of Dimitrova (2005) who had reported that pre-emergence application of atrazine at 0.25 kg ha^{-1} followed by manual weedings not only controlled the weeds but also enhanced the grain yield. Higher stover yield (13981 kg ha^{-1}) of sorghum was recorded in pre-emergence application of atrazine 0.25 kg ha^{-1} followed by two hand weedings at 30 DAS and 45 DAS, could be attributed to the reason that herbicide application might have killed the weeds at germination phase devoiding competition for crop growth from the inception of germination of the crop and late emerging weeds uncontrolled by manual removal at 30 DAS and 45 DAS. The results are in accordance with the reports of Baker and Terry (1991), in which he highlighted the advantages of atrazine application combined with manual weeding on sorghum yield and better weed control. Similarly, pre-emergence application of atrazine 0.25 kg ha^{-1} followed by pendimethalin 0.50 kg ha^{-1} as lay-by application also recorded comparable grain and stover yields of irrigated sorghum. Higher weed control efficiency and lower nutrient uptake by weeds might have influenced the growth of sorghum, consequently favouring higher yields of grain and stover.

Effects of integrated weed management methods on economics:

Pre-emergence application of atrazine 0.25 kg ha^{-1} +pendimethalin 0.50 kg ha^{-1} as lay by application gave maximum net return and B:C ratio (Rs.32014 and 3.02, respectively). Pre-emergence application of atrazine 0.25 kg ha^{-1} followed by two hand weeding at 30 DAS and 45 DAS was the next best treatment recording high B:C ratio of 2.95. The result is in line with the findings of Ramesh (1998) who had reported that, pre-emergence application of atrazine at 0.25 kg ha^{-1} followed by manual weeding under irrigated sorghum cultivation was the most profitable weed control practice.

Although, pre-emergence application of atrazine 0.25 kg ha^{-1} followed by two hand weedings at 30 DAS and 45 DAS recorded higher gross return, due to high labour requirement the cost of cultivation was increased, resulting in lesser B:C ratio (2.95) compared to pre-emergence application of atrazine 0.25 kg ha^{-1} + pendimethalin 0.50 kg ha^{-1} as lay-by application (3.02).The results of this study indicated that application of pre-emergence application of atrazine 0.25 kg ha^{-1} followed by pendimethalin 0.50 kg ha^{-1} as lay-by application not only proved economical but also timely weed management option for irrigated sorghum.

Conclusion :

Growth and yield attributes of sorghum were higher with PE Atrazine 0.25 kg ha^{-1} + HW at 30 and 45 DAS (T_2) through effective control of wide spectrum of weeds and recorded higher grain yield than the rest of the treatments.PE Atrazine 0.25 kg ha^{-1} + Pendimethalin 0.50 kg ha^{-1} at 30 DAS (Layby application) (T_{11}) gave the highest net return and B:C ratio.

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