AGRICULTURAL FLAMING GUIDE:

About This Guide by Flame Engineering
This Agricultural Flaming Guide offers background information on methods, history, early practices and current methods and equipment. It is a work in progress and as new information is received the guide will change to reflect these new concepts or and equipment. Thank you for your time and interest in agricultural flaming and our company. If you have any questions, thoughts or ideas, feel free to contact us.

Please scroll down to read about the various crops discussed in this guide.

Row Crop Flaming History
In 1938 an Alabama farmer had an idea. Price McLemore discovered that the flame from a kerosene burner would destroy the weeds in his cotton and corn. A machine was assembled and several acres of his corn and cotton were flamed cultivated. This first known attempt at flame cultivation from a tractor-mounted unit consisted of two kerosene burners per row on a two-row unit. The fuel tank was pressurized with a bicycle pump, which would supply the necessary fuel to the four burners. This must have been quite a site to neighboring farmers as he drove the tractor with one hand and pumped like crazy with the other hand. It was crude but effective.

For several years he attempted to arouse interest in his process by presenting it to agricultural research institutions andexperiment stations. Most of his efforts were met with disbelief and laughter. Finally, in 1942 Louisiana State University began experimenting with flame weeding in sugar cane under the direction of Dr. H. T. Barr. The Delta Branch Experiment Station included flame cultivation in their 1943 cotton weed control project, and in 1944 they began work with corn and soybeans. Results of these experiments were very promising, especially in cotton, and generated a great deal of interest among farmers in Louisiana, Mississippi, and Arkansas. It is estimated that by 1946 there were at least 1,000 flame cultivators in the cotton fields of the Mississippi Delta.

Soon after, the International Harvester Company began researching flame cultivation and developed a cast iron burner. It produced a relatively flat, fan-shaped flame which improved the coverage area as the unit moved through the field. However, this project was abandoned due to a corporate decision.

One of the next developments in row crop cultivation was the addition of another burner, sometimes under a hood, to control the weeds and grass between the rows. This was not universally accepted, according to J. W. Gotcher Sr., President of Gotcher Engineering and Manufacturing Co., an early manufacturer of flaming equipment. "Most growers thought it was necessary to stir the soil at regular intervals throughout most of the growing season for maximum plant growth and production" according to Gotcher. The third burner technique became popular when frequent rains caused the fields to be too wet to cultivate in the conventional manner.

It is estimated that by 1960 there were 15,000 flaming units in the fields, most of which were being used in cotton with some used in corn and soybeans. About this same time interest was growing in non-selective flaming of mint and alfalfa.

In the years that followed, research proved that flame cultivation, can be used on 30 to 40 different crops with good results. Although the majority of the research has been done with corn, cotton, and soybeans, many other crops such as milo, garlic, blueberries, strawberries, radish, lettuce, potatoes, asparagus, grapes, fruit trees, and the Australian tea tree all have been successfully flame cultivated.

Row Crop Flaming Practices and Techniques

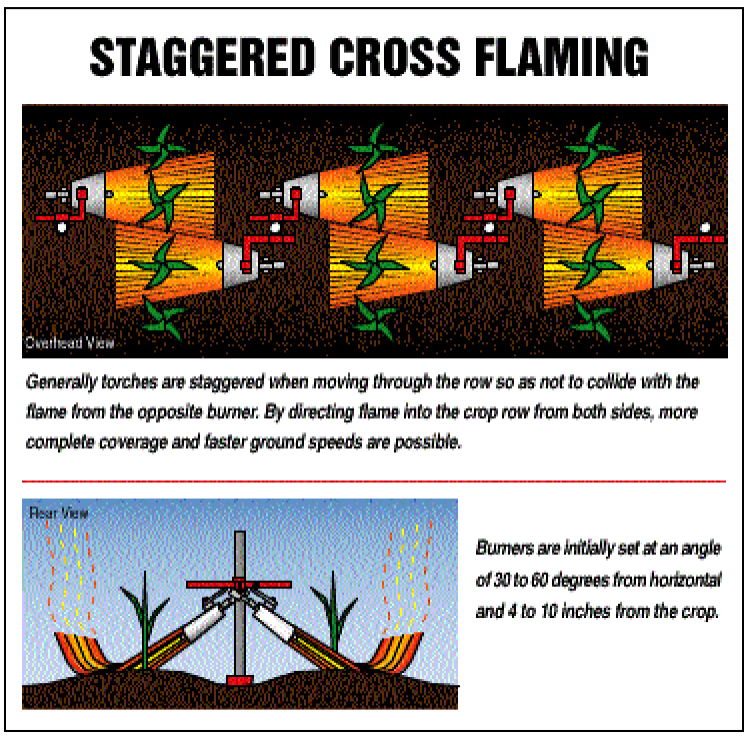
The objective of row crop flaming is not to "burn the weeds to a crisp" but to expose the weed to enough heat to vaporize the water in the plant cells. This will destroy the plants ability to move moisture and carry on photosynthesis and in a short time will cause the plant to wither and die. The time that the flame must be in contact with the weed will vary with the type and size, but in most cases 1/10 of a second is enough exposure. Small, tender plants are more susceptible to heat than more mature growth; therefore the crop needs to be larger than the weeds or grass to be controlled. Some plants by nature are more resistant than others to the 2000° F. blast of heat from the torch. Thebest way to tell if you have sufficiently exposed the weed is to perform "The Fingerprint Test". To perform this test, squeeze the leaf between your thumb and finger. If you leave your "fingerprint" the weed has been exposed to enough heat to kill it. When preparing to flame, the speed, torch angle, fuel pressure, and other variables need to be considered.

Proper burner setting is necessary for weed control and to prevent damage to the crop. In some cases the crop will be stressed, however it will recover in a very short period of time. Normally the burners are set at an angle of 30-60° from horizontal (See figure 1), 4-10 inches from the crop and a pressure of 25-70 PSIG. Tractor speed will vary from 2.5 to 5 mph. Generally, torches are staggered when moving through the row so as not to collide with the flame from the opposite burner (See figure 1). By directing flame into the crop row from both sides, more complete coverage and faster ground speeds are possible.

A different application would be pre-emerge flaming, sometimes called seedbed sterilization. This is generally performed before the crop is planted to remove any weeds in the seedbed and to give the crop a viable start. A variation to this technique is to flame 3-4 days after planting, just before crop emergence, to give the crop a good weed free start.

Flame Engineering Inc. manufactures complete units and kits, which mount to the producer's toolbar. Our complete unit comes with skid style legs, tank cradle, and protection cage. When ordering a kit, the producer has the option of either skid style legs, like the complete unit, or drop down legs suspended from the toolbar. The kits do not include tank cradle or roll over protection.

Figure One



Crop Flaming Recommendations

Corn

The flaming of corn, popcorn, field corn, or sweet corn, can be done at an early vegetative state. Typically corn can be flamed when it reaches a height of 4 inches and can be flamed until the corn reaches canopy. Tractor speed should remain in the 3-5 mph range. Other work has been done on "flaming off" of corn. This approach is when the weeds are the same height of the corn and the whole field is flamed off. Corn can withstand one "flaming off" with only a 4.5% of plants eliminated (Parks 13). "Flaming off" can be a viable option if a producer is about to lose his corn crop to weeds. Smith offers these three recommendations for flame cultivation of corn.

1. Prepare the seedbed and plant so that the row band (5-6 inches on each side of the planter) is relatively smooth and flat. Then the flame can get to the weeds and will not be deflected into the crop.

2. Flame cultivate when the weed growth indicates a need for cultivation. This should be

done while the weeds are small and tender (less than 2 inches tall). Corn can be flamed before it is two inches tall, if cultivation is needed. To prevent injury to the crop when corn is flamed at this early stage, do not flame again until the corn reaches a height of 6-8 inches.

3. Do not move soil into the flame-treated row band when cultivating. This soil is a source of new weed seeds. (7) Seed corn companies have also found a specialized use for flaming. In the production of seed corn, they look for ways to extend the length of time that the male corn plants produce pollen to pollinate the female corn plants. The burners are set to direct the flame at the head of the male corn plant. This causes maturity differences between the plants and different plants create pollen at different times. This is accomplished through either a timer switch or a manual switch which allows intermittent flaming of the corn heads.

Soybeans

Flaming soybeans is slightly more dependent upon critical timing. It is not recommended to flame soybeans until the plant height reaches approximately 10-12 inches (Smith 6). With soybeans, staggered cross flaming is the standard burner pattern with ground speed ranging from 3-5 mph. When flaming soybeans, the burners must be set properly so as to direct flame at the base of the plant and try and also keeping heat off the leaves. The following are recommendations for the flaming of soybeans.

1. Prepare the seedbed and plant so that the row band (5-6 inches on each side of the planter) is relatively smooth and flat. Then the flame can reach the weeds and not be deflected into the crop.

2. The first flame cultivation should not be applied until the soybeans are 10-12 inches tall. Succeeding flame treatments should be dictated by the weed growth.

3. Do not move soil into the flame treated row band when cultivating. This soil is a source of new weed seeds. (Smith 7)

Grain Sorghum

Flaming of grain sorghum usually begins once it reaches a height of approximately 8 inches. Staggered cross flaming is the recommended method of flaming with ground speed ranging from 3-5 mph. According to Parks, if the weeds and the grain sorghum emerge at the same time one "flaming off" application can be performed before the terminal bud comes through the soil surface. Normally, the grain sorghum plant is 3-4 inches in height when the growing point (terminal bud) reaches the soil surface (10).

Cotton

Flame cultivation of cotton can begin once it reaches a height of 4-8 inches. It works best with staggered cross flaming. Tractor speed is in the 3-5 mph range. Typically, for best control of perennials in cotton a second application of flame cultivation should occur 2-3 days after the first flaming. According to Byrd, "some of the advantages to flame cultivation in cotton include: spectrum weed control, repeat treatment as often as desired, low cost, no residue, no activation required, can flame when too wet to cultivate, controls large, annual morning glory species, provides immediate results, and weed response is

independent of environmental stress." (1)

Potatoes
Flame cultivation is performed on potatoes for control of the Colorado potato beetle (CPB). According to Moyer, these burners were directed towards the row at 45° from horizontal of the boom and tilted downward at a 45° angle. The flamer was operated at speeds from 3, 4, 5 and 6 mph (6). Moyer also stated that "the flaming technique provided 70-80% control of overwintering adult CPB. It was also determined that flaming reduced egg hatch by 35%, lowering the number of first generation CPB larvae (6)."

Another use for flaming in potato fields is potato vine desiccation before harvest. Vine desiccation is accomplished by using Red Dragon Liquid Spray Torches. Speeds traveled when desiccating vines will range from 2-4 mph depending on pressure settings and vine density.

Tomatoes
It has been proven that tomato plants have the ability to withstand flaming. Chappell has shown that eight week old transplanted tomato plants can be safely flamed with excellent weed control and very little stress to the tomato plants. (56) The burner setting was staggered cross flaming and tractor speed was 3-4 mph.

Cole Crops
The flaming of cole crops, such as broccoli, cabbage, brussel sprouts, and cauliflower, has been shown to control weeds. Staggered cross flaming provides the best results with tractor speeds being around 2 mph (Wilson 21). Cabbage and brussel sprouts can be flamed approximately 3 weeks after the plants are transplanted, whereas broccoli and cauliflower can be flamed around two weeks after transplanting. No decreased yields are seen with one flame application, and if a second application is needed it should be done at higher tractor speeds to decrease crop injury.

Alfalfa Flaming

Background Information
Broadcast flaming is a technique that is used for weed and pest control in alfalfa. Alfalfa flaming was a common practice throughout the High Plains in the 1960's before herbicides and pesticides were available. Liquid propane spray, directed towards the ground, creates combustion at the point of contact. Flaming takes place anytime after the first killing freeze in the fall up until the alfalfa plants start new growth in the spring. Flaming early in the growing season removes stubble and reduces the breeding habitat for alfalfa weevils. Also, a producer can flame after his first cutting if alfalfa weevil pressure warrants another treatment. Normally, flaming ends after the first cutting.

Practices and Techniques
To properly flame alfalfa there are some general guidelines to follow. The liquid spray bar needs to be raised to a point that it will clear the foliage. Next, the spray bar needs to be adjusted so that the liquid propane is directed to hit the ground about 18 inches behind

the spray bar. The pressure should be adjusted to maintain liquid spray across the entire spray bar. Pressure gauge readings will vary with temperatures, but a good rule of thumb is to set pressure at approximately 40 PSI when the temperature is 30°F., approximately 80 PSI when the temperature is 90°F. Ground speed and fuel consumption will depend on the air temperature and humidity. On hotter days the plants need less exposure to the flame than on colder days. For example, on a 100°F. day, itis only necessary to increase the temperature of the plants and pests 120°F to create steam from internal moisture. On a 30°F. day, it is necessary to increase the temperature 190°F to obtain the same results. So when air temperature is around 30°F., speeds will be around 3 to 5 mph and when the air temperature is around 90°F., ground speed will be around 6 to 8 mph. Foliage and residue in the field also effect travel speed. Flaming alfalfa on windy days is not recommended. Head winds or tail winds may cause flames to sweep over hoses and controls creating a hazardous situation.
At Flame Engineering Inc we produce the Red Dragon TD-12 LPS Alfalfa Flamer. It utilizes our patented liquid spray process developed by Flame Engineering Inc. The 12' unit is usually pulled behind a propane tank trailer.

Grapevine Berm Flaming

Background Information
Grapevine berm flaming is an excellent method of weed management. The first recorded flaming of grapevine berms occurred in Michigan in 1963 (NGPA 35), which also included a study of flaming blueberries and strawberries. The GP 750 and GP 1000 were originally designed for flaming grapevine berms but have been adapted for use in fruit and nut orchards. The flaming of grapevine berms helps to remove weeds and debris, thus reducing insect habitat and breeding grounds, which in turn lowers insect populations. The alley attachment is an option which allows one pass control of weeds on the berms and in the alley. As with all forms of agricultural flaming, grapevine berm flamers reduce herbicide use and operating costs.

Practices and Techniques
Flaming of grapevine berms can be done on a year-round basis. In the summer it is used approximately every two weeks and in the winter a pass will remove plant residues. The burners are set so that weeds in the row and on the side of the grapevine berms are flamed. In an orchard setting, the burners are set to control the weeds and grasses that grow under the tree canopy and between the trees. Ground speed will vary with weed pressure and gas pressure with an average speed of 3 miles per hour at 45 psi, producers can expect to use 11 to 21 gallons of fuel an hour. With the alley attachment, fuel consumption will double.

The GP 750 and the GP 1000 are an economical and effective method of weed control. In addition to saving growers' money and labor, the flamers reduce environmental damage from pesticide use.

Works Cited

Byrd and Snipes, C. E. Flame Cultivation in Cotton. 1996. <http://www.mssstate.edu/extension> (August 8th, 1999).

Chappell, W. E. "Flaming of Corn, Soybeans, and Vegetable Crops" Fifth Annual Symposium on Thermal Agriculture (1968) 55-56.

Moyer, Dale D. Development of a Propane Flamer for Colorado Potato Beetle Control. Cornell Cooperative Extension. 1991.

Parks, Jack H. "Progress of Flame Cultivation in the Texas High Plains and Rio Grande Valley." Proceedings of First Annual Flame Symposium. (1964) 8-17.

Smith, Bryant, and Hall, M. Flame Cultivation to Control Weeds. University of Kentucky Cooperative Extension Service. Bulletin 269. Undated.

Wilson and Ilnicki, R. D. "Control of Annual Weeds in Cole Crops." Proceedings of Third Annual Symposium. (1966) 18-21.