



Effect of glyphosate and other herbicides on management of weeds in rainfed cotton (*Gossypium hirsutum* L.) grown under high density planting system

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ABSTRACT : A field experiment was conducted at the Regional Research and Technology Transfer Station, Bhanwanipatna, Odisha during *kharif*, 2014 to evaluate different weed management practices in cotton grown under High Density Planting System (HDPS). The trial was laid out in randomized block design with three replications and eleven treatments comprising of T₁: Pendimethalin @ 1.0 kg a.i./ha as Pre-emergence + one hand hoeing at 40 DAS, T₂: Quizalofop ethyl @ 50 g a.i./ha at 20 DAS + one hand hoeing at 40 DAS, T₃:Pyriothiac Sodium @ 62.5g a.i./ha at 20 DAS + one hand hoeing at 40 DAS, T₄: Pendimethalin @ 1.0 kg a.i./ha as Pre-em + Quizalofopethyl @ 50g a.i./ha at 20 DAS + one hand hoeing at 40 DAS, T₅- Pendimethalin 1.0.kg a.i./ha as Pre- em + Pyriothiac Sodium @ 62.5g a.i./ha at 20 DAS + one hand hoeing at 40 DAS, T₆: Pyriothiac Sodium @ 62.5g a.i./ha + Quizalofopethyl @ 50g a.i./ha at 20 DAS + one hand hoeing at 40 DAS, T₇: One hand hoeing at 20 DAS + Glyphosate @ 0.5 kg a.i./ha as directed spray at 40 DAS, T₈: One hand hoeing at 20 DAS + Glyphosate @ 0.75 kg a.i./ha as directed spray at 40 DAS, T₉: One hand hoeing at 20 DAS + Glyphosate @ 1.0 kg a.i./ha as directed spray at 40 DAS, T₁₀: Weed free check (manual weeding and hand hoeing at 20, 40 and 60 DAS) and T₁₁: Weedy check. The cotton variety Suraj was sown on 07.07.2014 with a spacing of 60 cm x 10 cm. Maximum seed cotton yield (3013 kg/ha), number of bolls/plant (6.6), bolls/m² (167) and boll weight (3.1 g) was recorded in weed free check. Among the integrated approaches, one hand hoeing at 20 DAS + Glyphosate @ 1.0 kg a.i./ha at 40 DAS recorded maximum seed cotton yield (2677 kg a.i./ha), bolls/plant (5.8), bolls/m² (132) and boll weight (2.9 g) being *at par* with one hand hoeing at 20 DAS + Glyphosate @ 0.75 kg a.i./ha at 40 DAS and one hand hoeing at 20 DAS + Glyphosate @ 0.50 kg a.i./ha at 40 DAS. Weed free check recorded the maximum net return (Rs. 84,026/ha) but the B:C ratio (3.29) was the maximum in one hoeing at 20 DAS + Glyphosate @ 1.0 kg a.i./ha at 40 DAS. Weedy check recorded the minimum net return (Rs.5,802/ha) and B:C ratio (1.19).

Key words : High density planting system, glyphosate, pendimethalin, pyriothiac sodium, quizalofop ethyl, weeds control efficiency, weed density, weed management,

Cotton is grown as a cash crop in the western and southern parts of Odisha under upland rainfed conditions in medium deep and shallow soils. The crop occupied 1.58 lakh ha during the year 2018-19 with a production of 4.55

lakh bales of 170 kg and productivity of 490 kg lint/ha while the area, production and productivity of cotton in the country was 122.38 lakh ha, 361 lakh bales and 501 kg/ha, respectively during the same year. The

productivity of cotton in Odisha is below the national average (501 kg lint/ha) and world average (779 kg lint/ha). (Source: Annual Report, AICRP on Cotton, 2018-2019). The productivity of cotton can be increased in the state by adoption of high density planting system (HDPS) in the rainfed areas with soil having shallow depth. HDPS is the cotton production technology in which the number of plants/ha is increased from 18,500/ha to 1,66,600/ha by reducing the spacing to 60 x 10 cm from the normal spacing of 90 x 60 cm. The yield of seed cotton is higher in HDPS than that in normal planting due to higher plant population though the bolls/plant and boll weight is reduced.

There is severe crop weed competition during the slow initial growth stage of cotton. Due to wider row spacing the crop is infested with grasses, sedges and broad leaf weeds under upland ecosystem during the rainy season. The yield reduction due to weed infestation could be to the tune of 60 per cent (Sadangi and Barik, 2007). The crop weed competition for moisture and nutrients aggravates under HDPS in the rainfed cotton growing tracts. Manual weeding and intercultivation are costly and difficult due to closure crop canopy, low soil moisture and at times incessant rainfall during vegetative stages. It is common recommendation to apply pendimethalin as pre-emergence spray supplemented with two to three intercultivations (Prabhu *et al.*, 2010). Several workers evaluated the use of post emergence herbicides like pyriproxyfen sodium (Rao, 2011), glyphosate (Prabhu *et al.*, 2011 and Rao, 2011), and quizalofop-p-ethyl (Prabhu *et al.*, 2011 and Rao, 2011) either alone or in combination. The primary mode of action of pendimethalin is to

prevent plant cell division and elongation in susceptible species. Pyriproxyfen sodium inhibits acetolactase synthase, a key enzyme in biosynthesis of branched chain amino acids. Quizalofop-p-ethyl inhibits acetyl CoA carboxylase, a key enzyme in biosynthesis of fatty acids. Glyphosate kills plants by inhibiting enol pyruvyl shikimate phosphate synthase, a key enzyme necessary for the biosynthesis of aromatic amino acids like phenylalanine, tyrosine and tryptophane, auxins, phytoalexins, folic acids, lignin and many other secondary products. Limited work has been done in Odisha on weed management in cotton under HDPS. Thus an attempt was made in this study for sequential application of pendimethalin and quizalofop ethyl, tank mixed pyriproxyfen sodium and quizalofop ethyl and post-emergence application of glyphosate at different doses having different modes of action along with one hand hoeing at 20 and 40 DAS in order to achieve the most effective and economic method of weed management in cotton grown under HDPS.

The field experiment was carried out at the research field of the All India Coordinated Research Project on Cotton located in the Regional Research and Technology Transfer Station, Bhawanipatna under the Odisha University of Agriculture and Technology during *kharif*, 2014 to evaluate different weed management methods in cotton grown under HDPS. The experiment was laid out in a randomized block design with three replications with eleven treatments as T₁: Pendimethalin @ 1.0 kg a.i./ha as Pre-em + one hand hoeing at 40 DAS, T₂: Quizalofopethyl @ 50 g a.i./ha at 20 DAS + one hand hoeing at 40 DAS, T₃: Pyriproxyfen Sodium @ 62.5g a.i./ha at 20 DAS + one hand

hoeing at 40 DAS, T₄: Pendimethalin @ 1.0 kg a.i./ha as Pre-em + Quizalofopethyl @ 50g a.i./ha at 20 DAS + one hand hoeing at 40 DAS, T₅: Pendimethalin 1.0.kg a.i./ha as Pre-em + Pyriothiac Sodium @ 62.5g a.i./ha at 20 DAS + one hand hoeing at 40 DAS, T₆: Pyriothiac Sodium @ 62.5g a.i./ha + Quizalofopethyl @ 50g a.i./ha at 20 DAS + one hand hoeing at 40 DAS, T₇: One hand hoeing at 20 DAS + Glyphosate @ 0.5 kg a.i./ha as directed spray at 40 DAS, T₈: One hand hoeing at 20 DAS + Glyphosate @ 0.75 kg a.i./ha as directed spray at 40 DAS, T₉: One hand hoeing at 20 DAS + Glyphosate @ 1.0 kg a.i./ha as directed spray at 40 DAS, T₁₀: Weed free check (manual weeding and hand hoeing at 20, 40 and 60 DAS) and T₁₁: Weedy check. The soil of the experimental site was clay loam in texture, low in available N, medium in available P and K with pH of 7.3. The cotton variety Suraj (duration- 165 days, staple length- 32.3 mm, micronaire-5.0, bundle strength- 21.0 g/tex and seed cotton yield- 1898 kg/ha) was sown on 07.07.2014 with a spacing of 60 cm x 10 cm and seed rate of 12.5 kg/ha. A uniform dose of fertilizer i.e. 90:45:45 kg/ha was applied in three splits (at the time of sowing, 30 DAS and 60 DAS). FYM was applied @ 5 t/ha at the time of final land preparation. The weed control measures were adopted as per the treatment. Pendimethalin was applied as pre-emergence (Pre-em) spray @ 1.0 kg a.i./ha at one DAS. Post-emergence (Post-em) application of pyriothiac sodium @ 62.5 g a.i./ha and quizalofop ethyl @ 50 g a.i./ha was made at 20 DAS and glyphosate @ 0.5 kg a.i./ha, 0.75 kg a.i./ha and 1.0 kg a.i./ha was done at 40 DAS. All the herbicide applications were followed by one hand hoeing at 40 DAS except glyphosate and the weedy

check. One hoeing was done at 20 DAS in the glyphosate treated plots. In the weed free treatment, three hand hoeing and weeding were carried out at 20, 40 and 60 DAS. The herbicides were sprayed with Knapsack sprayer fitted with flat fan nozzle using the spray volume of 500 litre of water/ha. Weed density and dry weight were recorded at 30, 60 and 90 DAS. Total rainfall received during the cropping season (June to December-2014) was 1357.8 mm in 48 rainy days. Average maximum temperature, minimum temperature, maximum relative humidity and minimum relative humidity were 32.02°C, 19.37°C, 78.69% and 69.13%, respectively.

Weed flora: The predominant weeds observed in the experiment were *Cynodon dactylon*, *Cyperus rotundus*, *Echinochloa colona*, *Commelina benghalensis*, *Amaranthus viridis*, *Ageratum conyzoides* and *Portulaca oleracea*.

Weed density: All the weed management practices significantly reduced the number of weeds and weed dry weight compared to the weedy check (Table 1). The number of weeds/m² was significantly minimum in weed free check at 30 DAS (44), 60 DAS (20) and 90 DAS (12.7). Among the herbicide treated plots, the minimum number of weeds/m² was observed with one hoeing at 20 DAS + Glyphosate @ 1.0 kg/ha at 30 DAS (131), 60 DAS (73) and 90 DAS (51) followed by one hoeing at 20 DAS + Glyphosate @ 0.75 kg/ha at 40 DAS and one hoeing at 20 DAS + Glyphosate @ 0.50 kg/ha at 40 DAS. The weed density was the maximum in weedy check plot. Weed population showed a decreasing trend from 30 DAS to 90 DAS in all

Table 1. Effect of weed management practices on cotton yield attributing characters, seed cotton yield and weed density and weed dry weight in cotton

Treatments	SCY (kg/ha)	Bolls/ plant	Bolls/ m ²	Boll weight (g)	Weed density (No./ m ²)			Weed dry weight (g/ m ²)			Weed control efficiency (%)		
					DAS			DAS			DAS		
					30	60	90	30	60	90	30	60	90
T₁ - Pendimethalin @ 1.0 kg a.i./ha as Pre- em + one hoeing at 40 DAS	1436	3.0	62	2.4	272	214	192.7	184.7	153.8	144.5	21.3	25.5	27.5
T₂ - Quizalofop ethyl @ 50 g a.i./ha 20 DAS + one hoeing at 40 DAS	1147	2.6	54	2.3	284	226	205.3	193.3	163.0	154.0	17.6	21.2	22.8
T₃ - Pyriithiobac Sodium @ 62.5g a.i./ha 20 DAS + one hoeing at 40 DAS	1476	3.4	71	2.4	247	189	168.3	168.2	136.3	126.3	28.5	34.2	36.9
T₄ - Pendimethalin 1.0kg a.i./ha + Quizalofop ethyl 50g a.i./ha at 20 DAS + one hoeing at 40 DAS	1584	4.5	93	2.3	227	169	147.7	154.1	121.4	110.8	34.4	41.4	44.6
T₅ - Pendimethalin 1.0kg a.i./ ha + Pyriithiobac Sodium @ 62.5g a.i./ha 20 DAS + one hoeing at 40 DAS	1632	4.6	97	2.6	211	153	132.3	143.7	110.4	99.3	38.7	46.5	50.1
T₆ - Pyriithiobac Sodium @ 62.5g a.i./ha + Quizalofop ethyl 50g a.i./ha at 20 DAS + one hoeing at 40 DAS	1544	4.3	89	2.3	258	200	178.7	175.2	143.8	134.0	25.5	30.6	33.0
T₇ - One hoeing at 20 DAS + Glyphosate @ 0.5kg a.i./ha as directed spray at 40 DAS	2605	5.1	107	2.8	202	144	122.7	137.1	103.4	92.0	41.5	49.8	53.7
T₈ - One hoeing at 20 DAS + Glyphosate @ 0.75kg a.i./ ha as directed spray at 40 DAS	2632	5.4	113	2.9	179	121	100.3	121.9	87.4	75.3	48.1	57.8	62.4
T₉ - One hoeing at 20 DAS + Glyphosate @ 1.0 kg a.i./ ha as directed spray at 40 DAS	2677	5.8	132	2.9	131	73	51.7	88.9	52.3	38.8	62.2	74.7	80.6
T₁₀ - Weed free check (manual weeding at 20, 40 and 60 DAS)	3013	6.6	167	3.1	44	20	12.7	29.9	14.4	9.5	87.2	93.1	95.2
T₁₁ - Weedy check	884	1.9	40	1.9	346	288	266.7	235.1	207.1	200.0	0	0	0
SEM +	164.4	0.22	4.67	0.13	6.74	6.49	6.51	4.58	4.68	4.87	1.81	2.21	2.34
CD (p=0.05)	465.21	0.67	14.02	0.38	20.21	19.49	19.50	13.74	14.04	14.62	5.44	6.58	6.97

the treatments.

Weed dry weight: Minimum weed dry weight/m² was recorded in weed free check at 30 DAS (29.9 g), 60 DAS (14.4 g) and 90 DAS (9.5 g). Among the herbicide treated plots, the minimum weed dry weight/m² was observed with one hoeing at 20 DAS + Glyphosate @ 1.0 kg a.i./ha at 30 DAS (88.9 g), 60 DAS (52.3 g) and 90 DAS (38.8 g) followed by one hoeing at 20 DAS + Glyphosate @ 0.75 kg a.i./ha at 40 DAS and one hoeing at 20 DAS + Glyphosate @ 0.50 kg a.i./ha at 40 DAS. The weed dry weight was

maximum in weedy check plot. Weed dry weight showed a decreasing trend from 30 DAS to 90 DAS in all the treatments.

Weed control efficiency: The weed control efficiency was maximum in weed free check at 30 DAS (87.2 %), 60 DAS (93.1 %) and 90 DAS (95.2 %). Among the herbicide treatments, the highest weed control efficiency was observed with one hoeing at 20 DAS + Glyphosate @ 1.0 kg a.i./ha at 30 DAS (62.2 %), 60 DAS (74.7 %) and 90 DAS (80.6 %) followed by one hoeing at 20 DAS + Glyphosate @ 0.75 kg

Table 2: Effect of weed management practices on economics of cotton

Treatments	Seed cotton Yield (kg/ha)	Gross returns (Rs/ha)	Cost of Cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio (Rs/Re)
T₁ - Pendimethalin @ 1.0 kg a.i/ha as Pre-emr + one hoeing at 40 DAS	1436	58,158	33,500	24,658	1.74
T₂ - Quizalofop ethyl @ 50 g a.i/ha 20 DAS + one hoeing at 40 DAS	1147	46,453	33,000	13,453	1.41
T₃ - Pyriithiobac Sodium @ 62.5g a.i/ha 20 DAS + one hoeing at 40 DAS	1476	59,778	34,000	25,778	1.76
T₄ - Pendimethalin 1.0kg a.i/ha + Quizalofop ethyl 50g a.i/ha at 20 DAS + one hoeing at 40 DAS	1584	64,152	34,300	29,852	1.87
T₅ - Pendimethalin 1.0kg a.i/ha + Pyriithiobac Sodium @ 62.5g a.i/ha 20 DAS + one hoeing at 40 DAS	1632	66,096	35,500	30,596	1.86
T₆ - Pyriithiobac Sodium @ 62.5g a.i/ha + Quizalofopethyl 50g a.i/ha at 20 DAS + one hoeing at 40 DAS	1544	62,532	34,800	27,732	1.80
T₇ - One hoeing at 20 DAS + Glyphosate @ 0.5kg a.i/ha as directed spray at 40 DAS	2605	1,05,502	32,500	73,002	3.24
T₈ - One hoeing at 20 DAS + Glyphosate @ 0.75kg a.i/ha as directed spray at 40 DAS	2632	1,06,596	32,800	73,796	3.25
T₉ - One hoeing at 20 DAS + Glyphosate @ 1.0 kg a.i/ha as directed spray at 40 DAS	2677	1,08,419	33,000	75,419	3.29
T₁₀ - Weed free check (manual weeding at 20, 40 and 60 DAS)	3013	1,22,026	38,000	84,026	3.21
T₁₁ - Weedy check	884	35,802	30,000	5,802	1.19

Note: The sale price of seed cotton: Rs.40.50 per kg.

a.i./ha at 40 DAS and one hoeing at 20 DAS + Glyphosate @ 0.50 kg a.i./ha at 40 DAS.

Seed cotton yield and yield attributing characters: Maximum seed cotton yield (3013 kg/ha), number of bolls/plant (6.6), bolls/m² (167) and boll weight (3.1g) was recorded in weed free check (Table-1). This was due to the reduced crop weed competition during the early growth stage of the crop. Among the integrated weed management approaches one hoeing at 20 DAS + Glyphosate @ 1.0 kg a.i./ha at 40 DAS recorded maximum seed cotton yield (2677kg/ha), number of bolls/plant (5.8), bolls/m² (132) and boll weight (2.9 g) being *at par* with one hoeing at 20 DAS + Glyphosate @ 0.75 kg a.i./ha at 40 DAS and one hoeing at 20 DAS + Glyphosate @ 0.50 kg a.i./ha at 40 DAS. Similar results in managing the weed flora in cotton by using glyphosate as post-em spray was reported by Prabhu *et al.* (2011) and Rao (2011).

Weed free check recorded maximum gross return (Rs. 1,22,026/ha) and net return (Rs. 84,026/ha) but the B:C ratio was maximum (3.29) in one hoeing at 20 DAS + post-emergence application of Glyphosate @ 1.0 kg/ha as directed spray at 40 DAS. Weedy check recorded the minimum net return and B:C ratio (Table-2.)

CONCLUSION

Integrated method of one hoeing at 20 DAS + post-emergence application of Glyphosate @ 1.0 kg/ha as directed spray at 40 DAS was the most effective and economic method of weed management in rainfed cotton grown under high density planting system.

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