What's Cropping Up?

A NEWSLETTER FOR NEW YORK FIELD CROPS & SOILS VOLUME 5, NUMBER 2, 1995

When is the Best Time to Cultivate Corn?

Jane Mt. Pleasant
Soil, Crop and Atmospheric Sciences

With increased concern over environmental effects and regulatory requirements associated with herbicides, many growers are looking to alternative weed control practices that reduce or eliminate herbicide use. Cultivation can provide excellent weed control in corn, although complete reliance on it usually requires two to four passes through the field. This has been the major drawback to cultivation, particularly for dairy farmers, who have competing demands on their time at cultivation time. Recent research at Cornell and other institutions has found that banded applications of herbicide over the row combined with one or two cultivations, reduce herbicide use by 65%, while greatly reducing the time and labor usually associated with cultivation.

Another concern with cultivation has been the importance of timeliness for effective weed control. Availability of labor and wet field conditions frequently prevent timely cultivation. Both researchers and growers have assumed that failure to cultivate weeds at the proper time results in significant yield reductions.

Field experiments were established at the Aurora Research Farm to determine the importance of timing for weed control. We also wanted to know if timing was equally important when cultivation alone was used, compared to combined cultivation with chemical weed control.

Three weed control practices were compared: 1) cultivation alone; 2) banded herbicide plus cultivation; and 3) broadcast herbicide plus cultivation. In each case, cultivation consisted of a single pass with a row crop cultivator, but the timing of cultivation varied. Cultivation was performed at the 2-leaf, 4-leaf, 6-leaf or 8-leaf stages of corn development. We expected that timing would be very important with cultivation alone, and less important when cultivation was combined with herbicide use. After 3 years, the results have been somewhat surprising.

Largest differences in weed biomass and corn yields have been associated with the three different weed control treatments (Tables 1 and 2). Cultivation alone always had more weeds and lower yields compared to combined cultivation with herbicide. This is not surprising since weed control in the cultivation-only treatment consisted entirely of one pass with the cultivator.

Timing of cultivation has had little effect on either weed biomass or corn yields (Tables 1 and 2). In 1992 cultivation at 8-leaf stage resulted in more weeds and lower yields compared to corn cultivated earlier, but this late cultivation did not affect weeds or yields in the other two years. In all 3 years, there was no difference between corn cultivated at the 2-, 4-, and 6-leaf stages. Even more surprising was the fact that timing of cultivation had as little impact in the cultivation-only treatment as it did in treatments which combined cultivation with herbicide.

Timing of cultivation may be relatively unimportant because corn is such a competitive crop. Most studies examining timeliness of weed control have used crops like soybean, cotton, and peanut which are much less competitive and more vulnerable to weed pressure. Corn, with its large seed, germinates and establishes a leafy, vigorous canopy very quickly.

Although we intend to continue this experiment for one more year, these early results indicate that:

- Timing of cultivation in corn may not be as important as previously thought.
- Degree of competition depends largely on weed density and water availability in any particular year.
- Given a choice, cultivate early. Weeds that germinate after early cultivation are unlikely to be competitive.
- Even late cultivation (8-leaf stage) will not necessarily lead to large yield losses.

One final word of caution: weeds in this experiment consisted primarily of annual broadleafs and grasses. Weed populations dominated by perennial species would probably be much more competitive, particularly when cultivation was delayed.

Tables on Page 7

SOIL MANAGEMENT

Moderate Overfertilization Increases Ground-Water Nitrate Levels

Harold van Es, Charissa Yang, & Stu Klausner, SCAS
Larry Geohring, Agricultural & Biological Engineering

Cornell University's nitrogen fertilizer recommendations are based on the *optimum economic rate* and have been developed through extensive field studies of yield response to fertilizer rates under an array of crop rotations and manure management practices. It is implied that the economic rate of fertilization also reduces the potential of nitrate contamination of groundwater, because it minimizes excess soil nitrogen at the end of the season. In a previous article (*Can Corn Be Grown Without Nitrate Contamination of Groundwater?*,Vol. 4, Number 5), we discussed nitrate levels in shallow groundwater under moderate fertilization rates. It was concluded that nitrate concentrations can be maintained under the 10 parts per million (ppm) federal standard for drinking water if moderate fertilizer applications rates are used accounting for other (esp. organic) sources of nitrogen, and if most of the fertilizer is applied at sidedressing.

Many farmers, however, may be inclined to supply additional "insurance" fertilizer. From a crop production perspective, this is a management decision in which financial consequences from overfertilization is borne by the decision maker. From an environmental perspective, this management decision may have consequences beyond the farm boundaries by possibly generating elevated nitrate levels in groundwater.

The Study

A field study was conducted at the Willsboro Research Farm in Northern New York to determine the effect of nitrogen management on nitrate leaching potential. Two sites on the same farm were used for this study: a fine-textured Kingsbury clay and a coarse-textured Cosad loamy fine sand. Each site contains sixteen plots (60-by-60 feet and 45-by-45 feet on the clay and sand site, respectively) with a subsurface drainage system at 3 feet depth. Drain lines terminate into manholes which allow for sampling of drainage water. Each plot is surrounded by impermeable PVC lining to a depth of six feet to make them hydrologically independent.

A 3-year old alfalfa sod was plowed down in September 1991 on the clay site and corn was grown during the 1992 and 1993 growing seasons. On the sand site, a 20-year grass sod (primarily fescue) was plowed in the spring of 1992 and corn was similarly grown in 1992 and 1993. Three fertilizer rates were applied in replicated plots: 20 lbs/ac (at planting), 90 lbs/ac (20 at planting and 70 as sidedress; not applied on the clay site in 1992), and 120 lbs/ac (20 at planting and 100 as sidedress). During the first year, the low fertilizer rate was expected to be adequate due to the organic N availability from the plowed sods, and the high rate (120 lbs/ac) was deemed to be excessive. The intermediate rate was based on the results of a soil test. During the second year, the low rate would be below the Cornell recommendation, the intermediate application (90 lbs/ac, still based on the soil test) was close to the recommended rate, and the high rate would be slightly above the Cornell recommendation.

We measured corn yields, N crop uptake, and soil nitrate levels (down to 4 ft) after crop removal in both years. Shallow groundwater samples were obtained by collecting drain outflow whenever possible. In most cases, no flow occurred in the winter (frozen soil) and summer (dry soil), and samplings occurred primarily in the spring and fall.

Results

Tables 1 (for the clay site) and 2 (for the sand site) show silage yield and leftover soil nitrate for each year by fertilizer treatment. In addition, the right-side column shows groundwater nitrate levels (flow-weighted) for the subsequent fall and spring when most soil nitrate is expected to be leached. For 1992, the clay site (Table 1) showed minimal benefits from fertilizer application due to N availability from the recently-plowed alfalfa sod. Leftover soil nitrate levels were high for the 120 lbs/ac rate, indicating that little fertilizer was taken up by the plant. Post-season groundwater nitrate levels were consequently higher under this rate, although they remained below 10 ppm. In 1993 (second-year corn), a yield response was measured between 20 and 90 lbs/ac, but leftover soil nitrate levels were similar (10.8 and 11.7 lbs/ac, respectively). An additional 30 lbs/ac did not increase corn yield, but generated higher end-of-season soil nitrate levels and increased groundwater nitrate levels by 3 ppm.

For the sand site (Table 2), we see that grass sod did not provide sufficient N in 1992, and a yield response was measured by increasing fertilizer from 20 to 90 lbs/ac. No additional yield gains were made by applying 120 lbs/ac. Leftover soil nitrate increased with fertilizer rate, as did nitrate groundwater in the fall, up to 9 ppm for the 120 lbs/ac rate. Nitrate levels were generally lower in the spring. The 1993 season showed a similar pattern, although nitrate in soil and groundwater were higher. For the high fertilizer rate, groundwater

Table 1. Corn yield, leftover soil nitrate, and seasonal groundwater nitrate levels for each fertilizer rate at the Kingsbury clay site.

Fertilizer Rate	Corn Silage Yield	Leftover N In Soil	Post-Season Groundwater Nitrate Concentrations	
		1992		
			Fall '92	Spring '93
20 lbs/ac	24.2 tons/ac	20.8 lbs/ac	3.9 ppm	4.4 ppm
120	26.1	84.3	6.1	7.4
		1993		
			Fall '93	Spring '94
20 lbs/ac	16.9 tons/ac	10.8 lbs/ac	0.9 ppm	2.0 ppm
90	21.7	11.7	1.1	3.2
120	22.3	16.9	4.6	5.9

Table 2. Corn yields, leftover soil nitrate, and seasonal groundwater nitrate levels for the Cosad loamy sand site.

Fertilizer Rate	Silage Yield	Leftover N In Soil	Post-Season Groundwater Nitrate Concentrations	
		1992		
			Fall '92	Spring '93
20 lbs/ac	18.5 tons/ac	10.6 lbs/ac	3.6 ppm	5.8 ppm
90	23.8	21.8	4.5	3.6
120	23.2	32.4	9.0	6.0
		1993		
			Fall '93	Spring '94
20 lbs/ac	18.3 tons/ac	8.1 lbs/ac	3.6 ppm	4.6 ppm
90	21.6	17.4	6.1	7.2
120	21.5	45.1	11.5	7.9

levels exceeded the 10 ppm standard in the fall.

Conclusions

Although results are specific to site and management conditions of this study, we can make some relevant conclusions. Except for 1992 on the clay site where the 90 lbs/ac rate was not applied, we observed a yield response by increasing the rate from 20 to 90 lbs/ac, but no additional gain from adding an additional 30 lbs/ac, i.e., the 120 lbs/ac plots were overfertilized. Our data show that additional fertilizer was in part used as luxury consumption by corn and the remainder was left in the soil at the end of the season.

Groundwater nitrate levels were raised by 0.8 ppm when increasing the rate from 20 to 90 lbs/ac, indicating that most additional N was taken up by plants. This is corroborated by yield data. In contrast, average groundwater nitrate for the 120 lbs/ac rate were 3.2 ppm higher than the 90 lbs/ac rate. In other words, additional nitrogen is not efficiently used by plants and therefore leaches readily to groundwater and may in some cases generate levels in excess of the drinking water standard.

We also observed a difference among soil types. On the sandy site, nitrates leached more rapidly resulting in higher groundwater levels in fall and lower levels in spring when the soil profile had partially been 'cleaned out'. For the clay site, the opposite pattern was observed where different percolation patterns caused the higher nitrate levels to occur in the spring. Also, average nitrate levels were lower for the clay than sand site, with only the latter showing levels above the standard. (It is noted that high nitrate levels were recorded on the clay site in the fall of 1991 and the spring of 1992 after fall plowing of the alfalfa sod, see previous article).

It can be concluded from this study that *accurate prediction of crop N needs is critical to preventing nitrate losses*. Moderate fertilizer rates, which account for alternate sources of N, such as implemented through Cornell's recommendations for field corn, provide optimum yields and maintain shallow groundwater levels below 10 ppm. In such cases, most fertilizer is taken up by the crop. Slight overfertilization, however, increases groundwater nitrate levels. As expected, the critical level for drinking water is more readily exceeded on coarse-textured soils (sands and gravels) than on medium and fine textured soils. This study will be continued for 2 more years to provide longer-term evaluation of the effects of N fertilization practices.

CROP MANAGEMENT

Corn Populations and Corn Quality

Bill Cox
Soil, Crop and Atmospheric Sciences

Many corn growers in New York produce corn on moderately well drained soils. For these soils, we recommend harvest populations of 30,000 plants/acre (plant 33,000 plants/acre) for silage production and 27,000 plants/acre (plant 30,000 plants/acre) for grain. We recommend these populations based on the average yield responses of many different commercial hybrids evaluated since 1988 for silage and since 1991 for grain (What's Cropping Up? Vol. 3 , No. 6, 1993 and Vol. 4, No. 2, 1994). Frequently, corn producers inquire how corn populations affect silage quality and grain quality. The data from 1988 to 1990 for silage and 1991 to 1993 for grain suggest that plant populations have a minimum effect on quality. In 1994, however, corn silage quality decreased somewhat at higher populations, especially as harvest populations exceeded 30,000 plants/acre.

Silage

We evaluated eight commercial hybrids at harvest populations of 20,000, 26,000, and 32,000 plants/acre from 1988 to 1990. When averaged across the 3 years and eight hybrids, neutral detergent fiber (NDF) increased 0.6%, net energy lacation (NEL) declined 0.06%, and crude protein decreased 0.4% as harvest populations increased from 20,000 to 32,000 plants/acre (Table 1). In 1994, however, NDF increased 1.7% and in vitro true digestibility (IVTD) decreased 1.5% as harvest populations increased from 18,000 to 30,000 plants/acre (Table 1). Nevertheless, we do not consider these differences in NDF and IVTD to be of biological significance (i.e. affect milk production) because differences did not exceed 2%. The further increase in NDF and decrease in IVTD as harvest populations

Table 1. Neutral detergent fiber (NDF), net energy lactation (NEL) or in vitro true digestibility (IVTD), and crude protein (CP) at three harvest populations in 1988, 1989, 1990 and 1994.

Harvest Population	NDF	NEL	CP	YIELD
	-------------	%	------------	-- tons/Ac --
		1988		
20,000	41.5	0.791	7.8	16.7
26,000	41.8	0.787	7.6	17.7
32,000	41.5	0.789	7.6	19.0
		1989		
20,000	41.1	0.770	7.6	23.2
26,000	41.5	0.764	7.3	24.3
32,000	41.5	0.762	7.1	25.6
		1990		
20,000	42.3	0.768	7.6	20.9
26,000	43.3	0.764	7.4	22.6
32,000	43.6	0.761	7.3	23.5
		1994		
18,000	38.0	80.1[t]	7.0	24.0
24,000	38.5	79.3	6.5	25.4
30,000	39.7	78.6	6.4	27.4
36,000	41.2	77.5	6.3	28.0
42,000	41.5	77.2	6.2	28.4

[t] In 1994, we measured IVTD instead of NEL.

increased to 36,000 plants/acre are of concern. We are not sure why silage quality declined at higher harvest populations in 1994, although the high yields may have been a contributing factor.

We continue to recommend harvest populations of 30,000 plants/acre despite somewhat lower silage quality in 1994 for two reasons. First, silage yields increased from 24.0 to 27.4 tons/acre as harvest populations increased from 18,000 to 30,000 plants/acre. We believe that a yield response of this magnitude offsets the slight decline in silage quality. Secondly, 1994 was the first year when the decline in silage quality of our recommended population approached biological significance. Nevertheless, we will continue to evaluate the silage quality response to plant populations for the next 2 years and update you annually in this publication.

Table 2. Grain yield, lodging, grain moisture, and test weight of eight hybrids at five harvest populations in 1991, 1992, and 1993.

HARVEST POPULATIONS	YIELD	LODGING	MOISTURE	TEST WT.
		1991		
21,000	116	0.0	19.8	59.4
24,000	121	0.0	20.0	59.5
27,000	126	0.0	20.2	59.5
30,000	128	0.0	20.3	59.5
33,000	125	0.0	20.7	59.6
		1992		
21,000	156	1.8	29.8	57.0
24,000	160	1.4	29.8	56.9
27,000	169	4.8	29.6	56.5
30,000	176	15.7	29.0	56.4
33,000	184	22.8	28.6	56.0
		1993		
21,000	132	1.3	25.3	56.9
24,000	139	3.6	25.1	57.5
27,000	142	5.4	25.4	57.0
30,000	139	12.0	25.8	57.2
33,000	142	12.6	25.5	57.2

Grain

Grain producers are most concerned at harvest with lodging, yield, % moisture, and test weight. We evaluated eight commercial hybrids at nine harvest populations from 1991 to 1993 for these four factors. Plant populations did not affect grain moisture or test weight in any year of the study (Table 2). Because 27,000 plants/acre at harvest resulted in close to maximum yield, minimum lodging, and comparable moisture and test weight, we recommend harvest populations of 27,000/acre for grain production. Lodging can increase significantly as harvest populations approach 30,000 plants/acre so grain producers should strive for harvest populations close to 27,000 plants/acre on moderately well drained soils.

WEED CONTROL

Broadstrike + Dual Provides New Weed Control Option

Russ Hahn
Soil, Crop and Atmospheric Sciences

Registration of Broadstrike + Dual in NY State provides a new option for broad spectrum weed control in field corn and soybeans. Broadstrike (flumetsulam) is the first member of a new herbicide family - the sulfonamides. Although this is a new family of herbicides, the mode-of-action is familiar. Like the imidazolinone (Pursuit) and sulfonylurea (Accent, Beacon, Pinnacle, etc.) herbicides, Broadstrike is an ALS (acetolactate synthase) inhibitor. These herbicides bind with this plant enzyme and disrupt amino acid synthesis. Sensitive weeds may be stunted and chlorotic (yellow) or purple.

As the name implies, Broadstrike has activity on a variety of annual broadleaf weeds. Research in NY State indicates that Broadstrike has good to excellent activity against velvetleaf and wild mustard, fair to good activity against redroot pigweed and common lambsquarters, but only poor to fair activity against common ragweed. Since Dual has good to excellent activity against annual grasses and yellow nutsedge, the pre-mix of Broadstrike + Dual has a good fit for most of the weeds found in NY corn and soybean fields. Research also indicates that Broadstrike may cause growth reduction in corn. Although this growth reduction may persist through much of the growing season, it does not necessarily result in yield reductions.

Research Results 1992-93

Field experiments conducted in 1992 at Aurora (Cayuga Co.) and Valatie (Columbia Co.) raised concerns about the margin of safety for field corn with preemergence (PRE) applications of Broadstrike + Dual. Corn growth reductions up to 13 and 20% with PRE applications of 2 pt/A of Broadstrike + Dual were recorded at Aurora and Valatie respectively in late June and persisted throughout the season. At Aurora, this stunting resulted in an 18 bu/A yield reduction compared with the standard treatment of 2.4 qt/A of Bicep Lite (Dual + atrazine). This yield reduction was attributed to the high soil pH (8.0) in the plot area and to the poor growing conditions (wet and cool) throughout the season. Ultimately, the Broadstrike + Dual label restricted use where soil pH is greater than 7.8. At Valatie, where soil pH was not a factor, grain corn yields with 2 pt/A of Broadstrike + Dual were not significantly different than with 2.4 qt/A of Bicep Lite. Growth reductions with Broadstrike + Dual were again observed in 1993 at these locations, however, grain corn yields were not affected.

Silage Experiments

Lingering concerns about potential corn injury led to the establishment of two experiments in 1994 to evaluate the effect of Broadstrike + Dual on corn grain and silage yields. Corn (Pioneer 3925) was planted May 20 and May 28, 1994 at Mt. Morris (Livingston Co.) and Valatie respectively with each plot split between no soil insecticide and a T-banded application of Lorsban (chlorpyrifos). PRE applications of 2.5 and 2.25 pt/A of Broadstrike + Dual were applied immediately after planting at Mt. Morris and Valatie respectively. Dual 8E was also applied alone at a rate equivalent to the amount of Dual in the pre-mix application. The plot areas received EPO applications of 1 pt/A of Banvel to control escaped annual broadleaf weeds. Finally, some treatments received PO applications of Accent (nicosulfuron) or Beacon (primisulfuron) when corn was in the 5- to 6-leaf stage.

Broadstrike + Dual did not cause corn growth reduction at either location with or without Lorsban. Significant stunting was observed with PO applications of Accent or Beacon following Broadstrike + Dual or Dual alone. Silage yields from Mt. Morris are shown in Table 1. There was no difference between the Dual only and the Broadstrike + Dual treatments (31.4 vs. 31.8 T/A). There was however, a 3.1 T/A yield

Table 1. Corn Silage Response To Broadstrike Followed By Accent or Beacon (Livingston Co. - 1994).

	Dual		Broadstrike + Dual	
Post Herbicide*	- Lorsban	+	- Lorsban	+
	----------T/A----------			
--	31.4	31.1	31.8	28.0
Accent 0.67 oz	30.9	29.5	30.5	29.5
Beacon 0.76 oz	30.2	27.8	29.6	28.3
LSD (0.05)	2.1	2.1	2.1	2.1

* All plots received 1 pt/A Banvel EPO

reduction when Lorsban had been T-banded at planting with Broadstrike + Dual compared with Dual alone (28.0 vs. 31.1 T/A). PO applications of Accent or Beacon had no impact on silage yields following PRE Dual without Lorsban, however, PO application of Beacon did cause a yield reduction with Lorsban. Beacon caused silage yield reductions with or without Lorsban following Broadstrike + Dual. Accent caused a yield reduction following Broadstrike + Dual with Lorsban only. There were no differences in silage yield at Valatie for any of these treatments.

Weed Control Results

In a separate experiment at Valatie, there were yield reductions attributed to a lack of common ragweed and common lambsquarters control. Control ratings for these species and grain corn yields for Broadstrike + Dual and standard treatments are shown in Table 2. Standard treatments of Bicep Lite or Prowl plus atrazine provided excellent (96-100%) control of both ragweed and lambsquarters. Broadstrike + Dual provided only 57 to 60% ragweed (AMBEL) control and 47 to 65% lambsquarters (CHEAL) control. Grain corn yields for the standard treatments averaged 143 bu/A while the Broadstrike + Dual treatments yielded 102 and 116 bu/A for the 1.75 and 2.0 pt/A rates respectively. Since no corn stunting was observed during the season, these yield differences were attributed to the lack of weed control.

My Recommendations

In addition to following the general use precautions on the Broadstrike + Dual label, NY corn growers should not apply this product where soil pH is greater than 7.5, where the soil organic matter is less than 1.5%, or where soils are extremely gravelly. For this first season of commercial use, it is recommended that growers use the lowest end of the application rate range on all soils. If common ragweed is a problem, 1.5 to 2.0 pt/A of atrazine should be tank-mixed with the Broadstrike + Dual unless there is evidence that the ragweed is triazine-resistant.

Table 2. Weed control ratings and grain corn yields with Broadstrike + Dual and standard herbicides (Columbia Co. - 1994).

Herbicides	Amt/A	AMBEL	CHEAL	Yield
		--------%----------		bu/A
Bicep Lite	2.40 qt	97	100	145
Broad + Dual	1.75 pt	57	47	102
Broad + Dual	2.00 pt	60	65	116
Prowl + Atrazine	3.60 pt 2.00 pt	96	100	141
LSD (0.05)		14	29	22

Continued from cover page

Table 1. Effect of weed control practice and time of cultivation on weed biomass sampled in late summer. Aurora, NY 1992-1994.

	1992	1993	1994
Weed Control	------------lbs/A------------		
Bcast + Cult	183b	89b	18b
Band + Cult	363b	311b	101b
Cult Only	748a	1033a	1144a
Time of Cultivation	------------lbs/A------------		
2 leaf	307a	502	341
4 leaf	371a	508	404
6 leaf	424a	377	423
8 leaf	623b	444	514

Table 2. Effect of weed control practice and time of cultivation on corn grain yields. Aurora, NY 1992-1994.

	1992	1993	1994
Weed Control	----------bu/A----------		
Bcast + Cult	101a	122a	145
Band + Cult	104a	116a	145
Cult Only	84b	108b	150
Time of Cultivation	----------bu/A----------		
2 leaf	101a	117	147
4 leaf	107a	115	148
6 leaf	95ab	116	148
8 leaf	83b	112	144

Calendar of Events

June 8	Small Grain Management Field Day, Aurora Research Farm, Aurora, NY
June 25-28	Northeast Branch American Society of Agronomy Meetings, University of Maine
June 29	Aurora Farm Field Day, Aurora Research Farm, Aurora, NY
July 12	Cornell Seed Field Day, Ithaca, NY 9-12 noon
July 12	Cornell Weed Days, Aurora Research Farm, Aurora, NY 1-5 pm
July 13	Cornell Weed Days, Ithaca/Freeville, NY
Oct. 24,25,26	Field Crop Dealer Meetings, Albany, Waterloo, and Batavia
Oct. 29-Nov. 3	American Society of Agronomy Meetings. St. Louis, MO

What's Cropping Up? is a bimonthly newsletter distributed by the Department of Soil, Crop and Atmospheric Sciences at Cornell University. The purpose of the newsletter is to provide timely information on field crop production and environmental issues as it relates to New York agriculture. Articles are regularly contributed by the following Departments at Cornell University: Soil, Crop and Atmospheric Sciences, Plant Breeding, Plant Pathology, and Entomology. **To subscribe, send a check for $8.00 along with the form at the right.**

What's Cropping Up? - Subscription

Name:

Affiliation:

Address:

City: State: Zip:

Make check payable to: **CORNELL UNIVERSITY**
and return to:

Department of Soil, Crop and Atmospheric Sciences - Extension
144 Emerson Hall
Cornell University
Ithaca, NY 14853

Cornell Cooperative Extension

Department of Soil, Crop and Atmospheric Sciences
144 Emerson Hall
Cornell University
Ithaca, NY 14853

Helping You Put Knowledge to Work