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Effect of Pethoxamid (TKC-94) Rate and Application Time on Weed Control and Phytotoxicity in Flue- cured Tobacco

By

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Research Article

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ABSTRACT

Due to the risk of weed resistance to herbicide control, there is continuous need for new chemicals to be tested for control of weeds. Such work is of major importance as herbicides form a vital line of defence against weeds which would otherwise cause yield losses of even up to 100%. In this work, the herbicide pethoxamid (TKC-94) was evaluated to establish the time and rate of application that would give efficacious weed control without causing phytotoxicity. In the first year, the herbicide was included in a simple screening trial comprising twelve herbicides arranged in a randomised complete block design. After it had stood out it was selected for further development. In the second year, in a split plot design with four blocks and six treatments, it was applied as TKC-94 at 1.88 kg a.i./ha applied just after holing out (a.h.o.) and TKC-94 at 1.88 kg a.i./ha applied immediately after planting (i.a.p.). Three controls, Dual 960 ec (Generic, a.i. s-metolachlor) at 2.2 kg a.i./ha i.a.p and Dual Magnum (original formulation, a.i. s-metolachlor) at 2.2 kg a.i./ha i.a.p as checks and an untreated control were included. This trial showed that applied a.h.o., TKC-94 was phytotoxic, stunted Tobacco and reduced yield and weed efficacy while the i.a.p. was ideal and showed no phytotoxicity and had good weed efficacy. In the third year, the i.a.p. time of application was tested in a similar design but now, more rates of TKC-94 were tested. The rates were, TKC-94 at 0.0 kg a.i./ha i.a.p, TKC-94 at 1.88 kg a.i./ha i.a.p., TKC-94 at 2.82 kg a.i./ha i.a.p., and TKC-94 at 3.76 kg a.i./ha i.a.p. Dual Magnum at 2.2 kg a.i./ha i.a.p was included as a check. This work confirmed the potential of the herbicide as a broad spectrum material and showed that the best rate that would ensure broad spectrum control was 2.82 kg a.i./ha. Further research could look at application of this material in irrigation water in order to cater for those farmers with centre pivots. In addition, the early post emergence control of weeds may also need to be researched in order to give the farmer more flexibility in using this herbicide.

Keywords: Pethoxamid, flue-cured, TKC-94, tobacco, s- metolachlor.

INTRODUCTION

Weeds are a major threat in all farming systems and herbicides are an important aspect of effective control. Control of weeds in Tobacco is very critical in the first 4 weeks of growth before the crop has developed a canopy able to smother weeds.

The use of herbicides can lead to a 100% yield improvement relative to weedy controls (Dhanapal, Borg & Struik 1998) and herbicide usage is normally associated with best weed control (Tremola & Carotenuto 1996; Yousafzai et al. 2007). Usually a Tobacco loses a kilogram of growth for every kilogram of weed growth. Most herbicides in most crops are applied at particular rates, time of application and method of application. Pethoxamid [2-chloro-N-(2-ethoxyethyl)-N-(2-methyl-1-phenyl-1-propanyl) acetamide], (TKC-94) was introduced for the management of broadleaf and grass weeds in Soya-beans and Maize. An acetamide; this herbicide is believed to inhibit fatty acid biosynthesis in target weeds. Time of application is pre emergence or early post emergence in Maize and only post emergence in Soya-bean at 1.2 kg a.i./ha. The herbicide has good control efficacy of the grasses, foxtail species (*Setaria geniculata*), large crab grass (*Digitaria sanguinalis*), barnyard grass (*Echinochloa crus-galli*) and broadleaf weeds like ladythumb (*Polygonum persicaria*), field bindweed (*Convolvulus arvensis*), redroot pigweed (*Amaranthus retroflexus*), and common lambsquarters (*Chenopodium album*) (Salzman 2001).

Wise herbicide usage requires weed identification, soil texture, soil organic matter, soil preparation, spray equipment and herbicide incorporation considerations (Johnson 2008). Herbicides applied before transplanting have the potential to inhibit root growth and hence early plant growth and development. This risk is usually less for herbicides applied at or within a short time after transplanting (Johnson 2008). Herbicides may also pose a risk to the crops following Tobacco in a rotation.

By and large, herbicide usage in Tobacco and indeed many other crops has several vital benefits. When used as supplement to other components of integrated weed management, herbicides become a vital and

useful component leading to very good weed control. Herbicides lead to good early season control, reducing weed competition and giving a young crop an important advantage over weeds. In most cases hand weeding is reduced or made faster, thus lowering the cost of hand weeding. In other cases, when fields become inaccessible because of wet periods, herbicides could be the only viable control method affording weed suppression following transplanting.

The aim of the trial was to establish the time and method of application of TKC-94 that would result in effective control without resulting in phytotoxicity. The herbicide was evaluated not only for control of the usual broadleaf and grass weeds it was supposed to be efficacious on but also for nut sedge control.

MATERIALS AND METHODS

Site considerations

This experiment was done under supplementary irrigation on a sandy loam soil (72.8% sand, 8.8% silt and 18.4% clay, <1% organic matter) at Kutsaga Research Station (17° 55' S, 31° 08' ; Altitude 1480m, Average annual rainfall 882mm).

Experimental design and protocols

The experiment which used the variety T26, was laid out as split plot design of two main plots and 5 subplots in an early-ploughed granite sand. One of the main plots was kept weed free and the other was not weeded. The weed free main plot was used to estimate phytotoxicity and yield while the weed control efficacy was estimated in the weedy plots. The subplots were the following 5 treatments:

1. TKC-94 at 1.88 kg a.i./ha applied just after holing out (a.h.o)
2. TKC-94 at 1.88 kg a.i./ha applied immediately after planting (i.a.p)
3. Dual 960 ec(Generic, a.i. metolachlor) at 2.2 kg a.i./ha i.a.p
4. Dual Magnum (a.i. Metolachlor) at 2.2 kg a.i./ha i.a.p
5. Untreated control

In the third year the treatments were slightly altered to:

1. TKC-94 at 0.0 kg a.i./ha i.a.p
2. TKC-94 at 1.88 kg a.i./ha i.a.p
3. TKC-94 at 2.82 kg a.i./ha i.a.p
4. TKC-94 at 3.76 kg a.i./ha i.a.p
5. Dual Magnum at 2.2 kg a.i./ha i.a.p

All herbicides were sprayed by knapsack. Weeds were counted using 7 quadrants (0.3 x 0.3 m) at 3 positions in each treatment subplot. The planted and treated plots measured 4.8 m x 17.92 m (4 rows) while the harvested & assessed plots were 2.4 m x 16.80 m (2 rows). Weed counts & dry mass were measured on 7 x 0.3 x 0.3 m quadrants at 3 positions along the length of the plot.

MEASUREMENTS/OBSERVATIONS

Stalk height measurement was done at topping in the weeded subplots. Weed counts were done at various designated times after planting and dry mass after final harvest, in the weedy plots. Yield was finally measured at the end of the experiment. The weed counts were square root transformed and subjected to analysis of variance (ANOVA) and mean separation achieved by LSD.

Rotations, Nematode Control and Fertilization

The plots were set up in land that had been planted to a nematode resistant grass, *Chloris gayana* cv Katambora Rhodes grass for three years. Nevertheless, the plots were fumigated with the nematicide EDB (98%) at 125 ml/100m of ridge. Supplementary irrigation was applied by sprinkler at 50% moisture depletion, estimated using the evaporation pan method. The land was ploughed and disced as is standard practice. Tobacco was grown on 0.2m high ridges, 1.2m apart in the inter-row and 0.56m apart in the intra-row. The Tobacco crop was kept weed-free by mechanical and chemical weed control methods as per treatment. The herbicides were applied as per treatments within seven days of transplanting and settled in with 12 mm of irrigation.

The Tobacco crop received a basic application of 700 kg ha⁻¹ of Tobaccofert (6-18-15) and was pre-irrigated to field capacity before transplanting. Topdressing applications of 100 kg N ha⁻¹ and 10 kg N ha⁻¹ as Ammonium nitrate (34-0-0) were applied at 3-4 weeks after planting and at topping, respectively. The fertilizer was applied by dollop placement 10 cm from the plant and 5 cm deep.

RESULTS

Broadleaf control in year 2 and 3

The herbicide, TKC-94 was screened together with many other herbicides in year 1, at which time it was applied immediately after transplanting as a broadcast spray (data not shown). Having given good broad spectrum control of weeds it was selected for further development. In year 2 it was applied at 1.88 kg a.i. /ha immediately after planting (i.a.p.) and after holing out (a.h.o.). All the herbicide rates showed better control of broadleaf weeds than the unsprayed control, as expected, in year 2 (Table 1) and year 3 (Table 2). The generic Dual (Dual 960ec) and standard Dual (Dual Magnum) which were the positive controls gave good control and were equalled by TKC-94 at 2 litres/ha applied i.a.p. (Table 1). The after holing out treatment (a.h.o) gave significantly poor ($P<0.05$) control than all the other treatments and was not different from the unsprayed control (Table 1). In year 3, TKC-94 at 2.82 kg a.i. /ha controlled broadleaved weeds better ($P<0.05$) than at 1.88 kg a.i. /ha (Table 2). At 3.76 kg a.i. /ha, however, control of broadleaved weeds was not improved (Table 2). No difference in broad leaf control at 67, 85, 166 d.a.s. was detected (data not shown).

Nut Sedge Control in Year 2 and 3

In year 2, a similar trend was observed with the control of nut sedge as was for broadleaf weeds, however, the Dual Magnum performed best followed by the generic and then TKC-94 i.a.p. (Table 1). The generic Dual and TKC-94 i.a.p. did not differ from each other while TKC-94 applied a.h.o was the worst of the herbicide treatments but was better than the unsprayed treatment (Table 1). In year 3 TKC-94 at 2.82 kg a.i., 3.76 kg a.i., and Dual Magnum gave similar nut sedge control (Table 2) while the lowest rate of TKC-94 gave the lowest but acceptable control. Contrasts, if fact, showed that the 2.82 kg a.i. /ha was not significantly ($P>0.05$) better while the 3.76 kg a.i. /ha rate was significantly ($P<0.01$) better than it. There was a significant ($P<0.01$) linear relationship for the rates. There were no difference in nut sedge control at 67, 85, 166 d.a.s. (data not shown).

Grass Weeds Control in Year 2 and 3

In year 2, the two Dual formulations gave the best control followed by TKC-94 at 1.88 kg a.i./ha applied i.a.p. The a.h.o. treatment gave the worst control but this was better than the treatment that did not receive a herbicide (Table 1). In year 3 grass control was the same for all treatments (Table 2) but all the treatments were better than the control. Similarly, no difference in weed control at 67, 85, 166 d.a.s. could be detected (data not shown).

Overall Weed Control

Total weed control was best with two dual formulations followed by TKC-94 i.a.p and lastly by TKC-94 a.h.o. in Year2 (Table 1). All herbicide treatments were also better than the control (Table 1). In Year 3 TKC-94 at 2.82 kg a.i. and 3.76 kg a.i and Dual Magnum gave similar control. Contrasts showed TKC-94 at 2.82 kg a.i. better than TKC-94 at 1.88 kg a.i. and similarly TKC-94 3.76 kg a.i. better than TKC-94 a 1.88 kg a.i.. The dry mass of weeds followed a similar trend as the total weeds except that the TKC-94 a.h.o was the same as the control. In terms of phytotoxicity all herbicides except TKC-94 a.h.o. did not stunt the crop.

Yield and Stalk Height in Both Years

In year 2 all the herbicides gave similar yields (weed free plots) except the a.h.o treatment which showed significantly ($P<0.05$) lower yield and hence phytotoxicity (Table 3). In year 3 all rates of herbicide gave very good yields which were as good as the control which was kept weed free. The stalk height was the same in the control

while the a.h.o. treatment caused phytotoxicity. Comparison of weedy and weed free plots shows how good weed control was for Dual formulations and TKC-94 i.a.p. (Table 3) in year 2 and for all herbicide treatments in year 3 (Table 4).

Table 1: Square root transformed weeds/m² - 36 d.a.s. (Year 2).

Treatment	Broad-Leaf	Nut sedge	Grasses	Total No. All weeds	Dry Mass (log)	Stalk Height
TKC-94 1.88 kg a.i. /ha a.h.o	4.40(19.4)	3.48(12.1)	7.13(50.8)	8.97(80.5)	2.14(9)	51.6
TKC-94 1.88 kg a.i. /ha i.a.p	3.37(11.4)	2.39(5.7)	3.85(14.8)	5.67(32.1)	1.01(2.8)	66.2
Dual 960ec (Generic) 2.2 kg a.i /ha	3.15(9.9)	1.70(2.9)	2.34(5.5)	4.17(17.4)	0.85(1.5)	65.7
Dual Magnum 2.2 kg a.i. /ha	2.98(8.9)	1.28(1.6)	1.69(2.9)	3.63(13.2)	0.34(0.4)	68.5
No Herbicide	5.47(29.9)	4.51(20.3)	10.71(115)	12.95(168)	2.81(16.4)	67.4
LSD	0.90*	0.92*	1.01*	0.97*	0.77*	4.33*

*significant at P<0.05

(back transformed data)

Table 2: Number of broadleaved weeds, nut sedge, grasses and total weed counts / m² (square root transformed) at 42 d.a.p. (Year 3).

Treatment	Broad-Leaf	Nut sedge	Grasses	Dry Mass (g/m ²)	Total No. All weeds
No herbicide	9.88(107)	7.34(56.2)	11.68(136)	24.40	17.2(299)
TKC-94 1.88 kg a.i. /ha	3.15(10.5)	1.99(3.5)	1.88(3.5)	0.80	4.13(17.6)
TKC-94 2.82 kg a.i. /ha	1.58(2.2)	1.32 (1.5)	1.00(0.6)	6.27	2.10(4.3)
TKC-94 3.76 kg a.i. /ha	1.97(4.3)	1.05(0.8)	1.08(1.1)	0.08	2.31(6.2)
DUAL 2.2 kg a.i. /ha	1.55(2.0)	0.91(0.5)	1.05(0.80)	0.22	1.85(3.2)
F-Test probabilities					
Treatment effects	*	*	*	*	*
Contrasts					
TKC-94 1.88 a.i. v TKC-94 2.82	0.0211	0.0598	0.0863	0.2499	0.0215
TKC-94 1.88 a.i. v TKC-94 3.76	0.0664	0.0145	0.1134	0.8762	0.0348
TKC-94 2.82 a.i. v TKC-94 3.76	0.5022	0.4088	0.8676	0.1979	0.7760
TKC-94 linear	0.0664	0.0145	0.1134	0.8762	0.0348
LCD for treatment effects	1.28	0.71	1.03	10.1	1.66

*significant at P<0.05

(back transformed data)

Table 3: Saleable yield (kg/ha) (Year 2).

Treatment	Main plots (Yield, kg/ha)	
	Weedy	Weed free
TKC-94 1.88 kg a.i. /ha a.h.o	1281	1406
TKC-94 1.88 kg a.i. /ha i.a.p	2472	2903
Dual 960 ec (generic) 2.2 kg a.i. /ha	2562	2860
Dual Magnum 2.2 kg a.i. /ha	2838	2978
No herbicide	1498	2763
LSD (within main plot)		648.8*
LSD (between main plots)		288.3*

*significant at $P < 0.05$

Table 4: Saleable yield (kg/ha) (Year 3).

Treatment	Main plots (Yield, kg/ha)	
	Weedy	Weed free
No herbicide	2542	3728
TKC-94 1.88 kg a.i. /ha	3635	3949
TKC-94 2.82 kg a.i. /ha	3573	3889
TKC-94 3.76 kg a.i. /ha	3442	3615
Dual Magnum 2.2 kg a.i. /ha	3420	3802
F-Test probabilities		
Treatment effects	*	ns
Contrasts		
TKC-94 Linear	0.3798	0.1476
TKC-94 1.88 a.i. v TKC-94 2.82 a.i.	0.7738	0.7825
TKC-94 1.88 a.i. v TKC-94 3.76 a.i.	0.3798	0.1476
TKC-94 2.82 a.i. v TKC-94 3.76 a.i.	0.5461	0.2259
LCD for treatment effects	471.4	477.3

*significant at $P < 0.05$

DISCUSSION

Broadleaf Control

The herbicide, TKC-94 was screened together with many other herbicides in year 1, at which time it was applied immediately after transplanting as a broadcast spray (data not shown). Having given good broad spectrum control of weeds, it was selected for further development. In year 2, it was applied at 1.88 kg a.i. /ha immediately

after planting (i.a.p.) and after holing out (a.h.o). The common broadleaf weeds encountered in the plots included *Acanthospermum hispidum*, *Tagetes minuta*, *Richardia scabra*, *Amaranthus hybridus*, *Portulaca oleracea*, *Hibiscus museei* and *Bidens pilosa*. The i.a.p. treatment was a spray soon after transplanting while the a.h.o treatment was done just before planting but after planting positions had been marked manually on the ridges. In essence, the fact that this method of application gave poor broadleaf weeds control suggests that human and other traffic during planting could have mixed the chemical unevenly with the soil. This could explain the observed poor control.

Nut Sedge Control

The common nut sedge species present in the plots was *Cyperus rotundus*. The rate used for Dual was the 2.2 kg a.i. /ha which is recommended for broadleaf, grasses and nut sedge control. In year 2, that TKC-94 at 1.88 kg a.i. /ha gave comparable control as the generic Dual formulation control is very important as Dual is an excellent herbicide. Once more, year 3 results indicated that the 2.82 kg a.i. rate might be the most ideal one if TKC-94 was to compete with excellent materials like Dual in the market. The good control of nut sedge was not anticipated since the herbicide was accepted as grass and broadleaf weed control herbicide. However, such findings arguably make the herbicide more valuable in Tobacco production as yellow nut sedge is an important weed of Tobacco in the region.

Grass Weeds Control

The common grass weeds encountered in the plots included *Rottboletia conchichinensis*, *Setaria pumula*, and *Eleusine indica*. Like the case with broadleaf weeds, the a.h.o. treatment compromised grass weed control. While the TKC-94 at 1.88 kg a.i. /ha gave a lower efficacy it was the same as the control checks and the other rates of TKC. The TKC-94 at 2.82 kg a.i. probably gives a better compromise since it was consistent in controlling the other weed types too. This good efficacy was anticipated since TKC-94 is known to have good control of grasses (Salzman 2001).

Overall Weed Control

In terms of total weed control, the superiority of the i.a.p time of application stood out. The weed dry mass comparisons also reinforce this finding and overall, the 2.82 kg a.i. /ha rate was confirmed as the best rate for one to achieve effective broad spectrum weed control.

Yield and Stalk Height

In the second year, this work showed that TKC-94 applied a.h.o. was phytotoxic and compromised yield relative to the i.a.p treatment and stalk height relative to the other control. As explained earlier, it is most likely that, applied in this manner, TKC-94 must have easily reached the root system at planting since the tradition is to apply water to an opened planting hole followed by inserting a seedling into the hole. Such effects of herbicides, when applied at pre-planting, have been reported with other herbicides (Johnson 2008).

CONCLUSIONS AND RECOMMENDATIONS

Overall, TKC-94 must be applied i.a.p. according to these findings. If this herbicide is applied a.h.o., it will cause stunting of Tobacco and consequent reduced yield as well as poor weed control in general. In addition, the rate should be 2.82 kg a.i. /ha in order for a broad spectrum of weed control to be achieved. Further research could look at application of this material in irrigation in order to cater for those farmers with centre pivots. In addition, the early post emergence control of weeds may also need to be researched in order to give the farmer more flexibility in using this herbicide.

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