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WEED MANAGEMENT IN *KHARIF* GRAIN SORGHUM (*SORGHUM BICOLOR*)

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ABSTRACT
A field study was conducted at Regional Agricultural Research Station, Palem during *kharif* 2013 on weed management of grain sorghum. The experiment comprising of ten weed control treatments of pre and post-emergence herbicides along with weed free and weedy check was conducted in Randomized Block Design with three replications on sandy clay loam soil with P^H 8.07. The experimental field was infested with *Cynodon dactylon*, *Dactylactenium aegypticum*, *Digitaria sanguinalis*, *Cyperus rotundus*, *Celosia argentea*, *Dinebra retroflexa, Ageratum conyzoides*, *Commelina benghalensis*, *Digera arvensis, Parthenium hyisterophorus* and *Phyllanthus niruri*. The weed free check recorded significantly highest grain (2843 kg/ha) and stover (7624 kg/ha) yields. However, grain yield was remained at par with pre- emergence application of Atrazine @ 0.5 kg a.i./ ha followed by two hand weedings at 30 and 45 DAS(T_2) and pre-emergnece application of Atrazine @ 0.25 kg a.i./ha + Pendimethalin @ 0.25 kg a.i./ha (Tank mixed) + 2,4- D @ 0.5 kga.i./ha as post- emergnece at 30DAS(T_7). Among the herbicidal treatments, pre- emergence application of Atrazine @ 0.5 kg a.i./ha followed by two hand weedings at 30 and 45 DAS recorded significantly lower grassy weed density (3.32/m^2), highest weed control efficiency (83%) at 60 DAS and the lowest weed index (5.7%).

INTRODUCTION

Sorghum has great potential as annual energy crop in climate change scenario. The great advantage of sorghum is that it can become dormant under adverse conditions and can resume growth after relatively severe drought, early drought stops growth before floral initiation and the plant remains vegetative but it will resume leaf production and flower when conditions again become favourable for growth while, late drought stop leaf development but not floral initiation (Srilaxmi and Ravindra, 2011). In India it is grown in an area of 7.38 m.ha with 7.0 m.t. production.The average productivity of sorghum in the country is 949 kg/ha (Directorate of Economics and Statistics, Department of Agriculture and Cooperation, 2012). While primarily grown for its grain; sorghum can also be grown for animal feed, fodder and industrial raw material.

Weeds are a major deterrent in increasing the sorghum productivity, especially during rainy season due to wider row spacing, slow initial crop growth rate, and congenial weather conditions for weed growth. Sorghum is mostly grown in rainfed areas, where soil moisture and nutrients are the most limiting factors. Weeds compete with sorghum for light, soil moisture and nutrients (Burnside and Wicks 1969, Smith *et al*., 1990) and reduce the grain yield by 15 to 83% depending on crop cultivars, nature and intensity of weeds, spacing, duration of weed infestation and environmental conditions (Mishra 1997, Shelke 1995, Stahlman and Wicks 2000). Therefore, appropriate weed management would help to improve sorghum productivity and input use-efficiency.

Manual weeding alone is expensive, tedious and time consuming (Rajput and Khushwah 2005). Akobundu (1987) gave Nigeria as an example of a country where labour requirements for weeding in sorghum fields accounts for 37% of the total labour requirements under traditional sorghum farming systems, where as Klingman and Ashton (1982), reported that weeding costs account for 42% of the total crop protection costs on commercial farmers in the United States of America. Present investigation aims to control early weeds of the sorghum crop during *kharif* season with the help of combinations of pre/post emergence herbicides and hand weeding. With this in view, an investigation of weed management in sorghum was conducted to study the relative efficacy of different herbicides and their doses to control weeds.

MATERIALS AND METHODS

Experiment was undertaken during *kharif* 2013 at Regional Agricultural Research Station, Palem,Telangana. The experimental site is situated at 16°35"N latitude, 78°1"E longitude and at an altitude of 642 m above mean sea level. The seasonal mean temperature ranged between 27.4° C and 37.6° C (Max) and 20.1°C and 24.4°C (Min). Total rainfall of 579.4 mm was distributed over 44 rainy days during the crop growing period.The experimental soil was sandy clay loam in texture, slightly alkaline (P^H 8.07), medium in organic carbon (0.38%), low in available N (213 kg ha^{-1}), medium in available P (34 kg ha^{-1}) and high in K (708 kg ha^{-1}). The experiment was laid out in a randomized block design with three replications

and ten treatments. The treatments were T_1: Atrazine (Atrataf) @ 0.5 kg a.i./ha as pre-emergnece (PE) + one hand weeding (HW) at 30 DAS, T_2: Atrazine @ 0.5 kg a.i./ha as PE + two HW at 30 and 45 DAS, T_3: Pendimethalin (Stomp) @ 0.5 kg a.i./ha as PE + one HW at 30 DAS, T_4: Pendimethalin @ 0.5 kg a.i./ha as PEfb 2,4-D (Fenoxone) @ 0.5 kg a.i./ ha as post- emergnece (PoE) at 30DAS, T_5: Atrazine @ 0.25 kg a.i./ha. + Pendimethalin @ 0.25 kg a.i./ha as PE (Tank mixed), T_6: Atrazine @ 0.5 kg a.i./ha + Pendimethalin @ 0.5 kg a.i./ha as PE(Tank mixed)), T_7: Atrazine @ 0.25 kg a.i. + Pendimethalin @ 0. 25 kg a.i./ha as PE(Tank mixed) + 2,4-D @ 0.5 kg a.i./ha as PoEat 30 DAS, T_8: Atrazine @ 0.5 kg a.i./ha as PEfb 2,4-D @ 0.5 kg a.i./ha as PoEat 30 DAS, T_9: weed free check and T_{10}: weedy check . The pre-emergence herbicides were sprayed immediately after sowing on wet soil. Herbicides, as per treatments, were applied in 500 l/ha spray volume with Knapsack sprayer fitted with flat-fan nozzle. The seed of PSV 56 variety was sown manually by labourers on 14.06.2013 with a spacing of 45cm between rows and 15 cm between plants. The crop was harvested on 21-09-2013.The recommended dose of nitrogen @ 80 kg ha^{-1} through Urea, P_2O_5 @ 40 kg ha^{-1} through Single Super Phosphate (SSP) and K_2O @ 40 kg ha^{-1} through Muriate of Potash (MOP) were applied. The entire dose of phosphorus and potassium and half of the nitrogen were applied at the time of sowing as basal. The remaining dose of nitrogen was applied at 30 DAS.

Weed population and weed dry matter (WDM), taken at 60 DAS was recorded by using the quadrate measuring $1m^2$/plot. Data on weed density was transformed using square root transformations. The weed control efficiency (WCE) and weed index (WI) was worked out. The weed control efficiency was calculated as

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

Where, DWC = Dry weight of weeds in weedy control plot, DWT = Dry weight of weeds in treated plot.

The weed index was derived as

$$WI = \frac{X-Y}{X} \times 100$$

Where, X = Yield from weed free treatment, Y = Yield from weed treatment for which WI is to be calculated.

RESULTS AND DISCUSSION

Weed flora

Species wise weed density recorded in the experimental field of sorghum during *kharif* season at 60 DAS indicated that there was predominance of monocot weeds. The major weed flora of the experiment plots were *Cynodon dactylon* (Bermuda grass), *Dactyloctenium aegyptium* (Crowfoot grass), *Digitaria sanguinalis* (Crab grass), *Cyperus rotundus* (Nut sedge), *Celosia argentea* (Cockscomb), *Dinebra retroflexa* (Viper grass), *Ageratum conyzoides* (Goat weed), *Commelina benghalensis* (Wandering jew), *Digera arvensis* (Chenchalikura), *Parthenium hysterophorus* (Carrot grass) and *Phyllanthus niruri* (Black catnip). Out of these, the first five species contributed about 80% of total weed density recorded at 60DAS. Among the grasses *Cynodon dactylon* and *Dactylactenium aegypticum* were predominant, *Cyperus rotundus* predominant among sedges. The predominance of monocot and sedge weeds reported by Gowda *et al*., 2002, Deore *et al*., 2009, Mundra and Maliwal, 2012.

Weed density and weed dry matter

Weed density and weed dry mater data presented in Table1 revealed that different treatments exhibited significant influence on weed density and dry matter of weeds. The density and dry matter of weeds were maximum in weedy check. However,

Table 1: Weed density, weed dry weight, weed control efficiency and weed index as influenced by different treatments

Treatment	Weed density / m^2 60 DAS Grassy weeds	Broad leaved	Sedges	Weed dry weight (g/m^2)	Weed control efficiency at 60 DAS (%)	Weed index (%)
T_1: Atrazine @ 0.5 kg a.i./ha as PE + one HW at 30DAS	4.12 (18.33)	3.14 (9.00)	4.51 (21.33)	61.3	68.8	41.3
T_2: Atrazine @ 0.5 kg a.i./ha as PE + two HW at 30 and 45 DAS	3.32 (11.67)	2.92 (8.00)	3.19 (9.33)	33.3	83	6.8
T_3: Pendimethalin @ 0.5 kg a.i./ha as PE + one HW at 30DAS	3.55 (11.67)	2.95 (8.00)	4.26 (18.00)	58.7	70.1	17.2
T_4: Pendimethalin @ 0.5 kg a.i./ha as PE + 2,4-D @ 0.5 kg a.i./ha as PoE at 30 DAS	6.65 (43.33)	2.85 (9.33)	2.33 (8.00)	90	54.2	41.1
T_5: Atrazine @ 0.25 kg a.i./ha + Pendimethalin @ 0.25 kg/ha as PE (Tank mixed)	5.33 (27.7)	2.83 (8.00)	4.08 (17.00)	88	55.2	48.6
T_6: Atrazine @ 0. 5 kg a.i./ha + Pendimethalin @ 0.5 kg a.i./ha as PE (Tank mixed)	5.60 (32.33)	3.33 (10.33)	2.92 (10.33)	86.3	56	36.4
T_7: Atrazine @ 0.25 kg a.i./ha + Pendimethalin @ 0.25 kg a.i. /ha as PE (Tank mixed) + 2,4- D @0.5 kg a.i./ha as PoE at 30DAS	6.00 (34.67)	2.06 (3.33)	3.17 (9.33)	66	66.4	9
T_8: Atrazine @ 0.5 kg a.i./ha as PE + 2,4-D @ 0.5 kg a.i./ha as PoE at 30DAS	5.86 (33.33)	2.90 (8.00)	3.49 (12.00)	83.3	57.6	42
T_9: Weed free check	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	0	100	0
T_{10}: Weedy check	6.44 (40.00)	5.51 (29.33)	7.93 (65.33)	196.3	0	56.1
SE m +/-	0.53	0.39	0.75	9.1	-	-
CD (p = 0.05)	1.57	1.15	2.23	27.3	-	-

Original figures in parenthesis were subjected to square root transformation ((X + 0.5)) before statistical analysis. DAS- days after sowing: HW-Hand weeding: PE- Pre-emergence application: PoE- Post-emergence application

Table 2: Yield and yield attributes of sorghum as influenced by different weed management treatments

Treatment	Grain yield (kg/ha)	Stover yield (kg/ha)	No. of grains /panicle	Test weight (g)
T_1:Atrazine @ 0.5 kg a.i./ha as PE + one HW at 30DAS	1668	6449	2095	3
T_2:Atrazine @ 0.5 kg a.i./ha as PE +two HWat 30 and 45 DAS	2650	7487	2264	3.2
T_3:Pendimethalin @ 0.5 kg a.i./ha as PE +one HW at 30DAS	2353	6349	2125	3.2
T_4:Pendimethalin @ 0.5 kg a.i./ha as PE + 2,4-D @ 0.5 a.i./haas PoE at30 DAS	1675	5816	2035	3
T_5: Atrazine @ 0.25 kg a.i./ha+ Pendimethalin@ 0.25 kg a.i./ha as PE(Tank mixed)	1461	6264	1986	3
T_6:Atrazine @ 0. 5 kg a.i./ha + Pendimethalin @ 0.5 kg a.i./ha as PE (Tank mixed)	1809	5783	1930	3.1
T_7:Atrazine @ 0.25 kg a.i./ha + Pendimethalin@ 0.25 kg a.i./ha as PE (Tank mixed) +2,4-D @ 0.5 kg a.i./ha as PoE at 30DAS	2587	6601	2306	3.2
T_8:Atrazine @ 0.5 kg a.i./ha as PE + 2,4-D @ 0.5 kg a.i./ha as PoE at 30DAS	1649	5523	1957	3.1
T_9: Weed free check	2843	7624	2471	3.3
T_{10}: Weedy check	1249	5131	1396	2.7
SE m+/-	60.2	146.1	42.2	0.21
CD (p=0.05)	180	437	126	NS

reduction in weed density and dry weight of weeds were observed when weeds were controlled either through chemical or combination of chemical and manual means. Among all the treatments, after weed free check pre- emergence application of Atrazine @ 0.5 kga.i./ha followed by two hand weedings at 30 and 45 DAS recorded significantly lower number of grassy weeds (3.32 / m^2), which was at par with Pendimethalin @ 0.5 kg a.i./ha as pre- emergnece followed by one hand weeding at 30DAS (T_3)and Atrazine @ 0.5 kg a.i./ha as pre- emergnece followed by one hand weeding at 30DAS (T_1).

After weed free check the lowest dicot weed density was recorded in Atrazine @ 0.25 kg a.i./ha + Pendimethalin @ 0.25 kg a.i./ha as pre-emergnece (Tank mixed) +2,4- D @ 0.5 kg a.i./ha as post- emergnece at 30 DAS (T_7), but which was at par with all the treatments except unweeded check. Next to weed free check the lowest sedge weed density was recorded with Pendimethalin @ 0.5 kg a.i./ha as pre- emergnece followed by 2,4-D @ 0.5 kg a.i./ha as post- emergnece at 30 DAS (T_4), but which was at par with all the treatments except weedy check. Among all the treatments after weed free check the lowest weed dry weight (33.3 g/m^2) was recorded with Atrazine @ 0.5 kg a.i./ha as pre- emergnece followed by two hand weeding at 30 and 45 DAS but which was at par with Pendimethalin @ 0.5 kg a.i./ha as pre- emergnece followed by one hand weeding at 30DAS (T_3). These results are in corroboration with the findings of Mishra *et al*. (2012), Priya and Kubsad (2013).

Weed control efficiency and weed index

The highest weed control efficiency at 60 DAS was found under weed free check (100%). The treatment pre- emergence application of Atrazine @ 0.5 kga.i./ha followed by two hand weedings at 30 and 45 DAS recorded highest weed control efficiency (83%) and the lowest weed index (5.7%) than other weed control treatments (Table 1) except weed free check. The yield reduction up to 56.1% was recorded if field kept un-weeded. This might be due to the continuous competition of sorghum crop with the obnoxious weed species for nutrients and moisture.

Yield

Perusal of the data presented in Table 2 indicates that grain and stover yields of sorghum were significantly influenced by the various treatments. The weed free check recorded significantly highest grain yield (2843 kg/ha). However, grain yield was remained at par with pre- emergence application of Atrazine @ 0.5 kg a.i./ha followed by two hand weedings at 30 and 45 DAS (T_2) and pre-emergnece application of Atrazine @ 0.25 kg a.i./ha + Pendimethalin @ 0.25 kg a.i./ha (Tank mixed) +2,4- D @ 0.5 kg a.i./ha as post- emergnece at 30DAS (T_7). Chhodavadia *et al*. (2014) reported that the highest grain and stover yield was recorded with weed free treatment in greengram. Jadhav (2012) and Priya and Kubsad (2013) also reported that the maximum average grain yield (4.42 t/ha) was recorded with pre-emergence application of Atrazine @ 0.5 kg a.i./ha, followed by post-emergence application of 2, 4-D @ 0.75 kg a.i./ha at 20 days after sowing and intercultivation at 30 days after sowing, which was at par with weed free treatment. Among the different hebicide treatments, pre-emergence application of Atrazine @ 0.5 kg a.i./ha followed by two hand weedings at 30 and 45 DAS (T_2) recorded significantly higher grain yield (3680 kg/ha) than rest of the treatments. But it remained at par with pre-emergnece application of Atrazine @ 0.25 kg a.i. /ha + Pendimethalin @ 0.25 kg a.i./ha (Tank mixed) +2,4- D @ 0.5 kg a.i./ha as post-

emergnece at 30 DAS (T_7). Significantly the highest stover yield (7624 kg/ha) was recorded with weed free check, which was at par with pre- emergence application of Atrazine @ 0.5 kg a.i./ha followed by two hand weedings at 30 and 45 DAS (T_2). This might be due to the lower weed density, dry weight of weeds and weed index which were negatively correlated with grain yield. Grain and stover yields recorded the minimum (1249 and 5131 kg/ha, respectively) when weeds were not controlled throughout the season. This caused severe competitive stress on crop plants for growth resources and led to inferior yield attributing traits, hence had minimum grain and stover yields.

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