Weed Control in Coffee

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Over the last few years, herbicides have become an accepted alternative to hand-weeding for weed control in coffee plantations in the highlands. Trials which examine the effectiveness and economics of various weed control programmes have been part of the herbicides trial work at Aiyura since early 1968. *Progress results of two of these trials are reported here. A more detailed account of both trials, with further information on herbicides, is given in* The Papua and New Guinea Agricultural Journal, *Vol.* 22, *No.* 2 (*May,* 1971).

IN this article, herbicides are generally referred to by the common name of their active ingredient, but, where details of trial treatments are given, the commercial product used in the trial is quoted and the quantity is the quantity of that product (not of the active ingredient). Naming of a commercial product does not imply any preference over another product containing the same active ingredient. *Table* 3 at the end of this article lists trade names of formulations of the herbicide chemicals referred to in this article.

Most of the weeds mentioned are illustrated in the booklet *Weeds of Coffee in the Central Highlands, Botany Bulletin No.* 4, by E. E. Henty, published by the Division of Botany, Department of Forests.

Herbicides can be divided into two groups. The soil-acting ones work on the principle of "prevention is better than cure". The herbicide is usually sprayed onto bare ground, and is taken up by the weed seedling along with the water from the soil before it germinates. The young weed is killed before it has time to grow.

The other group of herbicides act through the leaves of plants. They are therefore effective against established weeds. Some of this group kill only the leaves they contact, and not the whole plant. Others can be carried through the plant to the growing points which are then killed. This ability to move through the plant is important when treating perennial weeds which are able to regenerate from underground stems or rootstocks. A weed such as couch grass will not be killed if only its leaves are killed.

Spray programmes are based either on the herbicide paraquat (Trade name: Gramoxone) or the soil-acting herbicide diuron (Karmex, Diurex) but a number of other herbicides are also used to combat weed species not controlled by these two broad-spectrum herbicides. There is no one herbicide that will control all weeds encountered in highlands coffee.

Plate I.—Spraying with a knapsack spray

TRIAL 1

The first and largest trial compares four treatments, both on a hillside and a pit-pit site. Each treatment is being tested under three

shade conditions, namely fairly dense Casuarina, less dense Albizia, and unshaded, on plots which are 0.625 acre in size. The four treatments are—

1. *Paraquat-based treatment,* with no soil-acting, residual, herbicides. Applications were made as required. Spraying with other herbicides for specific weeds not controlled by paraquat was done as necessary, although for the first 30 weeks only paraquat was used. The other herbicides used were amitrole, dalapon, 2,4-D and MSMA.

2. *Diuron-based treatment.* Blanket applications (that is, spraying over the whole area) of diuron were supplemented with spot-sprayings of other herbicides on specific weeds as necessary. The Albizia and unshaded plots received three applications of diuron in the first year and two applications in each of the second and third years. The weed growth under Casuarina was considered too slight to justify expensive blanket applications, and apart from one initial blanket application on the hillside site, only spot applications were made, at the same frequency as on the other plots. Other herbicides used were dalapon, 2,4-D, MCPA30, paraquat, amitrole and MSMA.

3. *Hand-weeding.* Weeding was done as necessary, except that during wet weather it was postponed because in such conditions the weeding of perennial grasses is ineffectual. Hoes were used for most of the first 2 years but thereafter spades were used.

4. *Hand-weeding plus diuron.* The diuron application was made during the peak harvest period to recently weeded ground, except on one occasion, when standing weeds were treated with a spray mix of diuron and amitrole. As in treatment 3, weeding was done with hoes initially and then later with spades. Diuron was applied as 4 lb Karmex per acre in each year in the unshaded plots, while in the Albizia plots it was applied at 4 lb per acre in the first year and 3 lb per acre in the following years. In the Casuarina plots where weed growth was slight, it was generally not necessary to apply diuron to the whole area, and only the plot margins were blanket sprayed.

Costs

The weed problem in the trial area at the beginning of the trial was severe on the unshaded and Albizia plots, with perennial grasses, particularly thurston grass (*Paspalum conjugatum*), forming a high proportion of the weed population. For this reason, the costs of the herbicide treatments, particularly in the first year, and the cost of the hand-weeded treatment in all years, were high. The costs of the treatments for each of the first 3 years are given in *Table* 1. A summary of the performance of each treatment is given below.

RESULTS

1. *Paraquat-based treatment.* Under the dense Casuarina shade, weed growth was slight and much of the spraying was done around the edges of the plots. Control throughout was good. In the other shade plots, the first paraquat sprays reduced the heavy stand of thurston grass, but did not eradicate it. As long as the grass remained, frequent applications of paraquat at relatively high rates were necessary, and the costs of the treatment remained high. By applying amitrole four weeks prior to applications of paraquat, virtual eradication of the grass was achieved after two such double applications.

During the second year the sedge *Cyperus brevifolius* and to a lesser extent, *C. kyllingia* and couch grass (*Cynodon dactylon*) became serious weeds on the pit-pit site, particularly in the unshaded plot. The sedges had initially been present as small insignificant plants hidden under taller weed growth. With the elimination of other weeds (mainly thurston grass) the sedges spread to form a dense cover over about one third of the unshaded plot. Paraquat sprays had little effect on them but amitrole and MSMA achieved good control by the end of the third year. Relatively high rates of these herbicides were needed, however, and this, along with dalapon sprays to control couch grass, caused the cost of the treatment in the second and third years to remain high.

On the better drained hillside site, the sedges, although present, grew much less vigorously and reasonable control was maintained without using expensive applications. However, at the end of the third year they were then prominent weeds on plots which were otherwise substantially clean. Under Albizia shade on the hillside plot in the second and third years, weed control was maintained with applications of paraquat at a concentration of half a pint per 45 gallons of spray, and this is reflected in the lower costs obtained on this plot.

Table 1.—Costs per acre of weed control treatments in Trial 1

Treatment	Shade	Site	Costs			
			Year 1	Year 2	Year 3	Total
			$	$	$	$
Paraquat-based	Casuarina	Hillside	12.43	6.19	7.19	25.81
		Pit-pit	9.90	3.33	6.42	19.65
	Albizia	Hillside	27.22	10.90	10.54	48.66
		Pit-pit	33.61	21.84	27.58	83.03
	Unshaded	Hillside	37.20	18.72	22.89	78.81
		Pit-pit	39.56	33.52	42.26	115.34
Diuron-based	Casuarina	Hillside	20.64	11.08	10.33	42.05
		Pit-pit	10.57	7.67	7.36	25.60
	Albizia	Hillside	47.94	23.05	22.68	93.67
		Pit-pit	50.85	16.11	19.34	86.30
	Unshaded	Hillside	61.51	26.29	25.01	112.81
		Pit-pit	65.14	23.72	27.90	116.76
Hand-weeding	Casuarina	Hillside	12.82	12.82	9.87	35.51
		Pit-pit	10.10	10.10	10.65	30.85
	Albizia	Hillside	32.73	32.73	26.75	92.21
		Pit-pit	31.69	31.69	29.90	93.28
	Unshaded	Hillside	47.85	47.85	36.98	132.68
		Pit-pit	50.72	50.72	38.98	140.42
Hand-weeding plus diuron	Casuarina	Hillside	9.24	14.44	11.17	34.85
		Pit-pit	10.97	11.26	10.56	32.79
	Albizia	Hillside	28.00	24.39	17.53	69.92
		Pit-pit	31.14	21.53	16.89	69.56
	Unshaded	Hillside	50.52	38.48	28.33	117.33
		Pit-pit	42.27	34.61	28.96	105.84

Prices Used in Compiling Costs:

Agral 60 (wetting agent)	$6.20 per gal.	Teepol	$1.18 per gal.
Ansar 529	$8.00 per gal.	Weedazol TL Plus	$7.50 per gal.
Gramevin	$0.55 per lb	Weedkiller D (and Amoxone-50)	$5.19 per gal.
Gramoxone	$21.50 per gal.	Labour	10.1c per man hour
Karmex	$3.25 per lb		
Methoxone-30	$3.40 per gal.		

Although there was a range of paraquat concentrations used in this trial, in most situations 1 pint of Gramoxone per 45 gallons of spray is sufficient for initial applications, and lower concentrations down to half a pint per 45 gallons can often be used subsequently. The manufacturer recommends that half a pint of non-ionic surfactant such as Agral 60 be included, but other wetting agents have also been successfully used.

2. *Diuron-based treatment.* Weed growth under the dense Casuarina shade was slight and good control was maintained throughout. In the other shade plots the infestation of thurston grass was reduced to negligible proportions by the end of the first year. At this time, *C. brevifolius* was the most prominent weed although it was covering only a small proportion of the total plot areas. Diuron gives some control of the sedge even when applied to emerged plants, but at lower rates larger plants usually recover, so that spot treatment with other herbicides (amitrole or MSMA) is necessary. Eradication was attempted at the beginning of the third year by the spot application of a mixture of diuron and paraquat, but other plants subsequently appeared from seed.

The plots were maintained predominantly clean during the following 2 years. The main weeds which required spot applications with other herbicides during the 3 years were *C. brevifolius, C. kyllingia,* thickhead (*Crassocephalum crepidioides*), couch grass (*Cynodon dactylon*), *Paspalum orbiculare,* wandering jew (*Commelina diffusa*), and sweet potato regrowth (*Ipomoea batatas*). In this trial some plots initially received 5 lb of Karmex per acre, but elsewhere 4 lb per acre has been found to be adequate. For subsequent applications, 2 lb per acre is used giving a total of 8 lb per acre in the first year. In the following years, two applications of 2 lb per acre is sufficient.

3. *Hand-weeding.* Visual assessment indicated that there was no reduction in the weed density or change in the proportion of weed species present over the 3 years.

4. *Hand-weeding plus diuron.* Over the 3 years, the weed cover on these plots decreased and there was a change in the weeds present. In the unshaded plots on both sites, thurston grass decreased and wandering jew increased, while *P. orbiculare* increased on the hillside plot. In Albizia plots, thurston grass decreased only on the hillside site.

COMMENTS ON RESULTS

1. *Paraquat-based treatment.* Over the 3-year period, the paraquat-based treatment was the cheapest on shade conditions on the hillside site. On the pit-pit site, it was the cheapest treatment under Casuarina, but in Albizia and unshaded plots it was equal second with the diuron-based treatment, while hand-weeded plus diuron treatment was the cheapest.

The costs of paraquat-based treatments were higher on most plots in the third year than they had been in the preceding year. This was due to the cost of controlling the two sedge species and was most pronounced on the pit-pit site. These weeds now seem to be under control, so costs should decrease in the fourth year. Because control costs in the paraquat-based treatment remained relatively high on the pit-pit site, it was a more expensive treatment on this site in the second and third years in the Albizia and unshaded plots than the diuron-based treatment. On these plots it was only the high cost of the diuron-based treatment in the first year which resulted in the total costs of this treatment for the three years being greater than those of the paraquat-based treatment.

2. *Diuron-based treatment.* Although blanket applications of diuron maintain the treated area predominantly clean for extended periods, the presence of a few resistant species can mean that the total number of applications of all sprays is no less than in a paraquat-based treatment which uses no residual herbicides. In this trial, although many of the spot-applications in the diuron-based treatment required only small quantities of spray, it was only on the pit-pit site in the second and third years that this treatment required appreciably fewer applications than the paraquat-based treatment.

3. *Hand-weeding.* Hand-weeding costs were high in this trial, and should be much less in situations where perennial grasses are uncommon. It is possible that hand-weeding would be less costly than paraquat-based treatment in the first year but in later years the paraquat-based treatment would probably be less expensive treatment.

The figures given for the first and second years of the hand-weeding treatment are the same. It was felt that the actual figures obtained for the first year were unrealistically high, and that costs for the second year gave a more accurate picture of the situation.

At the end of the second year, the workers started using spades instead of hoes for hand-weeding. This explains the drop in costs between the second and third years.

4. *Hand-weeding plus diuron.* The hand-weeding costs in the "hand-weeding plus diuron" treatment decreased considerably in the second year because the diuron applications had decreased the weed cover. This continued into the third year, when the change from hoes to spades further reduced costs.

In some areas it is difficult to obtain casual labour during periods of high labour requirements. This makes it necessary to maintain a large permanent work force which during slack times could well be used in a "hand-weeding plus diuron" treatment. As wages rise, any treatment that involves hand-weeding will increase in cost compared with treatments that are based solely on herbicides.

Plate II.—Careful records are kept so that it is known which weedicide kills which weed

Effect of Shade

Table 1 clearly shows that weeds grow best in unshaded conditions, so lack of shade undoubtedly adds to maintenance costs, whatever method of weed control is used. Unshaded trees, however, give higher yields of coffee which more than offset the extra maintenance costs. Over the 11 years 1959-1970, the average annual yield of clean coffee per acre from unshaded plots was 600 lb higher than the Albizia plots and 500 lb higher than from the Casuarina plots in the area used for this herbicide trial.

TRIAL 2

A second smaller trial compared four herbicide treatments in unshaded coffee on the pit-pit site. Each treatment was applied to a plot of 0.625 acre which initially was infested predominantly with thurston grass. The four treatments were:—

1. *Paraquat and amitrole*: The amitrole applications preceded paraquat applications by four weeks, for as long as this proved necessary. Amitrole was used at concentrations of 2 to 4.5 pints of Weedazol TL Plus per 45 gallons for most of the first year. Later, rates of up to 8 pints per 45 gallons were used against the sedge *C. brevifolius*. Paraquat was used throughout at a concentration of 1 pint Gramoxone per 45 gallons.

2. *MSMA* applied as necessary, usually as a double treatment, with the two applications 4 or 5 weeks apart. Spray concentrations varied from 2 to 5 pints of Ansar 529 per 45 gallons, with most treatments at 3 or 4 pints per 45 gallons.

3. *Diuron plus amitrole,* applied together, the first application as a blanket spray (to existing weeds) and all subsequent applications as spot-sprays when required. The blanket application was at the rate of 3 lb of Karmex plus 4 pints of Weedazol TL Plus per acre in 43 gallons. The spot-sprayings for the first 18 months were made with sprays containing the

same concentrations of herbicides as the blanket application. After this time, the spray concentration was reduced to 2 lb Karmex plus 2 pints Weedazol TL Plus per 45 gallons.

4. *Diuron plus paraquat* applied together as for Treatment 3. As in the larger trial, it was not feasible to use only the prescribed treatment, and all plots required supplementary applications with dalapon (for couch and para grass (*Brachiaria mutica*)) and with MCPA (mostly for wandering jew and sweet potato). The blanket application was at the rate of 3 lb of Karmex plus one pint of Gramoxone per acre in 43 gallons. For the first 18 months, the spot applications were made with sprays containing the same concentrations of herbicides as the initial blanket application. Subsequently, the spray concentration was reduced to 2 lb of Karmex plus 2/3 pint Gramoxone per 45 gallons.

RESULTS

The costs of each treatment for the first 2 years are given in *Table* 2.

Table 2.—Costs per acre of weed control treatments in Trial 2

Treatment	Costs		
	Year 1	Year 2	Total
	$	$	$
Paraquat and amitrole	25.31	22.16	47.47
MSMA	39.82	34.16	73.98
Diuron plus amitrole	33.55	18.11	51.66
Diuron plus paraquat	39.53	18.37	57.90

All treatments eradicated the thurston grass, mainly within the first year and except for the MSMA plot, all plots were maintained predominantly clean throughout the first two years of the trial. MSMA controlled a smaller range of weeds than the basic treatments on the other plots. This resulted in more applications of other herbicides being required than was the case on the other plots. In spite of these additional applications, it remained the weediest of the four plots.

COMMENTS ON RESULTS

In the first year the paraquat-amitrole treatment was the least costly. In the second year there was a decrease in the cost of all treatments. This decrease was not great in either the paraquat-amitrole or MSMA treatments, but it was considerable in the two diuron-containing treatments. The cost of the paraquat-amitrole treatment was kept high by the need to apply high doses of amitrole to the sedge *C. brevifolius* which appeared towards the end of the first year. During the first year, amitrole was applied four weeks prior to paraquat as part of a sequential treatment but from the second year on was used only when necessary to control the sedge.

Although the diuron-containing treatments were less costly than the paraquat-amitrole treatment in the second year, the latter treatment was the least costly over the two year period.

COMPARISON OF COSTS IN THE TWO TRIALS

A comparison can be made between the results of the smaller trial and those of the larger one on the adjacent unshaded pit-pit plots.

The paraquat-amitrole treatment in the smaller trial was considerably less expensive than the paraquat-based treatment of the larger trial, for several reasons. In the smaller trial, treatment started on recently slashed vegetation, and not on growth that was knee-high. Amitrole was used from the start, quickly removing the thurston grass which had been the cause of high early costs in the larger trial, and later the sedge species were treated at an early stage before they became a serious problem. Lastly, areas of coffee in the larger trial were unhealthy and the absence of ground shade allowed more vigorous weed growth.

The diuron-containing treatments in the smaller trial were also less costly than the diuron-based treatment in the larger trial. This was true particularly in the first year, when the main difference in costs was due to the amount of diuron used. The smaller requirement for diuron when it was used as a spot-spray could be attributed to placing the herbicide only where it was needed. However, it was expected that more spot-applications would have been required in the first year than proved to be the case. After the initial blanket application, the two treatments received only two or three spot applications. In the second year there were either five or six spot applications and the total amount of diuron used was about the same as that used for the two blanket applications in the larger trial.

If diuron is used as a spot-spray, the possibility of lowering costs must be weighed against the disadvantage of not knowing how much diuron is being applied over a period to given small areas of coffee. In spot-spraying, there is some danger that a small area may get an excessive dose of herbicide which will damage the coffee.

CONCLUSION

The Aiyura trials have confirmed that herbicidal weed control can be cheaper than hand-weeding of coffee, at current labour costs. Coffee groves may be kept cleaner with herbicides than was ever practicable with hand-weeding.

No single herbicide will give control of all weeds found in coffee, and persistent use of one chemical is likely to result in a rapid build-up of species resistant to it. However, all the important weeds may be controlled by intelligent selection from the range of chemicals available. The information given in this article (and the more detailed paper in *The Papua and New Guinea Agricultural Journal*) should enable coffee growers to choose the right materials to eradicate problem weeds before they become too dense.

The trials are continuing, together with other large scale trials. They will be reported when results are available.

Table 3.—Glossary of trade names and common names

Common Name	Trade Names *
Paraquat	Gramoxone
Diuron	Diurex, Karmex
Amitrole	Weedazol TL Plus
Dalapon	Basfapon, Dowpon, Gramevin
2,4-D	Amoxone-50, Weedkiller D
MSMA	Ansar 529, Daconate
MCPA	Methoxone-30

*This list is not exhaustive, but includes products most readily available in Papua New Guinea.

Botanical Names

"BOTANICAL NAMES", said someone, "provide a method of insulting plants in Latin and Greek." The botanists, of course, would not agree. To them, botanical names provide a method of bringing order out of chaos.

The great value of a botanical name is that it is the same everywhere in the world, and therefore there can be no confusion on exactly which particular plant is being talked about. For example, what in English is called "sweet potato", in Pidgin is "kaukau", in Toaripi is "Kauari", in Motu is "kaema", in Kiunga is "ombarap", and so on. To make matters worse, in America they call a sweet potato a "yam", while in Papua New Guinea these are two different things.

But anywhere in the world, a botanist will call it *Ipomoea batatas,* and every other botanist will know what he is talking about (even if nobody else does!).

For those who would like to learn some of these names, and for those who ought to know them but have forgotten them, the list below gives the botanical names of a few well-known plants.

Common Name	Botanical Name
Coconut	*Cocos nucifera*
Tea	*Camellia sinensis*
Oil Palm	*Elaeis guineensis*
Rubber	*Hevea brasiliensis*
Cocoa	*Theobroma cacao*
Peanuts	*Arachis hypogea*
Highlands coffee	*Coffea arabica*
Lowlands coffee	*Coffea canephora*
Rice	*Oryza sativa*
Sweet Potato	*Ipomoea batatas*
Sugar cane	*Saccharum officinale*
Pitpit	*Saccharum edule*
Pyrethrum	*Chrysanthemum cinerariaefolium*
Passionfruit	*Passiflora edulis*
Orange	*Citrus sinensis*