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Weed Dynamics in Flue Cured Tobacco Crop as Influenced by Pre Transplant, Pre Emergence and Post Emergence Herbicides in Northern Light Soils of Andhra Pradesh

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ABSTRACT: One of the major challenges in flue cured (FC) tobacco is achieving effective weed control during early growth stages. Creating weed free conditions to facilitate early growth is extremely critical, however due to peak agricultural activity during the establishment phase, availability of labour is a major constraint. Grasses, broad leaved weeds and sedges constitute the weed flora infesting tobacco. Dominant weed species are *Echinochloa colona, Digitaria sanguinalis, Dactyloctenium aegyptium, Echinochloa crusgalli, Cleome viscosa, Amaranthus viridis, Cyperus compressus and Cyperus rotundus*. Due to non-availability of herbicides for tobacco specific weed control, an effective weed management program could not be established. In the recent past, substantial developments happened in the introduction of new herbicide molecules. A two year field experiments were conducted at Peddpauram village of West Godavari district (Andhra Pradesh) during (*Rabi*) seasons of 2018-19 and 2019-20, to study the effect of pre transplant, pre emergence and post emergence herbicides on weed dynamics of FC tobacco crop. The design of the experiment was Randomized Block Design with 11 herbicide management practices with 3 replications. The treatments were pre transplant application of Sulfentrazone at 0.3 kg a.i. ha^{-1}, pre emergence application of Pendimethalin at 0.75 kg a.i.ha^{-1}, Oxyfluorfen at 0.25 kg a.i. ha^{-1}, Alachlor at 0.75 kg a.i. ha^{-1}, post emergence application of Quizalofop at 0.05 kg a.i. ha^{-1}, Imazethapyr at 0.05 kg a.i. ha^{-1}, Fenoxaprop at 0.056 kg a.i. ha^{-1}, Propaquizafop at 0.05 kg a.i. ha^{-1} and Carfentrazone at 0.02 kg a.i. ha^{-1}. Statistically lower values of weed density and weed dry weight of grasses, BLW, sedges and total weed at 40 days after herbicides application and higher weed control efficiency (WCE) and lower weed index (WI) in both years of experimentation were obtained with pre transplant application of Sulfentrazone at 0.3 kg a.i. ha^{-1} which is equivalent to six inter cultivation and two manual weeding treatment.

Keywords: Pre transplant herbicide, pre emergence herbicide, post emergence herbicide weed control efficiency, weed index and FC tobacco.

INTRODUCTION

Flue cured tobacco accounts for 30 % of total tobacco produced in the India and used for manufacturing cigarettes. India ranks 3rd in production (230 million kg) of flue cured (FC) tobacco and 4th in exports of unmanufactured tobacco in the world valued at ₹ 5969 crores during 2019-20 (Tobacco board of India, 2020). Flue cured tobacco is most important commercial crop grown in Andhra Pradesh and Karnataka states. In Northern light soils of West Godavari district of Andhra Pradesh, India, FC tobacco grown under irrigated conditions. Weeds play a critical role in determining yield and quality of flue cured tobacco under both irrigated and rain fed production systems.

Conventionally weed management in tobacco is done by manual labour, which in the recent past not only became expensive but also scarce in availability. In such circumstances, weed management by using herbicides play an important role in effectively controlling weeds (Shilling *et al.*, 1986; Bruff *et al.*, 1997 and Wickliffe *et al.*, 1996; Kimberly *et al.*, 2015; Vikram *et al*., 2020), ensuring timely operations and reduce dependence on labour and production expenditure. Presence of weeds in tobacco influences yield and quality (Paunescu *et al.*, 1992; Wilson, 1995; Niel, 1996), cause interference during harvest, and serve as hosts for disease and insect pests. Farmer realizing a better yield on account of successful weed management practices, results in long term sustainability of the crop.

MATERIALS AND METHODS

Field experiments were conducted in two consecutive seasons in 2018-19 and 2019-20 (October to March) at Peddapuram village in West Godavari, Andhra Pradesh, India. The soil was sandy clay, slight acidic pH (6.41), with low organic carbon content (0.42%). Nine treatment combinations comprising of pre transplant (Sulfentrazone 39.6% SC @ 0.3 kg a.i. ha^{-1}) (Fisher *et al.,* 2004; Upenyu, 2013), pre emergence (Pendimethalin 30% EC @ 0.75 kg a.i. ha^{-1}, Oxyfuorfen 23.5 % EC @ 0.25 kg a.i. ha^{-1}, Alachlor 50% EC @ 0.75 kg a.i. ha^{-1}) and post emergence herbicides (Quizalofop-p- ethyl 5% EC @ 0.05 kg a.i. ha^{-1}, Imazethapyr 10% SL @ 0.05 kg a.i. ha^{-1}, Fenoxaprop ethyl 9% EC @ 0.056 kg a.i ha^{-1}, Propaquizafop Ethyl 10% EC @ 0.05 kg a.i. ha^{-1} at 25 DAT) were experimented with weedy check and Inter cultivation with manual weeding as checks. These treatments were arranged in a Randomized Block Design with three replications. All the herbicides were applied with high volume knapsack sprayer with flat fan nozzle delivering of 500 liters of spray fluid ha^{-1}. Sulfentrazone was applied two days before transplantation and Pendimthalin, Alachlor and Oxyfluorfen were applied as pre emergence herbicides within 2 days after plantation. Post emergence application of Imazethapyr, Quizalofop-p-ethyl, Fenoxaprop ethyl, Propaquizafop and protected spray of carftentrazone at 25 days after transplantation (DAT) was carried out.

Sixty day old tobacco seedlings of popular hybrid CH 3 were transplanted on ridges during 2nd week of November in both the years, with a plant population of 15,873 ha^{-1} by adopting a spacing of 105 × 60 cm. Hundred percent plant population was maintained by replacing the missing plants within one week after transplantation. Recommended fertilizers were applied (120:60:150; N: P_2O_5:K_2O kg ha^{-1}) and other production practices were followed in line with the recommendations of Central Tobacco Research Institute (ICAR). The entire dose of phosphorus was applied as basal, whereas nitrogen and potassium were applied in three splits – 7DAT, 20 DAT and 45 DAT. The ripe leaves were manually harvested in 5 - 6 harvests in February and March, and cured in a flue curing barn. The cured leaf was conditioned, bulked and graded treatment wise.

Data on weed density (number m^{-2}) and dry weight (g m^{-2}) at 40 DAHA (Days after herbicide application) were recorded randomly at four points in each treatment plot using a quadrat of 1 m × 1m. Weed samples were dried at 70°C and dry weight was recorded. Before subjecting to statistical analysis, the weed data were subjected to square root transformation $\sqrt{X+0.5}$ to normalize their distribution. Data obtained in the study were statistically analysed using F-test and CD values at P=0.05 to determine the significance of difference among treatments. Weed control efficiency (WCE) was computed by using the formulae based on total weed dry weight.

$$\text{Weed Control Efficiency} = \frac{WDM_c - WDM_t}{WDM_c}$$

Where

WDM_c = Weed dry weight (g m^{-2}) in control plot

WDM_t = Weed dry weight (g m^{-2}) in treated plot

Weed index (WI) was computed by using the formulae. All the indices are expressed in percentage

$$\text{Weed index} = \frac{X - Y}{X} \times 100$$

Where

X = Yield from minimum weed competition plot

Y = Yield from the treatment plot

RESULTS AND DISCUSSION

Weed flora. In experimental field, major weed species associated with tobacco crop among the grasses were *Echinochloa colona* (L.) Link. *Digitaria sanguinalis* (L.) Scop., *Dactyloctenium aegyptium* (L.) Willd., *Echinochloa crusgalli* (L.) Beauv. Among broad leaved weeds *Cleome viscosa* (L.), *Amaranthus viridis* Hook. F and *Cyperus compressus* (L.), *Cyperus rotundus* (L.) among sedges.

Weed density and weed dry weight. All the herbicide management practices were significantly affected the density and dry weight of grasses, broad leaved weeds (BLW), sedges (Upenya, 1999) and total weeds over control in both years of experiment (Table 1 and 2). Among weed management practices, Sulfentrazone at 0.3 kg a.i ha^{-1}, reduced the density of grasses to 1.42 No. m^{-2} and 2.59 No. m^{-2} and dry weight to 1.96 g m^{-2}, 2.14 g m^{-2} during two years of experimentation. The density and dry weight of BLW were 0.27 No. m^{-2} and 1.70 No. m^{-2} and dry weight to 0.5 g m^{-2} and 3.28 g m^{-2} and Sedges recorded weed density of 2.61 No. m^{-2}, and 2.58 No. m^{-2} and dry weight to 1.93 gm^{-2} 1.00 g m^{-2}. The total weed density and dry weights were 4.30 No.

m^{-2} and 6.87 g m^{-2} and dry weight to 4.39 g m^{-2} and 6.42 g m^{-2} at 40 DAHA during both years of 2018-19 and 2019-20. These results are comparable to weed management practices such as 6 inter cultivations and 2 manual weeding. Among the three types of weeds, grasses were the dominant flora followed by sedges and both of them were effectively controlled by pre transplant application of Sulfentrazone (William *et al.*, 2013; Kimberly *et al.*, 2015) at 0.3 kg a.i ha^{-1} and provided season long weed free environment. Contrarily, higher density and dry weight of weeds were observed in weedy check plot due to inadequate control of weeds.

Table 1: Effect of weed management practices on density of weeds (No. m^{-2}) in FC Tobacco at 40 DAHA during Rabi 2018-19 and 2019-20.

Treatments		2018-19				2019-20			
		Grasses	BLW	Sedges	Total	Grasses	BLW	Sedges	Total
T_1:	PRTR (pre transplant) Sulfentrazone 39.6% SC @ 0.3 kg a.i. ha^{-1}	1.39 (1.42)	0.88 (0.27)	1.76 (2.61)	2.19 (4.3)	1.76 (2.59)	1.48 (1.70)	1.75 (2.58)	2.71 (6.87)
T_2:	PE Pendimethalin 30% EC @ 0.75 kg a.i. ha^{-1}	4.18 (16.98)	2.00 (3.50)	7.79 (60.11)	9.00 (80.59)	4.11 (16.38)	1.80 (2.73)	7.40 (54.24)	8.59 (73.35)
T_3:	PE Oxyfuorfen 23.5 % EC @ 0.25 kg a.i. ha^{-1}	3.78 (13.8)	1.00 (0.50)	7.28 (52.55)	8.21 (66.85)	3.63 (12.65)	1.77 (2.62)	7.23 (51.78)	8.22 (67.05)
T_4:	PE Alachlor 50% EC @ 0.75 kg a.i. ha^{-1}	3.23 (9.93)	0.71 (0.00)	7.52 (55.99)	8.15 (65.91)	3.01 (8.54)	1.47 (1.67)	7.43 (54.70)	8.09 (64.91)
T_5:	POE Quizalofop-p- ethyl 5% EC @ 0.05 kg a.i. ha^{-1} at 25 DAT	1.10 (0.7)	5.02 (24.67)	8.85 (77.89)	10.19 (103.26)	2.40 (5.27)	4.89 (23.37)	9.09 (82.21)	10.55 (110.86)
T_6:	POE Imazethapyr 10% SL @ 0.05 kg a.i ha^{-1} at 25 DAT	4.36 (18.5)	0.71 (0.00)	4.08 (16.17)	5.93 (34.68)	4.43 (19.13)	1.15 (0.81)	4.12 (16.49)	6.08 (36.44)
T_7:	POE Fenoxaprop ethyl 9% EC @ 0.056 kg a.i. ha^{-1} at 25 DAT	3.15 (9.45)	3.17 (9.56)	8.44 (70.72)	9.50 (89.72)	4.11 (16.39)	4.39 (18.79)	8.04 (64.22)	9.99 (99.39)
T_8:	POE Propaquizafop Ethyl 10% EC @ 0.05 kg a.i. ha^{-1} at 25 DAT	1.35 (1.33)	4.76 (22.12)	10.28 (105.24)	11.37 (128.69)	2.04 (3.66)	4.66 (21.25)	10.52 (110.19)	11.64 (135.11)
T_9:	POE Carfentrazone ethyl 40 % DF @ 0.02 kg a.i. ha^{-1} at 25 DAT	10.97 (119.81)	1.52 (1.82)	5.83 (33.43)	12.47 (155.07)	11.56 (133.03)	1.46 (1.63)	5.51 (29.88)	12.85 (164.54)
T_{10}:	Farmers Practice (6 intercultivations & 2 Manual Weeding)	2.25 (4.57)	0.71 (0.00)	1.60 (2.07)	2.67 (6.63)	3.12 (9.22)	0.71 (0.00)	2.07 (3.78)	3.67 (12.99)
T_{11}:	Control (Weedy Check)	11.77 (137.98)	4.96 (24.13)	9.09 (82.14)	15.64 (244.26)	11.98 (143.05)	3.34 (10.64)	9.37 (87.30)	15.54 (240.99)
SEd		1.07	0.61	1.35	1.87	1.23	0.67	1.16	1.78
CD (P=0.05)		2.24	1.27	2.81	3.91	2.57	1.39	2.43	3.7

Figure in parenthesis are original values, which were transformed √X+0.5 and statistically analysed.

Table 2: Effect of weed management practices on weed dry weight (g m^{-2}) in FC Tobacco at 40 DAHA during Rabi 2018-19 and 2019-20.

Treatments		2018-19				2019-20			
		Grasses	BLW	Sedges	Total	Grasses	BLW	Sedges	Total
T_1:	PRTR (pre transplant) Sulfentrazone 39.6% SC @ 0.3 kg a.i. ha^{-1}	1.57 (1.96)	1.00 (0.50)	1.56 (1.93)	2.21 (4.39)	1.63 (2.14)	1.94 (3.28)	1.22 (1.00)	2.63 (6.42)
T_2:	PE Pendimethalin 30% EC @ 0.75 kg a.i. ha^{-1}	4.92 (23.70)	2.66 (6.55)	6.55 (42.40)	8.55 (72.65)	3.75 (13.55)	2.46 (5.56)	4.50 (19.72)	6.27 (38.83)
T_3:	PE Oxyfuorfen 23.5 % EC @ 0.25 kg a.i. ha^{-1}	4.43 (19.09)	1.19 (0.93)	6.12 (36.95)	7.58 (56.96)	3.32 (10.51)	2.36 (5.05)	4.40 (18.82)	5.91 (34.38)
T_4:	PE Alachlor 50% EC @ 0.75 kg a.i. ha^{-1}	3.78 (13.77)	0.71 (0.00)	6.24 (38.43)	7.26 (52.20)	2.76 (7.11)	1.88 (3.04)	4.47 (19.50)	5.49 (29.65)
T_5:	POE Quizalofop-p- ethyl 5% EC @ 0.05 kg a.i. ha^{-1} at 25 DAT	1.17 (0.87)	7.01 (48.67)	7.4 (54.33)	10.22 (103.88)	2.22 (4.43)	6.94 (47.71)	5.50 (29.75)	9.08 (81.89)
T_6:	POE Imazethapyr 10% SL @ 0.05 kg a.i. ha^{-1} at 25 DAT	5.15 (26.05)	0.71 (0.00)	3.41 (11.15)	6.14 (37.20)	4.03 (15.75)	1.40 (1.45)	2.53 (5.92)	4.86 (23.13)
T_7:	POE Fenoxaprop ethyl 9% EC @ 0.056 kg a.i. ha^{-1} at 25 DAT	3.74 (13.49)	4.41 (18.92)	7.02 (48.76)	9.04 (81.16)	3.73 (13.42)	6.25 (38.55)	4.85 (23.06)	8.69 (75.03)
T_8:	POE Propaquizafop Ethyl 10% EC @ 0.05 kg a.i. ha^{-1} at 25 DAT	1.50 (1.76)	6.67 (43.93)	8.65 (74.35)	10.98 (120.04)	1.89 (3.07)	6.64 (43.53)	6.36 (39.94)	9.33 (86.54)
T_9:	POE Carfentrazone ethyl 40 % DF @ 0.02 kg a.i. ha^{-1} at 25 DAT	12.94 (166.88)	2.01 (3.55)	4.89 (23.88)	13.94 (193.81)	10.48 (109.31)	1.87 (2.98)	3.34 (10.66)	11.11 (122.96)
T_{10}:	Farmers Practice (6 intercultivations & 2 Manual Weeding)	2.64 (6.49)	0.71 (0.00)	1.36 (1.35)	2.89 (7.84)	2.87 (7.75)	0.71 (0.00)	1.38 (1.41)	3.11 (9.16)
T_{11}:	Control (Weedy Check)	13.90 (192.80)	6.98 (48.22)	7.59 (57.11)	17.28 (298.13)	10.85 (117.21)	4.73 (21.87)	5.63 (31.23)	13.07 (170.31)
SEd		1.27	0.86	1.15	1.92	1.1	1.02	0.71	1.61
CD (P=0.05)		2.65	1.79	2.40	4.01	2.29	2.12	1.47	3.36

Figure in parenthesis are original values, which were transformed √X+0.5 and statistically analysed.

In addition to Sulfentrazone, the Pendimethalin (Yousafzai *et al.*, 2006; Yousafzai *et al.*, 2007), Alacholor & Oxyfluorfen (Krishna Murthy *et al.*, 1991) were also effective in controlling grassy weeds and the same herbicides were ineffective in controlling BLW and Sedges during both years of experimentation. Among post emergence herbicides, Carfentrazone is effective in controlling BLW and unable to control grasses and sedges in both crop seasons. Sulfentrazone was effective in controlling sedges (Andhale and Kathmale, 2019; Fisher *et al.,* 2001; Mashezha *et al.,* 2013; Vikram *et al.*, 2020), grasses and BLW and comparable with six inter cultivations and two manual weeding. Similar trends were observed with weed density and weed dry weight during both years in the same treatment.

Weed Control Efficiency. Higher weed control efficiency (Table 3) at 40 days after herbicide application was obtained with the application of Sulfentrazone (Mashayamombe *et al.*, 2013; Bailey *et al.*, 2014 and Mehar and Samar, 2018) at 0.3 kg a.i ha^{-1} and 6 inter cultivations and 2 manual weeding in both the crop seasons of 2018-19 and 2019-20. Among post emergence herbicides, Imazethapyr at 0.05 kg a.i. ha^{-1} recorded higher weed control efficiency in both the years (89.7 and 85.4%) and having stunting effect. Application of Quizalofop-p-ethyl (Krishna *et al.*, 2018), Propaquizafop and Fenoxaprop ethyl Pendimethalin (Yousafzai *et al.,* 2006; Yousafzai *et al.*, 2007) effectively controlled grasses with higher weed control. Carfentrazone recorded lower values (Bailey and Pearce, 2014) (21.8% and 25.4%) of weed control efficiency among herbicide treatments. The experimental data suggests a positive correlation between yield and weed control efficiency.

Table 3: Effect of weed management practices on Weed control efficiency (%) at 40 DAHA and weed index (%) in FC tobacco during Rabi 2018-19 and 2019-20.

Treatments		Weed Control Efficiency (%)		Weed index	
		2018-19	2019-20	2018-19	2019-20
T_1:	PRTR (pre transplant) Sulfentrazone 39.6% SC @ 0.3 kg a.i. ha^{-1}	98.8	95.1	5.2	4.8
T_2:	PE Pendimethalin 30% EC @ 0.75 kg a.i. ha^{-1}	87.3	74.9	8.0	9.5
T_3:	PE Oxyfuorfen 23.5 % EC @ 0.25 kg a.i. ha^{-1}	81.5	76.4	10.1	8.0
T_4:	PE Alachlor 50% EC @ 0.75 kg a.i. ha^{-1}	77.7	79.0	15.8	10.7
T_5:	POE Quizalofop-p- ethyl 5% EC @ 0.05 kg a.i. ha^{-1} at 25 DAT	71.4	50.2	21.0	17.0
T_6:	POE Imazethapyr 10% SL @ 0.05 kg a.i. ha^{-1} at 25 DAT	89.7	85.4	41.6	36.1
T_7:	POE Fenoxaprop ethyl 9% EC @ 0.056 kg a.i. ha^{-1} at 25 DAT	80.5	55.8	17.6	17.8
T_8:	POE Propaquizafop Ethyl 10% EC @ 0.05 kg a.i. ha^{-1} at 25 DAT	60.9	48.3	22.6	19.6
T_9:	POE Carfentrazone ethyl 40 % DF @ 0.02 kg a.i. ha^{-1} at 25 DAT	21.8	25.4	33.3	31.6
T_{10}:	Farmers Practice (6 intercultivations & 2 Manual Weeding)	95.8	92.8	0.0	0.0
T_{11}:	Control (Weedy Check)	0	0	42.9	42.9

Weed index. Higher values of Weed index (Table 3) were observed in Control (Unweeded) (42.9% and 42.8% in 2018-19 and 2019-20), respectively resulting in lower yield, which can be attributed to inadequate control on weed growth. Among herbicides, Sulfentrazone at 0.3 kg a.i. ha^{-1} recorded lower values (5.2 % and 4.8%) of weed index, while Imazethapyr at 0.05 kg a.i.ha^{-1} recorded higher values (41.6% and 36.1%). The data on weed index shows a negatively correlation with crop yield.

CONCLUSION

Studies from the current investigation indicates that pre transplant application of Sulfentrazone at 0.3 kg a.i. ha^{-1} efficiently controls grasses, BLW and Sedges in FC tobacco and is comparable to the practice of six inter cultivations and two manual weeding. The experimental data also suggests that pre emergence application of herbicides were more effective than post emergence herbicides in FC tobacco in Northern Light Soils of Andhra Pradesh, India.

FUTURE SCOPE

The investigation was taken up on Flue cured tobacco grown under irrigated conditions. Similar studies needs to be taken up to establish the weed control practices under rained conditions and other types of tobacco.

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Conflict of Interest. Authors have no competing interest and the formulations of various material used are available commercially in the market and used by growers cultivating Sugarcane and Soybean in different regions in India. These formulations are experimented for use on tobacco only to evaluate the effectiveness in controlling weeds, and enhance the knowledge base. The study is self-funded.

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