ORIGINAL ARTICLE

Impact of herbicides on some agronomic and chemical characteristics of flue-cured virginia (FCV) tobacco (*Nicotiana tabacum* L.)

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Abstract

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A field experiment was carried out at Tobacco Research Station Khan Ghari, Mardan, (NWFP)-Pakistan during spring 2003 to study the impact of herbicides on some agronomic and chemical characteristics of flue-cured virginia (FCV) tobacco (*Nicotiana tabacum* L.). The experiment was laid out in RCB design, replicated four times with ten treatments, comprising hand weeding, weedy check, pre-transplanting herbicides; S-metalocholar @ 1.92, pendimethalin (EC) @ 1.00, pendimethalin (CS) @ 1.00, and butralin @ 1.44 kg a.i ha^{-1} and the post-transplanting herbicides include; clodinafop @ 0.04, fenoxaprop-p-ethyl @ 1.00, acetochlor @ 0.125 and glyphosate @ 0.95 kg a.i ha^{-1}. None of the herbicides except S-metalocholar had a phytotoxic effect on tobacco. All the parameters except the number of leaves plant^{-1} were significantly affected by different treatments. The highest (228.3) weeds density m^{-2} was observed in weedy check while minimum (69) was recorded in pendimethalin (EC) treatment. The maximum grade index of 74.60% was

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recorded in acetochlor and minimum grade index of 53.88% was recorded in S-metalocholar treatments. Nicotine (%) was higher in pendimethalin (EC) treated plots with 2.362%; however it was comparable to all other treatments. The maximum percent reducing sugar of 18.22% was recorded in pendimethalin (CS) treatment, while minimum of 12.42% reducing sugar was recorded in weedy check. Similarly maximum yield of 2465 kg ha^{-1} was recorded in pendimethalin (EC) treatment and minimum yield of 1703 kg ha^{-1} was recorded in weedy check (control) treatment. Thus it can be concluded from the experiment that herbicides proved effective against weeds and their growth and promoted tobacco quality and yield. Hence the use of herbicides not only increases the net income of the farmers but also will make the weed seed bank poorer.

Key words : tobacco, weeds, herbicides, yield

In Pakistan tobacco contributes Rs 34 billion to GDP in addition to foreign earning of Rs 587 million by the cigarette manufactures. It generates six times more excise duty than cotton yarn (Anonymous, 2002). In Pakistan, tobacco was grown on an area of 43.9 thousand ha in 1991 and it increased to 46.6 thousand ha in 2003. Similarly, its production increased from 75 thousand tons in 1991 to 88.2 thousand tons in 2003 with average yield of 1891 kg ha^{-1} in Pakistan (Anonymous, 2003). Yield increase is due to adoption of a number of improved cultural practices, i.e. the use of complex fertilizer, optimum plant population, better management of weeds, use of standard pesticides, topping and desuckering and use of wet and dry bulb thermometer during curing. The tempo however, needs to be sustained rather further accelerated, as there exists a gap between the actual and potential yield of the tobacco at the farmer's fields.

Tobacco crop is highly fascinating by any yardstick. Not only dose it involves scientific treatment, but it also requires special attention by the producers during the production, curing and marketing stages. Our farmers are getting poor yields of tobacco as compared to the advanced countries of the world. There are several reasons for the lower yield of tobacco among which weed infestation is the most important one. Weeds compete with crop plants for nutrients, soil moisture, space and sunlight and hence reduce yield. Most of the weeds are more competitive than the crop plants. Reduction in tobacco yield has a direct correlation with weed competition. Generally an increase in one kilogram of weed growth corresponds to a reduction in one kilogram of crop growth (Rao, 2000). Weed control is an important practice in tobacco, since weed competition for moisture and nutrients has been realized.

Effective weed control in tobacco can be achieved by utilizing all available methods of weed control in mutually supportive manure. The use of herbicides in tobacco offers several important benefits, which supplement other components of the weed management program. Good early-season weed control with herbicides is important in reducing competition and allowing the rapid establishment of tobacco seedlings as labor requirements for hand hoeing and cultivation can be reduced by proper use of herbicides. All weeds do not respond in the same manner to all herbicides. Therefore, the weeds species expected to infest the field should be in focus when planning a weed control program. Several researchers have emphasized the importance of chemical weed control in tobacco. Tan *et al.* (1999) reported that herbicides were effective against weeds and even promoted the growth of tobacco. Dhanapal *et al.*, (1998) reported that the use of herbicides increased the tobacco yield by 80 to 100% when compared to control treatment. Use of herbicides effectively controlled the weeds and increased the yield (Tremola and Carotenuto, 1996).

Since no systematic research has been undertaken on the problem of weeds in tobacco in this locality, an experiment was conducted during March 2003, at Tobacco Research Station, Khan Garhi, Mardan, (NWFP)-Pakistan with the following objectives:

1. to quantify the efficacy of different post and pre-emergence herbicides on weeds.
2. to observe the phytotoxic effect of herbicides on tobacco crop, if any.
3. to figure out the impact of these herbicides on yield and yield components of tobacco.

Materials and Methods

A field experiment entitled "impact of herbicides on some agronomic and chemical characteristics of flue-cured virginia (FCV) tobacco (*Nicotiana tabacum* L.)" was carried out at Tobacco Research Station Khan Ghari, Mardan (NWFP)-Pakistan during 2003. The experiment was conducted on well-prepared soil, ploughed three times and the same number of planking for obtaining a bumper crop. Ridges were made by using a manual ridger. A single seedbed was 10 meters long and 1 meter wide. Seedbeds were kept east west so as to expose to the sunlight and were raised at least 15 cm above the normal surface of the surrounding soil. The soils of seedbeds were ploughed thoroughly. After that, seedbed was top dressed with 5 cm of well-decomposed, well ground, FYM and then lightly pressed. The seedbeds were sown with a seed rate of 2 g/bed. After agronomical practices i.e. bed sterilization, nursery fertilization and sowing of seeds, the beds were covered with polythene plastic sheets till germination. After germination the sheets were removed on sunny days and were replaced at night when the temperature was low. Precautionary sprays of fungicide and insecticide were carried out to avoid fungus and insect attack on the seedbeds.

Healthy seedlings, having 10 cm height, of cultivar 'Speight-G-28' were transplanted on 25th March, 2003. The experiment was laid out in RCB design with four replications. There were ten treatments in each replication. The number of rows per treatment was four. Plant-to-plant and row-to-row distance was 60 and 90 cm, respectively. The number of tobacco plants per row was 10 and the size of experimental unit for each treatment was 4 x 5.40^2 m.

The pre-transplanting herbicide was sprayed on 20th March 2003, five days before transplantation, while the post-transplanting herbicides were sprayed on 25th April 2003, one month after transplantation. A knapsack hand sprayer with four "T" jet nozzles adjusted at a distance of 45 cm between nozzles. Water at 200 L ha^{-1} was used as carrier at 40 Ibs psi after proper calibration. While spraying the herbicides all the precautionary measures were followed to avoid any herbicides injury.

Hand weeding was done three times in the concerned treatment with the help of a khurpa (a hand hoeing tool) after emergence of weeds. Weedy check (control) treatment remained weedy

Table 1. Different treatments used in the experiment.

S. No.	Treatment/ Trade Name	Common Name	Time of Application	Rate (Kg. a.i.ha^{-1})	Commercial Product
1.	Dual gold 960 EC	S-metolachlor	Pre-transplanting	1.92	2.0 l/ha
2.	Stomp 330 EC	Pendimethalin	Pre-transplanting	1.00	3.0 l/ha
3.	Stomp 455 CS	Pendimethalin	Pre-transplanting	1.00	3.0 l/ha
4.	Tamex 360g/L	Butralin	Pre-transplanting	1.44	4.0 l/ha
5.	Topik 15 WP	Clodinafop	Post- transplanting	0.04	266 g/ha
6.	Puma super 75 EW	fenoxaprop-p-ethyl	Post- transplanting	1.00	1.33 l/ha
7.	Acetor 50 EC	Acetochlor	Post- transplanting	0.125	0.25 l/ha
8.	Roundup 680g/kg	Glyphosate	Post- transplanting (directed)	0.95	1.4 kg/ha
9.	Hand weeding	----------	----------	-------	----------
10.	Weedy Check	----------	----------	-------	----------

for the whole season. All recommended agronomical techniques and insect pest control measures were followed during the experiment.

During the course of studies the data were recorded on weed density m^{-2} (one month after herbicide application), plant height (cm), number of leaves $plant^{-1}$, leaf area (cm^2), grade index (%), nicotine (%), reducing sugars (%) and yield (kg ha^{-1}). Standard procedures were adopted for recording the data on the above parameters. The data recorded for each parameter were individually subjected to the ANOVA technique by using MSTATC Computer Software Package and the significant means were separated by using Fisher's protected LSD test (Steel and Torrie, 1980).

Agro-Ecological Conditions

The experiment was conducted on a normal clay loam soil (having pH 6.95, OM content 1.05%, $CaCO_3$ equivalent 0.65%, TSS 0.017%, N 0.045%, P 7.80 ppm and K 373 ppm). Average temperature during growing season is 33-35ºC and 76 cm average rainfall was recorded.

Results and Discussion

Weed density m^{-2}: Data on weed density revealed that different post and pre-emergence herbicidal treatments had significant effect on final weed density m^{-2} (Table 2). The data showed that the highest weed density m^{-2} (228.3) was observed in weedy check treatment while minimum i.e. 69, 70.25, 76.25 and 78.50 weed densities m^{-2} were recorded in pendimethalin (EC), acetochlor, pendimethalin (CS) and S-metalocholar treatments respectively (Table 2). The weed density m^{-2} in glyphosate, hand weeding, fenoxaprop-p-ethyl, clodinafop, and butralin were statistically equal to each other. The respective values were 111.3, 112.5, 117.0, 124.3 and 134.3 weed density m^{-2} (Table 2). According to the findings, pre-transplanting application of pendimethalin (EC) gave excellent weed control. The major weeds infesting the experiment plots were *Cyperus rotundus*, *Echinochloa crus-galli*, *Convolvulus arvensis*, *Sorghum halepense*, *Euphorbia* sp., *Rumex* sp., *Coronopus didymus* and *Portulaca oleraceae* etc. Wang *et al.* (1997) reported that

Table 2. Impact of herbicides on some agronomic characteristics of FCV tobacco.

Treatments Rate (Kg. a.i.ha^{-1})	Weed density (m^{-2})	Plant height (cm)	Number of leaves $plant^{-1}$	Leaf area (cm^2)	Grade index (%)	Yield (kg ha^{-1})
S-metalocholar (1.92)	78.50 c	86.88 c	24.400	640.8 de	53.88 E	1788 cd
Pendimethalin (EC) (1.0)	69.00 c	101.8 ab	23.375	716.8 abcd	73.81 ab	2465 a
Pendimethalin (CS) (1.0)	76.25 c	101.9 ab	23.750	711.1 abcd	68.50 abcd	2246 ab
Butralin (1.44)	134.3 b	103.8 a	21.875	781.1 abc	63.88 bcde	2006 bc
Clodinafop (0.04)	124.3 b	100.0 ab	23.500	691.5 bcde	59.92 de	1819 cd
Fenoxaprop-p-ethyl (1.0)	117.0 b	100.1 ab	23.125	685.4 cde	60.08 cde	1776 cd
Acetochlor (0.125)	70.25 c	100.0 ab	24.000	827.8 a	74.60 a	2215 ab
Glyphosate (0.95)	111.3 b	97.38 ab	24.400	701.2 abcde	69.43 abcd	1980 bcd
Hand weeding	112.5 b	101.1 ab	22.750	825.0 ab	70.60 abc	1833 cd
Weedy Check	228.3 a	93.77 bc	21.625	566.1 e	59.40 de	1703 d
	LSD (0.01) 23.07	LSD (0.05) 9.50	▼ NS	LSD (0.05) 136.3	LSD (0.01) 10.54	LSD (0.01) 283.8

Means followed by different letters in the respective column are significantly different at either 0.01 or 0.05 probability level according to LSD test.
► Non-significant

herbicides controlled more than 85% weeds in tobacco. Our findings are also in conformity with those reported by Zilkey and Capell (1987), who stated that herbicides gave excellent control of grassy and broad leaved weeds.

Plant height (cm): The effects of various herbicides on plant height are shown in (Table 2). Maximum plant height of (103.8 cm) was recorded in butralin treatment, while minimum plant height (86.88 cm) was noted in S-metalocholar, which was followed by weedy check (93.77 cm) treatment. The plant height of all other treatments, pendimethalin (CS), pendimethalin (EC), hand weeding, fenoxaprop-p-ethyl, clodinafop, acetochlor and glyphosate were statistically comparable with each other. The respective values are 101.9, 101.8, 101.1, 101.1, 100, 100 and 97.38 cm. The minimum plant height recorded in Dual gold 960 EC treated plot is due to its phytotoxic effect on tobacco, which retarded plant growth for a short period. Our results are in line with the work of Tan *et al.* (1999) who concluded that in weedy check plots, presence of weeds restricted the growth of tobacco plants, which resulted in stunted tobacco plants growth.

Number of leaves plant^{-1}: The mean data of number of leaves plant^{-1} were not significantly different among the different herbicide treatments (Table 2). However, the maximum number of leaves plant^{-1} (24), was recorded in S-metalocholar, glyphosate and acetochlor treatments, respectively, following by pendimethalin (CS) (23.75), clodinafop, (23.50), pendimethalin (EC) (23.375) and fenoxaprop-p-ethyl (23.125) treatments. Lower number of 22.75, 21.875 and 21.625 leaves plant^{-1} were recorded in hand weeding, butralin and in weedy check treatments, respectively. As number of leaves is the genetic potential of each crop, leaves were not significantly affected by different herbicidal treatments.

Leaf area (cm^2): Leaf area (cm^2) means were also found significantly ($p<0.0142$) different among the different treatments (Table 2). Maximum leaf area of 827.8 cm^2 was recorded in glyphosate, which was followed by hand weeding (825 cm^2) and butralin treatment (781.1 cm^2). The minimum leaf area (566.1 cm^2) was recorded in weedy check treated plots, which was followed by S-metalocholar (640.8 cm^2) and fenoxaprop-p-ethyl (685.4 cm^2) treatments. These results agreed with Tan *et al.* (1999) who stated that S-metalocholar, pendimethalin and acetochlor gave satisfactory weed control and were safe to use on tobacco, even promoting the crop's growth. As herbicides controlled the weeds, the available resources needed for plant growth were utilized by the crop plants, which ultimately increased the leaf area. As leaf size is the final economic yield of tobacco, chemical/physical weed management in tobacco is recommended for the farmers to get higher yields.

Grade index (%): Statistical analysis of the data exhibited that grade index was significantly ($p<0.0001$) affected by herbicides. The data in (Table 2) show that maximum grade index of 74.60% was recorded in acetochlor, which was followed by that in pendimethalin (EC) 73.81% and that in hand weeding (70.60%) treatment. Minimum grade index of 53.88 % was recorded in S-metalocholar, followed by weedy check (59.40%) and then followed by clodinafop 59.92% treatments. Thus desirable grade index can be achieved if weeds are controlled at proper time. Our findings are in confirmation with the work of Kalinova and Kostova (1996), who stated that due to the use of herbicides, tobacco first leaf grade increased to 8.25 points.

Nicotine Content (%): Data of nicotine content (%) in tobacco leaves were also found to be significantly different among the different treatments (Table 3). It was significantly higher in pendimethalin (EC) treated plots with 2.362%, which was followed by acetochlor (2.345%), glyphosate (2.330%), pendimethalin (CS) (2.153%) and butralin (2.138%) treatments. In weedy check treatment (2.092%) nicotine was recorded. Reducing sugar and nicotine are the most important constituents for the evaluation of tobacco quality and exercise the most favorable influence on aroma, taste and quality of the tobacco leaf. The results are in confirmation with the inferences of Raghavaiah and Subbarao (1986) who stated that

Table 3. Impact of herbicides on some chemical characteristics of FCV tobacco.

Treatments Rate (Kg. a.i.ha^{-1})	Nicotine (%)	Reducing sugars (%)
S-metalocholar (1.92)	1.790 de*	14.37 de
Pendimethalin (EC) (1.0)	2.362 a	17.80 ab
Pendimethalin (CS) (1.0)	2.153 ab	18.22 a
Butralin (1.44)	2.138 ab	14.24 de
Clodinafop (0.04)	1.985 bcd	14.57 cde
Fenoxaprop-p-ethyl (1.0)	1.840 cde	15.83 bcd
Acetochlor (0.125)	2.345 a	16.57 abcd
Glyphosate (0.95)	2.330 a	13.05 e
Hand weeding	1.645 e	16.76 abc
Weedy Check	2.092 abc	12.42 e
	LSD (0.01) 10.54	LSD (0.01) 0.2771

Means followed by different letters in the respective column are significantly different at 0.01 probability level according to LSD test.

nicotine % and equilibrium moisture contents were higher for all herbicide treatments than that with hand weeding. Lolas (1994) also stated that all herbicidal treatments increased nicotine % plant^{-1} from control values.

Reducing sugar (%): Analysis of the data (Table 3) showed that statistically maximum reducing sugar 18.22% was recorded in pendimethalin (CS) treatment was followed by 17.80% in pendimethalin (EC) and 16.76% in hand weeding treatments; and 16.57% reducing sugar was found in acetochlor and 15.83% in fenoxaprop-p-ethyl. Minimum of 12.42 and 13.05% reducing sugar was recorded in weedy check and glyphosate treated plots, respectively. However, statistically it was equal to S-metalocholar, butralin and clodinafop. It is clear from the data that as the weed control efficiency decreased, the reducing sugar (%) decreased in tobacco leaves.

Yield (kg ha^{-1}): Analysis of variance of the data (Table 2) showed that maximum yield of 2465 kg ha^{-1} was recorded in pendimethalin (EC) treatment, followed by 2246 kg ha^{-1} in pendimethalin (CS) and 2215 kg ha^{-1} in acetochlor. Minimum tobacco yield 1703 kg ha^{-1} was recorded in weedy check treatment, followed by 1776 kg ha^{-1} in fenoxaprop-p-ethyl and 1788 kg ha^{-1} in S-metalocholar treated plots. Our findings are in agreement with the work of Kalinova and Kostova (1996). They stated that the use of herbicides increased the tobacco yield. Dimeska and Stojkov (1987) stated that in transplanted tobacco, Stomp (pendimethalin) was most effective, increased tobacco yield by 15-74%, and raised gross income by 35-95%. Our result was similar to those of Amerio (1969) and Palmer (1995), who reported that in tobacco, pre-emergence application of weedicides resulted in higher yield of better quality and reduced the cost of production. Dhanapal *et al.* (1998) stated that glyphosate at 500 g a.i ha^{-1} applied at 60 days after transplanting (DAT) and imazaquin at 10 g ai ha^{-1} applied at 30 DAT increased tobacco yields by 80 to > 100% compared to the untreated plots.

Conclusions

It may be concluded that the herbicide, pendimethalin (EC) at the rate of 1.0 kg a.i ha^{-1} decreased the weed density and the resources will be directly used by the tobacco crop and hence lead to an increased yield. It is therefore recommended for the tobacco farmers. Being a cheaper and common available in the local market pendimethalin (EC) should be used in tobacco. In the stage when weeds compete with tobacco, the weed removal is laborious and expensive, in the hot months of summer; therefore, herbicides prove to be effective, economical and cost-effective. If possible, hand weeding is the best method for small land holding farmers. However, farmers having large land holdings, they can use herbicides effectively. Herbicides not only increase the yield of tobacco but also increase the desirable chemical characteristics, e.g. nicotine, reducing sugar etc.

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