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Chemical weed management in hybrid cotton under southern dry zone of Karnataka

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Abstract
A field experiment was conducted during *Kharif* season of 2015 & 2016 at Krishi Vignana Kendra Haradanahalli, Chamarajanagara, Karnataka to study the efficacy of herbicide for controlling weeds in hybrid Cotton. The trial was comprised of three herbicides *viz.*, pendimethalin (38.75 EC) at 0.75 kg a.i.ha^{-1}, Tank mixture of pyrithiobac sodium (10 SC) @ 62.5 g a.i.ha^{-1} + quizolofop ethyl (5 EC) @ 37.5 g a.i.ha^{-1}, pendimethalin (38.75 EC) @ 0.75 kg a.i.ha^{-1}, followed by Glyphosate (41% SL) @ 1.0 kg a.i.ha^{-1}, were compared with weed free and weedy check and laid out in randomized complete block design and replicated four times. The results revealed that, tank mixture of pyrithiobac sodium (10 SC) @ 62.5 g a.i.ha^{-1} + quizolofop ethyl (5 EC) @ 37.5 g a.i.ha^{-1} at 2 to 4 leaf stages of weeds recorded higher weed index (16.6%), net monetary returns (48500/- Rs./ha) and returns per rupees spent (Rs.12.54) with kapas yield of 1702 Kg/ha as compare to other herbicides.

Keywords: Hybrid cotton, kapas yield, weed index and weed control efficiency

Introduction
Cotton (*Gossypium* spp) is an important cash crop of global significance which plays a dominant role in the world agriculture and industrial economy. In India it is cultivated for fibre and oil purpose and it is important raw material for the Indian textile industry and contributes nearly 65 per cent of its requirement and provides employment for about 60 million people in the country (Jaya Kumar *et al.*, 2015) [5]. In India it occupies an area of 11.9 m.ha with a production of 33.8 million bales and productivity of 484 lint kg ha^{-1}. The productivity is lower in India compared to world (760 lint kg ha^{-1}). In Karnataka, it is grown in an area of 6.3 lakh ha with a production of 20 lakh bales with average productivity of 537 lint kg ha^{-1} (Anon., 2016) [1]. India has to presently produce 47.5 million bales of lint to meet the domestic and export requirement. To fulfil this requirement the cotton productivity has to be increased considerably. The kapas yield and crop area is fluctuating year after year and it is mainly depending on the prevailing climatic conditions and managerial issues such as weeds, pests and diseases incidence. Since, cotton is long duration crop and very slow growth in the initial stages, the weeds compete with the crop and causes severe yield losses ranges from 50 to 85 per cent depending upon the nature and intensity of weeds and also reduces quality due to additional trails and staining of fibres leaving to low grades and prices. Besides, harbouring crop pests and pathogens. At present there is scarcity of labourers with hike in wages and limited availability of moisture under rainfed situation for cultural operation to control weeds, force to go for application of one or more than one herbicide either in combination or sequence proved more effective and economical in controlling diversity of weeds. Keeping these things in view, the present investigation was undertaken to identify the suitable herbicides for effective and economical weed management in hybrid cotton.

Materials and Methods
The field experiment was conducted during Kharif season of 2015 & 2016 at Krishi Vignana Kendra Haradanahalli, Chamarajanagara, Karnataka to study the efficacy of herbicides for controlling weeds in hybrid Cotton. The experimental site is medium black soil with clay loam in texture and neutral in reaction (pH 7.4) and normal electrical conductivity (0.4 dsm^{-1}). The organic carbon content was 0.32 per cent and low in available nitrogen (224.3 kg ha^{-1}), medium in available phosphorus (22.34 kg ha^{-1}) and high in available potassium (284.3 kg ha^{-}

(284.3 kg ha^{-1}). The trial was laid out in randomized complete block design and replicated four times. The experiment comprised of three herbicides *viz.*, T_1-pendimethalin (38.75 EC) at 0.75 kg a.i.ha^{-1}, as pre emergence spray at 3DAS, T_2-Tank mixture of pyrithiobac sodium (10 SC) @ 62.5 g a.i.ha^{-1} + Quizolofop ethyl (5 EC) @ 37.5 g a.i.ha^{-1} at 2 to 4 leaf stages of weeds, T_3-pendimethalin (38.75 EC) @ 0.75 kg a.i.ha^{-1} as pre emergence spray at 3 DAS, followed by Glyphosate (41% SL) @ 1.0 kg a.i.ha^{-1} as directed spray at 2-4 leaf stages of weeds, were compared with T_4 - weed free check (hand weeding twice at 20 and 50 DAS) and T_5- weedy check. The cotton hybrid DCH-32 was sown during 1st fort might of July in both the years. The recommended dose of nutrients *viz.*, 150:75:75 $NP_2O_5K_2O$ kg ha^{-1} was applied uniformly to all the treatments in the form of urea, super phosphate and potash respectively as per recommendation. The 50% of the recommended N and 100% of P_2O_5 and K_2O were applied at the time of sowing and remaining 50% of Nitrogen top dressed at 50 & 80 DAS in equal splits. The one time hoeing was carried out uniformly for all treatments at 60 DAS except weedy check. The observations on weed population and weed dry weight were recorded at 20 and 60 DAS and data was analysed using square root transformation (X + 0.5). The seed cotton yield recorded at net plot basis converted to hectare and expressed in kg ha^{-1} and the net returns and returns per rupees spent on weed control practices was worked out with prevailing market price for critical inputs and produce at the time of experimentation. The data was statistically analysed by adopting Fishers methods of analysis of variance as outlined by Gomez and Gomez (1984)

$$\text{Returns per rupees spent on weed control} = \frac{\text{Marginal returns (Rs. ha}^{-1})}{\text{Marginal cost (Rs. ha}^{-1})}$$

Marginal returns (Rs./ha) = Additional returns obtained from each treatment over weedy check treatment

Marginal cost (Rs./ha) = Cost incurred exclusively for weed control

Net returns (Rs./ha) = Gross returns (Rs. ha-1) – Total cost of cultivation (Rs./ha)

Results and Discussion

Growth Attributes

The growth indices *viz.*, plant height, monopodial and sympodiol branches varied significantly due weed control treatments recorded at harvest (Table 1). There is no significant differences was observed among herbicidal treatments with respect to plant height (99.9 to 117.9 cm), monopodial branches (1.7 to 1.9 No. plant^{-1}) and sympodial branches (14.5 to 15.7 No. plant^{-1}) but they were significantly superior over weedy check (88.4 cm, 0.9 No. plant^{-1} and 11.1 No. plants^{-1} respectively) on pooled mean basis. The better growth attributes in herbicidal treatments is mainly due to effective control of weeds in the early and later stages of crop growth by sequential and tank mixture application of more than one herbicides. Similar results were reported by Muhummad *et al.* (2011) [7] and Jyotsana (2016) [6].

Yield attributes

There is no significant differences among herbicidal treatment were observed with respect to number of bolls per plant and individual boll weight (Table 2). Among herbicidal treatment sequential application of pendimethalin (38.75 EC) @ 0.75 kg a.i.ha^{-1} as pre emergence spray at 3 DAS, followed by Glyphosate (41% SL) @ 1.0 kg a.i.ha^{-1} as directed spray at 2-4 leaf stages of weeds recorded higher bolls per plant (27 No./plant) and individual boll weight (4.7 g) which was on par with pendimethalin (38.75 EC) at 0.75 kg a.i.ha^{-1}, as pre emergence spray at 3 DAS (22.5 No. Plant^{-1} and 4.4 g, respectively) and Tank mixture of pyrithiobac sodium (10 SC) @ 62.5 g a.i.ha^{-1} + Quizolofop ethyl (5 EC) @ 37.5 g a.i.ha^{-1} at 2 to 4 leaf stages of weeds (25.7 No. Plant^{-1} and 4.5 g, respectively). However superior over weedy check (12.8 No. Plant^{-1} and 3.8 g, respectively). The improvement in yield component is mainly due to lower weed competition which resulted maximum utilization of nutrients, moisture, light and space by crop and led to better growth. The similar results were reported by Patel *et al*. (2013) [8] and Hiremath (2013) [3].

Seed Cotton Yield

The seed cotton yield was significantly influenced by weed management practices (Table 2). Among herbicidal treatments, pendimethalin (38.75 EC) @ 0.75 kg a.i.ha^{-1} followed by Glyphosate @ 1.0 kg a.i.ha^{-1} as directed spray at 2 - 4 leaf stages of weed, significantly recorded higher seed cotton yield (1750 kg ha^{-1}), which was on par with tank mixture of pyrithiobac sodium (10 SC) @ 62.5 g a.i.ha^{-1} + quizalofopethyl (5 EC) @ 37.5 g a.i.ha^{-1} at 2 to 4 leaf stages of weeds (1702 kg ha^{-1}) and superior over pendimethalin (38.75 EC) @ 0.75 kg a.i.ha^{-1} at 3 DAS (1335 kg ha^{-1}). The weedy check recorded lower seed cotton yield (550 kg ha^{-1}) on pooled mean basis. The increased seed cotton yield is due to better weed control during initial and later stages of crop growth with application of more than one herbicide in sequence or tank mixtures which act as broad spectrum of weed control and resulted better growth of the plants and led to higher seed cotton yield. These results are in confirmation with the findings of Verraputhiran and Srinivasan (2015) [11], Jyotsana (2016) [6] and Honnappa and Shekar (2018) [4].

Weed dynamics

The weed population and weed dry weight was significantly influenced by weed control treatments at 20 & 60 DAS (Table 3). At 20 DAS the application pendimethalin (38.75 EC) at 0.75 kg a.i.ha^{-1}, as pre emergence spray at 3 DAS recorded lower weed population (3.0 No./0.3 m^2) and weed dry weight (2.7 g/ 0.3 m^2) which was on par with tank mixture of pyrithiobac sodium (10 SC) @ 62.5 g a.i.ha^{-1} + Quizolofop ethyl (5 EC) @ 37.5 g a.i.ha^{-1} at 2 to 4 leaf stages of weeds (4.4 No./0.3 m^2 and 4.3 g/ 0.3 m^2, respectively) and pendimethalin (38.75 EC) @ 0.75 kg a.i.ha^{-1} as pre emergence spray at 3 DAS, followed by Glyphosate (41% SL) @ 1.0 kg a.i.ha^{-1} as directed spray at 2-4 leaf stages of weeds (3.1 No./0.3 m^2 and 3.2 g/ 0.3 m^2, respectively). Whereas, weedy check recorded higher weed population and weed dry weight (5.2 No./0.3 m^2 and 5.3 g/ 0.3 m^2, respectively) on pooled mean basis.

At 60 DAS application of pendimethalin (38.75 EC) @ 0.75 kg a.i.ha^{-1} as pre emergence spray at 3 DAS, followed by Glyphosate (41% SL) @ 1.0 kg a.i.ha^{-1} as directed spray at 2-4 leaf stages of weeds recorded lower weed population (2.4 No./0.3 m^2) which was on par with tank mixture of pyrithiobac sodium (10 SC) @ 62.5 g a.i.ha^{-1} + Quizolofop ethyl (5 EC) @ 37.5 g a.i.ha^{-1} at 2 to 4 leaf stages of weeds (2.9 No./0.3 m^2) and superior over pendimethalin (38.75 EC) at 0.75 kg a.i.ha^{-1}, as pre emergence spray at 3 DAS (3.7 No./0.3 m^2). There is no significant difference among

herbicidal treatment with respect to weed dry weight (3.7 to 5.6 g /0.3 m^2) at 60 DAS. The weedy check recorded higher weed population (5.2 No. /0.3 m^2) and weed dry weight (8.7 g /0.3 m^2) on pooled mean basis (Table 3). This is due to better weed control efficiency with sequential and tank mixture application of herbicides which resulted better growth of the plants which smother the weeds. Similar results were reported by Prabha *et al.* (2010) [9]

Weed Indices

Among herbicidal treatment application of pendimethalin (38.75 EC) @ 0.75 kg a.i.ha^{-1} as pre emergence spray at 3 DAS, followed by Glyphosate (41% SL) @ 1.0 kg a.i.ha^{-1} as directed spray at 2-4 leaf stages of weeds recorded higher weed control efficiency (81.3 %) and lower weed index (14.6%) followed by tank mixture of pyrithiobac sodium (10 SC) @ 62.5 g a.i.ha^{-1} + quizolofop ethyl (5 EC) @ 37.5 g a.i.ha^{-1} at 2 to 4 leaf stages of weeds (72.0% and 16.6% respectively) on pooled mean basis (Table 4). This is mainly due to effective control of weeds by sequential and mixture of herbicide application which resulted higher kapas yield. This is in confirmation with the findings of Salimi *et al.* (2010) [10] and Hiremath (2013) [3].

Economic analysis

Among herbicidal treatments application of pendimethalin (38.75 EC) @ 0.75 kg a.i.ha^{-1} as pre emergence spray at 3 DAS, followed by Glyphosate (41% SL) @ 1.0 kg a.i.ha^{-1} as directed spray at 2-4 leaf stages of weeds recorded higher gross returns (78750 Rs./ha) followed by tank mixture of pyrithiobac sodium (10 SC) @ 62.5 g a.i.ha^{-1} + quizolofop ethyl (5 EC) @ 37.5 g a.i.ha^{-1} at 2 to 4 leaf stages of weeds (76410 Rs./ha). Whereas, higher net monetary returns (48500 Rs./ha) and maximum returns per rupee spent (12.54) was observed with application of tank mixture of pyrithiobac sodium (10 SC) @ 62.5 g a.i.ha^{-1} + quizolofop ethyl (5 EC) @ 37.5 g a.i.ha^{-1} at 2 to 4 leaf stages of weeds (Table 4). This is mainly due to lower cost of weed control and higher kapas yield. These results are in line with the findings of Hiremath (2013) [3] and Jyotsana (2016) [6].

Table 1: Growth parameters of Cotton as influenced by weed control treatment recorded at harvest

Treatments	Plant Height (cm)			Manopodial branches (No./Plant)			Sympodial branches (No./Plant)		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
Pendimethalin (38.75 EC) 0.75 kg a.i/ha as Pre emergence at 3 DAS	107.8	91.9	99.9	2.0	1.3	1.7	15.9	13.1	14.5
Tank mixture (Quizalofopethyl (5 EC) 37.5 g a.i/ha + Pyrithiobac Sodium (10 SC) @ 62.5g a.i/ha) at 2-4 weed leaf stage	114.9	101.2	108.1	2.0	1.9	1.9	16.4	14.2	15.3
Pendimethalin (38.75 EC) 0.75 kg a.i/ha as Pre emergence at 3 DAS fb Glyphosate (41% SL) @ 1.0 kg a.i /ha as directed spray at 2-4 weed leaf stages	117.9	104.2	111.1	1.7	1.7	1.7	16.4	15.0	15.7
Weed free check	127.6	108.2	117.9	2.0	1.8	1.9	19.0	15.7	17.4
Weedy check	106.6	70.1	88.4	1.0	0.9	0.9	14.1	8.1	11.1
S. Em ±	3.98	5.50	4.5	0.40	0.10	0.32	0.80	0.70	0.60
C.D. (P = 0.05)	11.80	16.60	13.4	1.10	0.30	0.87	2.50	2.20	1.70

Table 2: Yield and yield parameter of cotton as influenced by weed management practices

Treatments	Bolls (No. /Plant)			Boll weight (gm)			Kapas yield (Kg/ha)		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
Pendimethalin (38.75 EC) 0.75 kg a.i/ha as Pre emergence at 3 DAS	23.7	21.2	22.5	4.8	4.1	4.4	1169	1500	1335
Tank mixture (Quizalofopethyl (5 EC) 37.5 g a.i/ha + Pyrithiobac Sodium (10 SC) @ 62.5g a.i/ha) at 2-4 weed leaf stage	26.6	24.7	25.7	4.5	4.5	4.5	1498	1906	1702
Pendimethalin (38.75 EC) 0.75 kg a.i/ha as Pre emergence at 3 DAS fb Glyphosate (41% SL) @ 1.0 kg a.i /ha as directed spray at 2-4 weed leaf stages	26.3	27.6	27.0	4.9	4.4	4.7	1492	2007	1750
Weed free check	33.3	35.0	34.2	5.3	4.8	5.1	1810	2267	2039
Weedy check	13.0	12.50	12.8	4.0	3.6	3.8	509	591	550
S. Em ±	2.40	1.70	1.90	0.30	0.20	0.20	66.07	125.0	93.20
C.D. (P = 0.05)	7.20	5.20	5.90	0.98	0.50	0.40	196.30	374.0	273.50

Table 3: Weed population and dry weight of weeds, as influenced by chemical weed management

Treatments	Weed Population (No.s/0.3 sq.mt)						Weed dry weight (gm/0.3 sq.mt)					
	20 DAS			60 DAS			20 DAS			60 DAS		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
Pendimethalin (38.75 EC) 0.75 kg a.i/ha as Pre emergence at 3 DAS	2.8 (8.0)	3.1 (9.0)	3.0 (8.5)	3.5 (13.2)	3.8 (14.0)	3.7 (13.2)	2.7 (8.0)	2.6 (6.3)	2.7 (7.2)	5.5 (30.5)	5.6 (30.7)	5.6 (30.3)
Tank mixture (Quizalofopethyl (5 EC) 37.5 g a.i/ha + Pyrithiobac Sodium (10 SC) @ 62.5g a.i/ha) at 2-4 weed leaf stage	4.9 (24.0)	3.8 (13.7)	4.4 (18.9)	3.3 (11.1)	3.4 (5.3)	2.9 (8.2)	4.8 (23.0)	3.8 (13.8)	4.3 (18.4)	5.2 (28.5)	3.6 (12.9)	4.4 (20.7)
Pendimethalin (38.75 EC) 0.75 kg a.i/ha as Pre emergence at 3 DAS fb Glyphosate (41% SL) @ 1.0 kg a.i /ha as directed spray at 2-4 weed leaf stages	2.8 (8.0)	3.3 (10.2)	3.1 (9.1)	2.7 (7.3)	2.1 (4.0)	2.4 (5.7)	2.8 (7.9)	3.3 (10.2)	3.2 (9.1)	4.2 (18.4)	3.1 (9.3)	3.7 (13.9)
Weed free check	4.1 (17.3)	1.7 (2.6)	2.9 (10.0)	1.2 (1.7)	1.5 (1.7)	1.4 (1.7)	4.0 (16.6)	1.7 (2.6)	2.9 (9.6)	1.9 (3.8)	2.2 (4.2)	2.1 (4.0)
Weedy check	5.5 (30.3)	4.9 (23.6)	5.2 (27.0)	4.7 (22.3)	5.6 (31.3)	5.2 (26.8)	5.4 (29.6)	4.9 (23.6)	5.3 (26.6)	8.5 (72.0)	8.9 (78.6)	8.7 (75.3)
S. Em ±	0.30	0.90	0.50	0.30	0.10	0.20	0.30	0.90	0.50	0.50	2.10	1.30
C.D. (P = 0.05)	0.80	2.60	1.60	0.90	0.40	0.70	0.90	2.60	1.50	1.50	6.30	3.90

Figure in parenthesis refers to original value

Table 4: Weed control efficiency, weed Index (%) and economics of hybrid cotton as influenced by chemical weed control

Treatments	Weed control efficiency (%)			Weed Index (%)			Economics (Mean of two years)		
	2015	2016	Mean	2015	2016	Mean	Gross returns (Rs./ha)	Net returns (Rs./ha)	Return per Rupees spent
Pendimethalin (38.75 EC) 0.75 kg a.i/ha as Pre emergence at 3 DAS	57.6	60.9	59.3	35.4	33.8	34.6	60075	33212	11.30
Tank mixture (Quizalofopethyl (5 EC) 37.5 g a.i/ha + Pyrithiobac Sodium (10 SC) @ 62.5g a.i/ha) at 2-4 weed leaf stage	60.4	83.6	72.0	17.2	15.9	16.6	76410	48500	12.54
Pendimethalin (38.75 EC) 0.75 kg a.i/ha as Pre emergence at 3 DAS fb Glyphosate (41% SL) @ 1.0 kg a.i /ha as directed spray at 2-4 weed leaf stages	74.3	88.2	81.3	17.6	11.5	14.6	78750	47869	7.62
Weed free check	94.5	94.7	94.6	-	-	-	91755	57755	6.56
Weedy check	-	-	-	71.9	73.9	72.9	24750	950	-

*Selling price of Kapas (Rs.45/Kg)

Conclusion

Based on the results it can be inferred that application of tank mixture of pyrithiobac sodium (10 SC) @ 62.5 g a.i.ha^{-1} + quizolofop ethyl (5 EC) @ 37.5 g a.i.ha^{-1} at 2 to 4 leaf stages of weeds found suitable and economical herbicides which recorded comparable kapas yield, gross returns and weed control efficiency with that of sequential application of herbicides and higher net monetary returns and profit per rupee spent on weed control compared to other herbicides tested in hybrid cotton under southern dry zone of Karnataka.

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