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FROM THE EDITORS

Some years ago, Isely was editor of a journal in the agricultural field that is now called *Seed Science*. After a term of six years, he signed off with a valedictory address entitled *Commandments for Communication*. It was published a few years later (Isely, D. 1969. *Commandments for Communication*. Sida 3: 285-288.)

The following, abstracted from the *Commandments*, may be regarded as supplementing the *Information for Authors* printed on the back cover of each issue of the JOURNAL. The *Commandments* were originally directed to scientists but some are equally applicable in the humanities.¹

The *Commandments*:

1. *Publish quickly*. Preliminary experiments have provided some ideas. Get them in print. Follow-up work, if necessary, can be done later and will provide an additional title for your publication list.
2. *Recognize that writing is unimportant to a scientist*. Writing is the sphere of Professors of English and those who prepare advertising copy.
3. *Do not cite competing authors*. As far as possible, indeed, do not read publications relating to your study. This affects your purity of thought and requires time that could better be used otherwise.
4. *Ignore journal format*. Journals commonly publish a set of recommendations for prospective authors. These represent an expression of the eccentricities of the editors and are an invasion of the authors' rights.
5. *Master mechanics of manuscript preparation*. Manuscripts are conventionally typed. Single spacing will save paper; changes can be handwritten (hard pencil is best) in the margin. Variation in heading format and use of one's own abbreviations and symbols add variety, spice, and a personal touch. If a bibliography is included, avoid the monotony of a stylized format; don't verify the citations, and leave some incomplete. Most readers are graduate students who need experience in library search.
6. *Study effective writing*. One object is to keep the reader fooled as long as possible. Sprinkle a single topic, together with others, in several paragraphs. Present some of the "Observations" under "Materials and Methods" and again in the "Discussion." Repeat what was said in the summary and the abstract; this drives the point home. Write as you would speak and expansively; it helps an editor's ego to take a paragraph and boil it down to a single sentence. So be good to him.

¹ A few readers of the original publication failed to detect its facetious nature and wrote the author censorious letters. He, therefore, presently takes the precaution of suggesting that the bottle be turned upside down—or at least sideways.

7. *Don't neglect tables, figures, and computer print-outs.* The results of research commonly are numbers which are obtained by counting, measuring, or reading dials. We call these numbers data. Something has to be done with them. One procedure is to stack them into piles and stuff them in tables. The best are many-columned, each with neat rows of figures; they have a pleasingly hypnotic effect. Be sure to present the original data, not summaries. The scope of possibilities is now enhanced by plugging these data into a computer and offering print-outs of various alternative programs with which to amaze the reader.
8. *Interpret data wisely.* There are four options.
 - a. The simplest gambit is just to ignore tables, figures, etc. Proceed with a learned and philosophical discussion of your conclusions but don't refer to the data. It might confuse both the reader and you.
 - b. Alternatively, meet the data head on. This is the best choice for no-nonsense pragmatic individuals. Table 17 tabulates the fact that 10% of smokers in Iowa get lung cancer, 17% in New York, 5% in North Carolina, and so on through the rest of the states. Reiterate this verbally in the "Results" and possibly also in the "Discussion." This provides the necessary emphasis.
 - c. Always draw firm conclusions. A conclusion is only as good as the vigor of its enunciation. An illustration of the relationship between observations and conclusions follows: My neighbor used to own a small dog that loved to chase butterflies. One day, a butterfly flew across the street and the dog went after it. He was hit by a car. He was laid up but recovered. Thereafter he was deathly frightened by butterflies and would flee screaming whenever he saw one.
 - d. The most courageous way of dealing with data is simply to do without it. The following statement comes from a well known biological text (Stebbins, 1977. *Processes of organic evolution*, ed. 3, p. 253) where the author considers the reproductive rates of beautiful and less beautiful women. He states "Beautiful women do not on the average have the most children, largely because of competing interests of stage, screen, and promiscuous manhunting." The elegance of this thought-provoking statement is its apparent freedom from any kind of organized data.
9. *Avoid manuscript reviews.* Some authors are worry-warts. They scan their manuscripts again and again and annoy their colleagues with requests for reviews. A wasteful procedure that betrays lack of confidence and alienates your friends! When a thing is done, it is done. Move on?
10. *And publish.* We have gone full circle. Our first commandment was to publish. So is the last. It is numbers that count. Rapid and continuous publication is essential for professional growth, and status with grant foundations. It is alleged that St. Peter examines the publication lists of all defunct scholars.

FOREARM LIQUID CRYSTAL THERMOGRAMS DURING SUSTAINED AND RHYTHMIC HANDGRIP CONTRACTIONS¹

Jackie Puhl²

ABSTRACT. Ten subjects performed four consecutive handrip exercises 1 min. each) consisting of (a) a sustained contraction at 50% maximal voluntary contractile strength (MVC), (b) rhythmic contractions at 50% MCV, (c) maximal rhythmic contractions, and (d) a maximal sustained contraction. Photographs of forearm liquid crystal thermogram patterns taken before, during (0.5, 1 min.), and after (0.5, 1, 2, 3, 5, 15 min.) each exercise showed that temperatures overlying major superficial veins increased during all workloads, increased further during recovery, and usually returned to near resting skin temperatures by the end of the recovery period. There was a greater skin temperature rise and longer elevation of skin temperature during recovery from maximal tension exercises compared to 50% MVC exercises. Some qualitative differences in thermogram changes were observed between sustained and rhythmic exercise performed at the same tension. These results suggest liquid crystal thermography may be useful as a qualitative tool to assess blood flow changes under certain conditons.

Index words: skin temperatures, handgrip exercise, liquid crystal thermography, forearm venous patterns.

INTRODUCTION

Liquid crystal (LC) thermography is a technique used to provide a map of skin (surface) temperatures. Cholesteric liquid crystals have a unique color-temperature sensitivity (Ferguson, 1964) such that when applied to the skin, skin temperatures are shown in vivid colors. The temperature of a specific site is determined by the color exhibited on the thermogram. Cholesteric liquid crystals are nontoxic, easy to apply, and have a rapid response time. The unique value of LC themography, however, is that it provides a skin temperature map of large surface areas so that temperature contrasts may be readily observed.

Liquid crystal thermography has been used in a variety of medical research situations where a higher skin temperature may indicate a greater blood flow (Crissey et al., 1961; Davison et al., 1972; Davison et al., 1973; Logan, 1974; Peterson et al., 1971; Selawry et al., 1966). Liquid crystal thermography has also been used to examine thermoregulatory responses to exercises by observing forearm temperature patterns and changes during leg cycling

¹ This study was supported in part by funds from the Department of Health, Education, and Welfare supplied to the Iowa State University Research Grants Program.

² Associate Professor, Department of Physical Education and Leisure Studies, Iowa State University, Ames, Iowa 50011.

exercise and recovery under various workload and environmental conditions (Puhl and Golding, 1975). It has not been used to observe skin temperature changes resulting from contraction of underlying muscles. The purpose of this investigation, therefore, was to examine forearm liquid crystal thermogram patterns and pattern changes during sustained and rhythmic contractions of muscles involved in handgrip exercise.

METHODS AND PROCEDURE

Ten healthy, physically active subjects (eight men and two women) aged 21 to 48 (\bar{X} = 29 years) volunteered to participate in this study following approved informed consent procedures. Preliminary measurements and practice sessions occurred prior to testing. Measurements of body weight, height, and skinfolds indicated that the subjects were average or low-average in percentage of body fat. Mid-anterior forearm skinfolds (average of three measurements) and mid-forearm girths ranged from 2.0 to 3.0 mm and from 22.3 to 29.8 cm respectively. Maximal voluntary contractile (MCV) strength during handgrip exercise varied from 30 to 55 kg between individuals. MVC was measured during five maximal effort handgrip contractions using a handgrip dynamometer (Lafayette Instruments) and the best two values for each subject were used.

During each test, room temperature (18.4° C dry bulb) remained constant ($\pm 0.4^\circ$ C, S.D.). The cooler than normal ambient temperature was selected so the thermograms would show acceptable color-temperature contrast between areas over superficial veins and adjacent skin surfaces (preliminary investigations). Each subject sat in a chair with the elbow placed on a padded wooden block with the right forearm parallel to, but elevated above, the table top. Elbow angle was approximately 120°, and the subject's hand rested comfortably around the grip of a fully supported hand dynamometer. Each subject was instructed to breathe normally throughout the testing period. Following a 15 to 20 minute acclimation period, anterior forearm temperatures were recorded with a skin thermistor (YSI Model 409) and a YSI telethermometer. Resting skin temperatures (28-33.5° C) were used to select the appropriate range of liquid crystals which would produce color variation at rest yet allow visualization of increased skin temperature during exercise. Appropriate liquid crystal materials with 3° C range (Liquid Crystal Biosystems) were applied as previously described (Puhl and Golding, 1975) except that aerosol cans of carbon-black paint and calibrated liquid crystal materials were used. The carbon-black paint provides a background so that the colors of the liquid crystals may be seen. The colors (red, blue, and green) represent the underlying surface temperature of the object to which they have been applied when those temperatures are within the temperature range for that particular liquid crystal mixture. Each color corresponds to a specific temperature. For example, if a 3° C liquid crystal mixture with a temperature range of 28 to 30° C is used, the areas where red appears have an underlying temperature of 28° C (coldest), green areas have an underlying temperature of 29° C (intermediate), and the temperature under blue areas (warmest) is 30° C. Following application of the appropriate range liquid crystal materials, the subject rested for 15 to 20 minutes to allow re-equilibration of the skin with ambient temperature.

The subject then performed four handgrip exercise experiments, each consisting of one minute of exercise followed by a 15 minute recovery period. The four sequential workloads (performed on the same day) were (a) sustained contraction at 50% MVC, (b) rhythmic contractions (30/minute) at 50% MVC, (c) sustained maximal contraction, and (d) maximal rhythmic contractions (30/minute). Subjects attempted to maintain the prescribed workload throughout each exercise period. Each subject was instructed to relax the hand and forearm as completely as possible during all recovery periods and during relaxation phases of the rhythmic exercises. A metronome (60 bpm) set the pace for the one second of contraction followed by one second of relaxation for the 30 consecutive rhythmic contractions.

Workloads, environmental conditions, exercise duration, recovery time, and exercise sequence were selected based on preliminary investigations at 10%, 25%, 50%, 75%, and 100% MVC during sustained and rhythmic exercises and recovery times up to 30 minutes. The selection of experimental conditions is supported by data from Quarry and Spodick (1974), who reported that 50% and 100% MVC produced significant cardiovascular effects in one minute, and from Humphreys and Lind (1963), who observed an increased blood flow up to fatigue during sustained handgrip exercise at tensions similar to those in this study. The selection of one minute exercise bouts is also supported by the observation that the fatigue point occurs within one to two minutes during 50% MVC and sooner with 100% MVC exercise (Bowie and Cumming, 1971; Funderburk et al., 1974; Humphreys and Lind, 1963). Recovery time was based on unpublished observations and from indications that forearm blood flow returns near pre-exercise levels within 15 minutes after exercise (Humphreys and Lind, 1963).

In each test sequence, photographic records were made at rest, at 30 seconds and minute 1 of exercise, and during recovery at 30 seconds and minutes 1, 2, 3, 5, and 15. A Minolta camera and two Honeywell Strobolar flash units were mounted on a tripod with the camera positioned at a height just above the subject's forearm. Forearm and camera positions were identical throughout each testing session.

RESULTS

The photographs from subject NS (Fig. 1) demonstrate the major liquid crystal thermogram changes observed in most subjects in this study. On a thermogram using a 3° C range liquid crystal material, red, green, and blue represent the coldest, the intermediate, and the warmest, respectively, of the three specific temperatures. Brown and black indicate that the underlying temperature is out of range for the liquid crystal material being used.

50% MVC Sustained Contraction (Subject NS, Fig. 1)

During sustained contraction at 50% MVC, the thermogram showed an initial small (0.5° C) temperature decrease over the mid-forearm followed by an increase (0.5° C) over superficial vessels arising from the palmar arch. Within one-half to one minute of the recovery period, there was an increase of approximately 1° C over superficial veins from the palmar and dorsal venous networks (mainly basilic vein and tributary). The elevation in skin temperature

continued for an additional two to three minutes and there appeared to be irradiation of heat from blood vessels to surrounding tissue. Skin temperatures began to decrease about five minutes into recovery and were about 0.5°C higher than the pre-exercise values by the end of the recovery period. However, skin areas over the basilic vein and tributary were still $1\text{--}2^{\circ}\text{C}$ warmer than pre-exercise temperatures.

50% MVC Rhythmic Exercise (Subject NS; Fig. 1)

The resting skin temperature over some major superficial veins was slightly higher (0.5°C) than in the previous exercise indicating the incomplete recovery from the 50% MVC sustained contraction. No noticeable decline in skin temperature occurred at the onset of the 50% MVC exercise. During exercise, there was a more noticeable increase in skin temperature over superficial veins compared to static exercise at the same tension, which could have been influenced by the higher resting skin temperatures over some of these superficial veins. By the end of exercise, there was a greater temperature increase in the "venous pattern" than with the previous exercise. Recovery was similar to that observed with sustained exercise at 50% MVC, but based on pre-exercise temperatures, recovery was more complete.

100% MVC Sustained Contraction (Subject NS; Fig. 1)

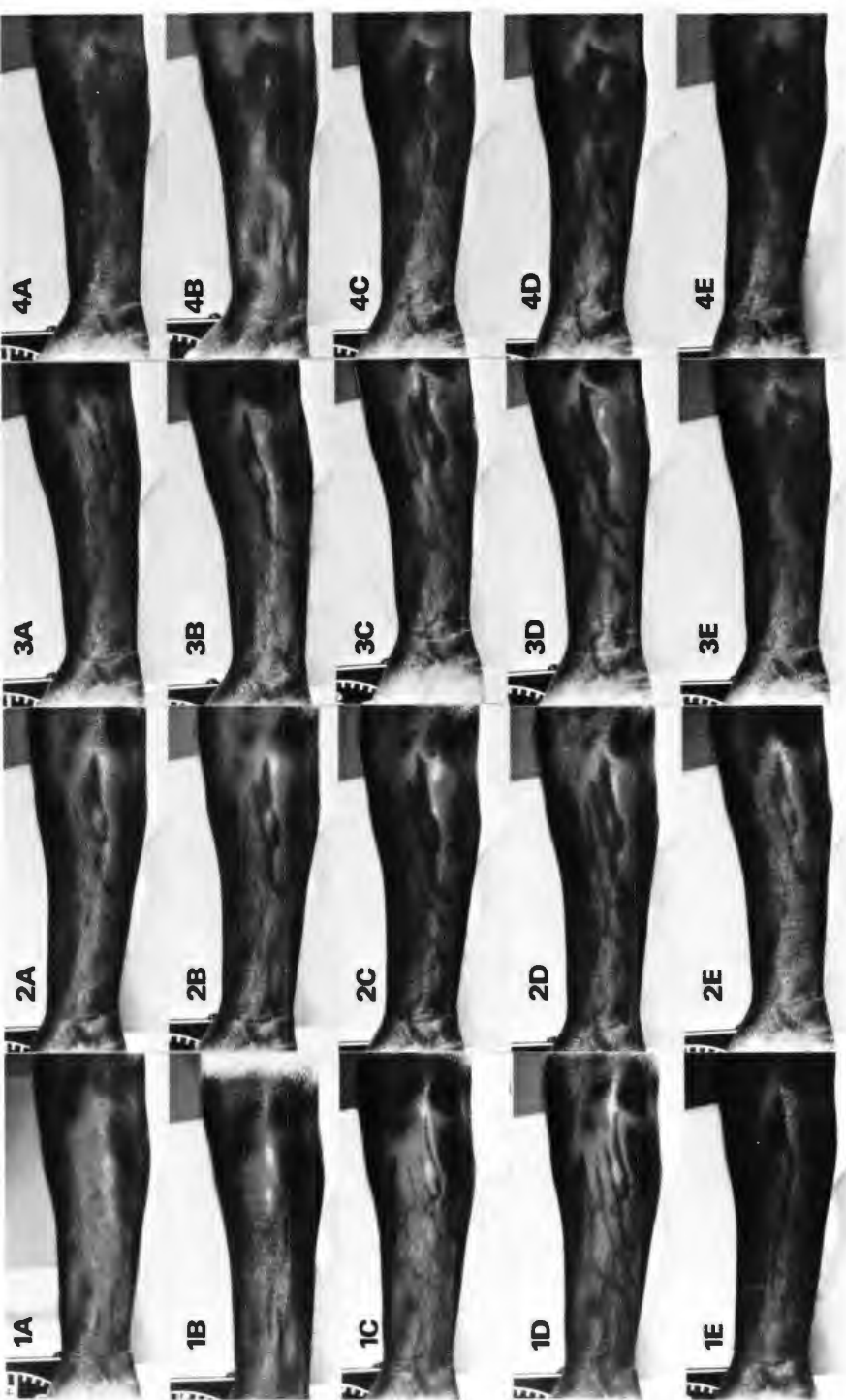
Resting skin temperatures and pattern were similar to those observed before the previous exercise. During exercise, there were noticeable skin temperature increases in areas overlying the major superficial veins. During recovery, the temperature increase over the veins persisted longer and more heat appeared to be conducted through the surrounding tissue early in recovery (5 minutes) compared to sustained or rhythmic exercise at 50% MVC. Recovery was also slower and, after 15 minutes, was incomplete with skin temperature in several areas still about $1\text{--}2^{\circ}\text{C}$ higher than before this exercise.

100% MVC Rhythmic Contractions (Subject NS; Fig. 1)

Pre-exercise skin temperatures were slightly higher than before the other exercise situations. During exercise, a temperature increase occurred over some

Figure 1. (on facing page) Forearm Liquid Crystal Thermograms During Sustained and Rhythmic Handgrip Exercise (Subject NS)

- | | |
|------------------------|-----------------------|
| 1. 50% MVC - Sustained | A. Rest |
| 2. 50% MVC - Rhythmic | B. 30 sec. - exercise |
| 3. Maximum - Sustained | C. 30 sec. - recovery |
| 4. Maximum - Rhythmic | D. 1 min. - recovery |
| | E. 15 min. - recovery |



major veins. In recovery, elevated temperatures over major veins persisted longer, and there appeared to be greater heat irradiation than in the other exercise situations. Recovery to pre-exercise temperatures was incomplete after 15 minutes, but skin temperatures were closer to resting values than after sustained exercise at 100% MVC.

General Trends (All Subjects)

The trends observed in the thermograms of subject NS (Fig. 1) existed for other subjects with observable venous patterns, although prominence of venous patterns varied (see Fig. 2). Most of the forearm changes in temperature occurred over the veins during exercise and recovery. In some cases, a small temperature decrease over blood vessels at the wrist and mid-forearm was observed at the onset of exercise. During exercise, there was an increase in temperature over some major superficial veins (primarily median antebrachial and basilic) and an apparent temperature increase over several smaller tributaries, especially from the palmar venous network. The temperature increases over veins were more apparent during maximal contractions. These temperatures were also slightly higher during sustained compared to rhythmic contractions at the same percent MVC.

During recovery, there was a further increase in skin temperature overlying some major superficial veins and several smaller superficial veins became apparent in most test situations. Recovery patterns in subjects with observable venous patterns were similar to subject NS (Fig. 1). In these cases, the temperature over some major superficial veins and tributaries continued to increase during the early part of recovery. With both maximal exercises, the elevated temperature persisted longer in recovery, and there was a greater heat irradiation into the surrounding tissue compared to the 50% MVC exercises. Recovery of skin temperature patterns was usually complete within 15 minutes after the 50% MVC exercises, although skin temperatures following the maximal contractions were sometimes slightly higher than pre-exercise temperatures even after 15 minutes of recovery. There was a trend toward more complete temperature recovery following the rhythmic contractions than the sustained contractions.

Some subjects had less evident venous patterns and appeared to have more pronounced heat conduction through tissue than other subjects. The two women, who presumably had smaller and perhaps less superficial veins, had more "gradient" (Puhl and Golding, 1975) thermogram patterns. During exercise, their thermograms showed a skin temperature increase over lower forearm veins arising from the palmar arch. During recovery these temperatures continued to increase, especially following the maximal exercises.

One phenomenon that was observed in four subjects was a decrease in skin temperature over the cephalic vein during the last half of exercise. The temperature decrease continued for one-half to two minutes of recovery regardless of the type of intensity of the exercise. Even though skin temperature decreased over the cephalic vein, there was a temperature increase over the anterior forearm veins (median antebrachial and tributaries) arising from the palmar arch. There was also a temperature increase over the basilic vein caudal to the point where it joins the median cubital vein. This was surprising since both the cephalic vein and the basilic vein arise from the dorsal venous network of the

hand (cephalic vein from the radial or lateral side and basilic vein from the medial or ulnar side). In situations where temperature had decreased over the cephalic vein during exercise, the temperature then increased during the third to fifth minute of recovery. With maximal tension exercises, the increase of temperature over the cephalic vein was delayed longer than after the 50% MVC exercises.

DISCUSSION

The resting forearm liquid crystal thermogram patterns and the variability of patterns in this study were similar to those previously observed in resting subjects in a neutral environment (Puhl and Golding, 1975). The thermogram changes in the present study suggest that liquid crystal thermography may provide a qualitative assessment of blood flow changes in superficial forearm veins during and following the handgrip exercises. This is predicated on the assumptions that (a) the exercises used in this study produced an increase in hand and forearm blood flow and (b) the liquid crystal thermograms, via changes in venous patterns, reflected a change in blood flow. Support for these assumptions comes from previous studies and from interpretation of the thermograms.

First, it is well known that handgrip contractions produce an increase in forearm blood flow (Humphreys and Lind, 1963; Lind and McNicol, 1967a; Lorentsen, 1975; Quarry and Spodick, 1974; Wahren, 1966). Generally, investigators have reported a rapid rise in forearm blood flow during handgrip contractions (up to about 60% MVC) with the rate of rise being proportional to the relative work intensity (Lind and McNicol, 1967a) and related to metabolic needs (Wahren, 1966). Some studies on static handgrip exercise indicate an increase in forearm blood flow during work at lower tensions which can be continued for longer periods of time (Bowie and Cumming, 1971; Lind et al., 1964; Lind et al., 1966; Mottram, 1973). The fatigue point typically occurs within one to two minutes during 50% MVC work and may occur sooner with 100% MVC exercise (Bowie and Cumming, 1971; Funderburk et al., 1974; Humphreys and Lind, 1963; Mottram, 1973). Consequently, by the end of one minute of exercise used in this study, maximal or near maximal forearm blood flow for each tension (50% MVC and 100% MVC) might be expected. In this study, deviations from prescribed tensions occurred presumably because of fatigue, particularly at the 100% MVC workloads. However, in all situations, including maximal tension exercises, each subject attempted to maintain the prescribed tensions. Since tensions were very near 50% MVC or were maximal efforts, it is unlikely that any tension reduction which did occur would have affected expected forearm blood flow responses.

Second, that the liquid crystal thermogram patterns can identify superficial venous patterns is apparent by visual observation; however, an assumption that the changes in these patterns reflect changes in blood flow is equivocal. Interpretation of liquid crystal thermograms, particularly when associated with exercise, must consider the many factors which can influence skin temperature such as environmental temperature, cutaneous blood flow, evaporative cooling effects, metabolic heat from underlying tissues, and heat from blood flow through major arteries and veins.

Blood flow through active and inactive limbs has been examined using a variety of techniques including skin temperature (Abramson, 1967; Bränekmark and Ericksson, 1972; Chimosky, 1972; Detry et al., 1972; Greenfield et al., 1963; Halböök et al., 1970; Lind and McNicol, 1967a; Tal, 1973; Wahren, 1966; Zelis et al., 1969). Because skin temperature may be influenced by so many factors, skin temperature changes may not be dependable indicators of changes in blood flow through underlying tissues. Nevertheless, it has been suggested that under certain conditions, such as constant environmental temperature, skin temperature may reflect changes in blood flow through underlying tissues (Abramson, 1967). Since skin temperature differences of 3-4° C are observed between blood vessels and areas only 1-2 cm away (Crissey et al., 1961), the location of small skin thermistors is critical if skin temperature is to be used as even a gross reflection of underlying exercise-induced blood flow changes. Liquid crystal thermography may be more valuable than skin thermistors as an indicator of underlying blood flow changes because it allows observation of skin temperature patterns over large areas and can demonstrate superficial venous patterns of a limb. It seems reasonable that liquid crystal thermography, if interpreted cautiously, may provide assessment of skin temperature pattern changes which, when reflected by obvious venous patterns, may grossly reflect changes in blood flow through superficial veins of a limb.

In light of the above discussion, it is assumed that the exercises in this study produced an increase in hand and forearm blood flow and that LC thermography can identify superficial venous patterns. The hypothesis that liquid crystal pattern changes observed in this study may, at least in part, reflect blood flow changes will be considered in the following discussion. It is recognized that the return of blood from forearm skeletal muscles by way of deep veins is normally not detectable by liquid crystal thermography.

The thermogram changes in venous patterns observed in this study reflect skin temperature changes over superficial veins which return blood from the hand. Blood flow through the hand may have been influenced by forearm arterial inflow, alterations due to forearm muscle contraction, intramuscular pressure in the hand, and dynamometer pressure against the hand. In the early part of the exercise, the liquid crystal thermograms showed a small decrease of skin temperature over some major superficial veins, particularly during the 100% MVC exercises. It is plausible that a decrease in blood flow through the hand may have occurred because of handgrip pressure on the dynamometer or intramuscular pressures in the hand and forearm.

As exercise continued, there was a clear increase in skin temperature over major superficial veins and an apparent dilation of tributaries suggesting a possible increase in blood flow to the hand. This interpretation is supported by the concept of autoregulation of blood flow to skeletal muscles. As metabolic needs continue during muscle contractions and if blood flow is hindered, a condition of hypoxia may occur. Possibly an increased perfusion pressure and vasodilation may overcome, or partially overcome, the mechanical resistance on blood vessels and facilitate blood flow (Humphreys and Lind, 1963; Lind and McNicol, 1967a). In this study, skin temperature increases over major superficial forearm veins and apparent dilation of some tributaries were more pronounced during the 100% MVC exercises when metabolic needs would be higher than during 50% MVC exercise. A slightly greater increase in skin temperature overlying superficial forearm veins occurred during rhythmic exercises

compared to sustained contractions at the same tension. This supports the idea of intermittent rather than a continuous impedance of blood flow, resulting in an increased blood flow during the relaxation periods of rhythmic exercise (Barcroft and Dornhurst, 1949; Folkow et al., 1970).

Studies on blood flow through the forearm during handgrip exercise have demonstrated that there is a reduction of final blood flow with increasing tension (Humphreys and Lind, 1963). It has been suggested that forearm arterial inflow may be occluded at tensions about 70% MVC (Humphreys and Lind, 1963) or perhaps at some lower tensions (Barcroft and Millen, 1939). Nevertheless, the liquid crystal thermogram patterns and pattern changes in this study suggest that blood flow to the hand was not completely occluded during handgrip exercises at either 50% or 100% MVC.

An increase in skin temperature directly over a superficial blood vessel could be interpreted as an increase in blood flow, an increase in blood temperature, or increased metabolic heat from active muscles. The existence of venae comitantes in the forearm could provide a heat exchange between deep veins and arteries supplying blood flow to the hand. Possibly, increased temperature of skin over superficial veins observed on the thermograms could be a consequence of a mixing of blood from deep and superficial veins. Wahren (1966), however, has presented evidence that little mixing of blood from deep and superficial forearm veins occurs during exercise. Also, elevated temperature in active forearm muscles during handgrip exercise is more likely due to increased blood flow rather than to the heat generated during contraction (i.e., metabolic heat) (Lind and McNicol, 1967a). Thus, it is suggested that the increase in skin temperature over superficial veins was not due to increased metabolic heat from forearm muscles or to a mixing of blood between deep and superficial veins but was due either to an increase in blood temperature from the metabolic heat of hand muscle contraction being transported away from the hand or to increased hand blood flow. Based on (a) the nature of the thermogram changes, (b) the known increase in forearm blood flow during such exercise, and (c) forearm liquid crystal thermogram changes which occur during leg exercise in response to thermoregulatory needs (Puhl and Golding, 1975), it seems probably that the observed increase in skin temperature over superficial veins was due, at least in part, to increased hand blood flow.

Furthermore, there appears to be an increased blood flow from both the palmar and dorsal venous networks of the hand during exercise. The frequently observed decrease in skin temperature over the cephalic vein in this investigation does not appear to be related to exercise intensity or type and occurred even when a temperature increase was observed over the basilic vein. This suggests a reduction of blood flow through the lateral dorsal arch or a shunting of blood from the lateral to the medial dorsal arch. Such a specific shunting of blood could result from greater involvement of lateral hand muscles when compared to the medial side.

During recovery, the delayed increase in skin temperature over the cephalic vein (three to five minutes) appears to reflect a delayed restoration of normal blood flow through the lateral dorsal arch. The continued increase in post-exercise temperatures over superficial veins suggests a continued increase in blood flow to the hand during the first few minutes of recovery. This interpretation is consistent with known post-exercise hyperemic responses to handgrip exercise at tensions similar to those in this study (Clarke et al., 1958;

Clarke and Hellon, 1959; Coles and Cooper, 1957; Grant, 1938; Humphreys and Lind, 1963; Jessup, 1973; Lind et al., 1964; Lind et al., 1964; Lind and McNicol, 1967b).

A more prolonged temperature increase over superficial veins following sustained exercise compared to rhythmic exercise might be expected, because of more hypoxic conditions resulting from sustained exercise (Lind and McNicol, 1967a). In this study, recovery thermograms following sustained and rhythmic contractions showed little difference in skin temperature over superficial veins. However, it is likely that differences in blood flow did exist in the post-exercise hyperemic responses following sustained versus rhythmic hand-grip contractions but that liquid crystal thermography was not able to clearly detect these differences.

The return to normal blood flow should be proportionately longer with higher tensions. In this study, the return of temperatures over major veins to resting temperatures was longer following the higher tension exercises. These results imply that liquid crystal thermograms may be able to reflect gross increases in blood flow as indicated by changes in skin temperature over superficial veins. This may not be true, however, during conditions of rapid blood flow (Abramson, 1967).

The diffusion of heat observed on the thermograms, particularly during recovery from 100% MVC exercises, could be due to heat irradiation over the superficial vessels in both 50% and 100% MVC exercises which indicates that these changes were due primarily to increased blood flow and/or blood temperature through these veins rather than directly or indirectly from previously active forearm muscles.

Liquid crystal thermography should be considered a qualitative, not a quantitative tool. In this study, changes in the thermograms indicated an increased skin temperature over superficial veins and tributaries from the hand which suggest increased blood flow through the hand. The frequent observations of a decrease in skin temperature over the cephalic vein during exercise and the early part of recovery imply a reduction in blood flow returning from the lateral dorsal arch and suggest a preferential hand blood flow response during handgrip exercise. The increased skin temperatures over superficial veins during exercise at both 50% and 100% MVC suggest that hand blood flow was not completely occluded even with maximal tension exercise. The skin temperature increase over superficial veins during recovery and return to near resting temperature levels within 15 minutes is in agreement with known post-exercise hyperemic responses to handgrip exercise. A qualitative difference between 50% MVC and maximal tensions was noted in the apparent post-exercise hyperemic response. Based on these observations, it is suggested that liquid crystal thermography may qualitatively reflect changes in blood flow through the hand and forearm during and after handrip contractions via changes in skin temperature patterns. However, LC thermography is probably not a sensitive indicator of blood flow changes in underlying tissues when blood flow is high.

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MANAGEMENT OF EXISTING HARDWOOD STANDS CAN BE PROFITABLE FOR PRIVATE WOODLAND OWNERS¹

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ABSTRACT. In recent years, many acres of forested land in Iowa have been converted to agricultural uses. Although this practice generates positive economic returns in some situations, it is not necessarily the optimal course of action according to economic criteria. Given the high cost of conversion and the investment potential that exists in timber management, conversion of existing hardwood stands to other uses may not be the most efficient use of available investment capital.

Index words: economic analysis, hardwood management, non-industrial private forest lands, land conversion, timber management, woodlots, economics.

INTRODUCTION

Throughout the Midwest, forest lands in recent years have given way to pressures for competing land uses—primarily agricultural and urban development. The bulk of this land conversion has taken place on non-industrial private forest (NIPF) lands. Nationwide, NIPF lands account for 58% of the commercial timber land in the United States (Wall, 1981). In Iowa, 91% of the total commercial timber land in the state is privately owned, and, of this, 74% is owned by farmers (Ostrum, 1976).

In most areas where agriculture is well developed, sites that are flat and well drained already are being cultivated or are committed to other uses. Steeper wooded slopes often are poorly suited for agricultural development. Yet these sites frequently are cleared and converted to pasture or cropland, and their conversion causes soil erosion and water-quality problems. Additionally, this trend threatens to further limit the future supply of quality hardwood timber.

By clearing woodlands, farmers are implicitly foregoing an investment in timber production. While some may make this investment decision consciously and in a businesslike manner, many perceive no other option. In areas heavily dominated by agriculture, timber production often is an unfamiliar activity. Consequently, many farmers think that more can be made by expanding the cultivatable acreage of their farms than from managing the existing timber resource. Land clearing is an activity that farmers have been engaged in

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for a long time, and old ideas and notions typically are not easily or quickly changed.

Years of mismanagement and subsequent infrequent and poor returns have created the impression that timber production is not a profitable enterprise. In a study of Illinois' rural woodland owners, more than three-fourths of those surveyed reported that their woodlands did not make a significant contribution to their income; nearly 80% thought that fencing their woodlands to protect them from livestock was not important and less than 15% felt that there was an important countrywide forestry conservation problem (Beazley and Holland, 1973). In the same study, two-thirds of the residents in one heavily agricultural county believed that woodlands made a negative contribution to the value of their farm, and 40% reported that forest cover was not the best use for their woodlands. In a similar survey of woodland owners in Delaware, where 43% of the forest lands in the state are owned by farmers, over half of the respondents said they owned timber simply because it was part of their property (Kingsley and Finley, 1975). The results of these surveys reflect the attitudes shared by many private woodland owners throughout the Midwest as well as other regions of this country.

Traditionally, the economics of hardwood timber production has supported the view that a landowner cannot plant seedlings, wait for a crop to mature, and realize a return worthy of such a long-term investment. To many landowners, however, the issue is not whether to plant a timber crop, but rather what to do with the existing forest resource. Thus, there is the question whether conversion is the most efficient use of the available investment capital given the large initial cost of clearing and the potential value of the resource being destroyed.

Some have suggested that either public land acquisition or some new restrictions on the rights of property owners are the best hope of maintaining existing forest lands for timber production, wildlife habitat, and recreation. Because of the prohibitive cost of the former suggestion and lack of political support of the latter, neither solution is likely to be implemented. Private individuals have repeatedly demonstrated their unwillingness to produce for a public good. This study, therefore, was undertaken to determine whether conversion is the most efficient use of available capital, and, if not, to show woodland owners the economic potential of woodlands as an encouragement for them to practice sound forest management.

PROCEDURES

This study took place in Iowa, a state in which significant land conversion has occurred. From 1954 to 1974, 40% of Iowa's timber land (1,058,700 acres) was converted to a variety of other uses, primarily agricultural and urban development (Thomson, 1980). This trend is especially alarming because only 4% of the state remains in forests (Ostrom, 1976).

Our specific objective was to compare the returns from converting woodlands to agricultural production with those from managing the existing timber resource and to create a framework of analysis to assist managers faced with a similar land utilization decision. To accomplish this, a series of alternative land-management strategies (or investments) were analyzed on the basis of

internal rate of return (IRR), present net worth (PNW), benefit cost ratio (B/C), and undiscounted cash flow. The woodland conversion alternatives analyzed included two different row-crop rotation patterns, pasture, and Christmas tree production. The timber management alternatives analyzed included fuelwood, sawlogs and fuelwood, and sawlog management strategies.

This study focused on Warren County, located in central Iowa, approximately 15 miles south of the city of Des Moines. Warren County is predominantly agricultural, but approximately 6% of the county is forested (Ostrum, 1976). Cropland and pasture account for 46% and 30% of the county respectively. Farms in Warren County are mostly in the 200 to 300 acre range with corn, soybeans, and hay being the most common crops. Soils are rich and well suited for agriculture. A typical situation faced by an average central Iowa farmer was formulated, and a series of assumptions were made upon which the analysis was based. It was assumed that a farmer owned a 15-acre fully stocked oak-hickory stand, which was approximately 60 years old. The stand was assumed to be growing on Sharpsburg soil, with a site index of 60 feet (on a 50-year basis for oak species).³

Given this situation, farmers might consider clearing and converting their woodlands to agricultural uses (i.e., row crops or pasture), clearing their land and planting a crop of Christmas trees, or maintaining the present forest cover and producing saw timber and/or fuelwood. This is not an exhaustive list, but it includes many of the most likely alternatives farmers might be expected to consider.

All costs and returns expected in the first 40 years for each alternative were itemized on an annual basis, and IRR, PNW, and B/C were calculated for each alternative. The costs and revenues in this study are in terms of constant dollars. Including a constant inflation factor in the calculations and using a higher current discount rate would have produced identical results (GREGersen, 1975). Because this is a comparative analysis, the effects of inflation will not affect the ranking of alternatives.

When comparing alternatives on the basis of PNW or B/C, the choice of an appropriate discount rate is important. By most standards a 3% to 7% rate of real growth (above the effects of inflation) is considered characteristic of a good business opportunity. Thus, 5% was used.

"NC Return" (Schweitzer et al., 1967), a computer program developed by the U.S. Forest Service at the North Central Forest Experiment Station, was employed to calculate IRR, PNW, and B/C for costs and revenues occurring in the first 40 years of each alternative. This program, designed as a tool for evaluating forestry investments, is useful for analyzing any investment for which a stream of costs and revenues over time can be generated.

THE ALTERNATIVES

To determine the effects of the assumptions and possible price changes on IRR, PNW, and B/C, many variations of each alternative were analyzed, but only representative combinations are presented here.

³ Oak trees would be 60 feet tall at age 50.

Alternative 1. Row Crops: Corn, Oats, and Hay

Given the situation previously described, farmers may choose to convert their woodlands to row-crop production. This procedure requires an initial investment of somewhere between \$400 and \$600 per acre in clearing costs.

Subsequent production costs are typical of those encountered by farmers in central Iowa, with farms of 320 to 440 acres. Machinery costs are based on six-row planting and three-row harvesting and assumes that the machinery is already owned. Labor in this and all alternatives is assumed to cost \$5.00 per hour. Costs for chemicals are typical of present production procedures. Crop rotation is important in maintaining soil fertility and minimizing pest problems, so the recommended corn, oats, hay, and hay rotation schedule is used in this alternative (USDA, 1978).

Costs for this alternative are primarily from Stoneberg, Edwards, and Thompson (1979), and per-acre yield estimates are from the 1978 Soil Survey for Warren County (USDA, 1978). Total annual production costs, including real estate taxes and labor costs, are calculated to be: \$178.32/acre for corn, \$84.44 acre for oats, \$130.01/acre for hay establishment, and \$108.37/acre for second-year hay production. Corn is assumed to yield 110 bu/acre at \$2.25/bu; oats, 80 bu/acre at \$1.15/bu; plus 1 ton of straw/acre at \$50/T; and hay, 4 tons/acre (harvested in large round bales) at \$43/T.

Clearing and destumping the land is assumed to cost \$450 per acre. The standing timber removed in the clearing operation is assumed to be piled and burned on site (a common practice); consequently, there is no cost associated with slash disposal.

Alternative 2. Row Crops: Corn and Soybeans

Alternative 2 is essentially the same as Alternative 1, except that it involves a different crop rotation schedule. In this alternative a corn and soybean rotation is used. The corn and soybean rotation pattern is less than optimal from an erosion and soil fertility standpoint, but its popularity makes it worthy of consideration for this study.

All assumptions (e.g., clearing costs, machinery, and farm size) are the same as in Alternative 1. Corn is assumed to yield 110 bu/acre at \$2.25/bu and soybeans yield 40 bu/acre at \$6.25/bu. Total production costs, including labor costs and property taxes, are \$178.32/acre for corn and \$113.79/acre for soybeans.

Alternative 3. Pasture

Many farms in central Iowa are a combination, crop and livestock operation. A common pattern is to convert timber land to grazing land when market conditions are conducive to expanding the livestock portion of the farm operation or when more productive pasture land is converted to row crops. Eventually, this pasture land may make its way into row-crop production, and pasture is a common intermediary step in this progression.

The intensity of pasture management is diverse. Herein, it is assumed that a moderately intensive level of management would be implemented with

pasture renovation treatments being carried out every ten years. These renovation treatments include disking, seeding, and applications of fertilizer.

The itemization of costs are derived primarily from Schaller and Edwards (1977), with updating of some equipment costs to 1979 levels from Edwards and Stoneberg (1979). Total first-year establishment cost, including \$450/acre clearing expense, is calculated to be \$555.79/acre. Annual administrative costs and property taxes are \$9.77/acre, and the ten year renovation treatments cost \$81.07/acre.

The value of pasture is ambiguous because the product produced by pasture land (forage) is not exchanged in the market place. In this study, forage is assumed to be valued at \$12/ton (Stoneberg, McGrann, and Edwards, 1978). The management regime described can be expected to produce 4.5 tons per acre annually, or the equivalent of 225 animal unit days (AUD) (USDA, 1978).

Alternative 4. Christmas Trees

This alternative, like the previous three, requires clearing the site. Site preparation is assumed to consist of plowing and disking. Planting of 1090 trees/acre is assumed to be done by using a mechanical planter, which in Iowa can be borrowed from the state district forester. It is assumed that an herbicide would be applied at planting and in the following two seasons to control weed competition. Subsequently, weed competition between rows is assumed to be controlled by mowing three times a year, every year, until the trees are harvested. All costs for this alternative are from Wray and Countryman (1979), except that labor costs have been updated from \$3 to \$5 per hour.

It is assumed that 90% of the trees would survive to maturity, and that of these 90% (883 trees/acre) would be marketable. Harvesting and marketing costs are assumed to be \$0.85/tree, and returns are \$7/tree.

Alternative 5. Fuelwood

Faced with rising fuel costs, many Americans are giving increased attention to heating with wood. This trend has brought about a tremendous increase in demand for firewood throughout the Midwest and Northeast. Because Iowa has a small amount of timber to supply this demand, prices are attractively high (e.g., approximately \$100 to \$125 per cord in central Iowa). Consequently, this situation provides an attractive opportunity for Iowa's woodland owners. For the price of a chain saw and perhaps a mechanical log splitter, a landowner could be in the fuelwood business.

Given the assumption that the stand is 60 years old and has a 60-foot site index (on a 50-year basis, for oak species), an estimate of total stand volume was made by applying a cordwood volume equation developed in central Iowa for oak species by Hartz (1980) to the diameter of age distributions of Schnur (1937) for midwestern oak stands. By Duerr's financial maturity model, a rotation age of 30 years was found to maximize present net worth at 6% discount rate (Davis, 1956). A sustainable annual harvest was calculated by using Hanzlik's annual cut formula (Davis, 1956). It was calculated that 1.5 cords/acre would be harvested annually in the first 30 years, or until the woodlot is fully regulated, and then one cord/acre annually would be harvested thereafter. It is assumed that firewood would be the only product produced

and that the present 60-year-old stand would be converted to a 30-year-old stand over a single rotation (30 years). Growth and output above the assumed level might be expected through tree response to decreased competition within the stand.

Estimated transportation costs are based on 1979 operating costs for a half-ton pickup truck, and it is assumed that firewood would be delivered a half cord (i.e., approximately 2000 lb) at a time in a 30-mile transportation radius and at a delivered price at \$100/cord.

A suitable chain saw is assumed to cost \$300 and to have a useful life of ten years. A hydraulic log splitter is assumed to cost \$1200 and to have a useful life exceeding 40 years. To keep the analysis on a per-acre basis, the total cost of equipment purchased has been divided by the number of acres (15) assumed. Total variable production costs are calculated to be \$67.90/cord, including labor and transportation costs.

Fuelwood production has some subtle advantages, which although not reflected in IRR or PNW, should be considered. For example, federal income tax regulations have provisions that make timber management more attractive. The resource depletion allowance provision permits a deduction (from the gross timber revenue received in a given year) of a certain portion of the original cost of the stand, plus management expenses that have been incurred but not previously used as a deduction. Operating expenses such as the cost of fire, pest, and disease control, insurance, short-lived tools (e.g., axes, saw, etc.) and professional management advice can be deducted from ordinary income in the year in which these costs occurred (Behlen, 1979). Also, income received from assets held for more than one year (e.g., standing timber) can be treated as capital gains rather than regular income (U.S. Department of the Treasury, 1979). However, the greatest advantage, which may not be immediately recognized, is the inherent flexibility of the fuelwood operation itself. With few limitations, a stand of hardwood timber managed for fuelwood can be thought of as a savings account, from which withdrawals can be made periodically. Interest accrues to the growing stock in the form of increased growth, which for timber is tax free until harvest.

Alternative 6. Sawlogs

Iowa sawmills receive nearly 60 million board feet (bd ft) of sawlogs annually, and veneer-grade material is bought and sold in the state (Ostrom, 1976). The potential to produce high-quality sawlogs varies, of course, from stand to stand depending primarily on past management practices.

Given the assumption of a stand 60 years old with a site index of 60 feet for oak species (on a 50-year basis), a rotation age of 67 years was found to maximize present net worth (at a 6% discount rate) by using Duerr's financial maturity model (Davis, 1956). It is assumed that the first timber sale would be made in the seventh year and that timber harvesting would be carried out thereafter on a ten-year cutting cycle.

Growth and yield figures are based on a computer-simulated growth model, which projects growth response after thinning, for central Iowa oak stands (Dale, 1973). Based on market information published by the Iowa State Forestry Department (Wray, 1977), stumpage prices are assumed to be \$88/M bd ft. The harvestable volume for each sale was determined by using Von

Mantel's allowable cut formula (Davis, 1956). Under these assumptions about the stand's characteristics, a sustained yield of 300 bd ft of annual yield per acre should be obtainable. With 15 acres of timber, and 300 bd ft of annual yield per acre, each sale at a ten-year interval will yield 45,000 bd ft.

For this analysis it has been assumed that \$20 per acre will be spent every ten years for post-harvest timber stand improvement. This figure would be reduced substantially by including forestry incentive program (FIP) cost-sharing payments in the analysis.

Under this alternative, property taxes and management expenses are the only annual costs, both of which are partly recoverable through deductions on the landowner's federal income tax return. Expenditures for timber stand improvement can be deducted as an operating expense or capitalized and eventually subtracted from gross receipts received at harvest for tax purposes (USDA, 1975).

Alternative 7. Sawlogs, Unmanaged

This option is similar to the previous one except that it is a management strategy more oriented toward the present than the future with no investment in management practices. Volume and allowable cut calculations are the same as under Alternative 6, and all costs are the same except that there is no timber stand improvement expense incurred. Consequently, the harvestable volume is assumed to decline over time to reflect the deterioration of the resource base (3000 bd ft/acre; 2500 bd ft/acre; 2000 bd ft/acre; and 1500 bd ft/acre respectively for the first, second, third, and fourth timber sales). Stumpage prices are assumed to remain constant at \$88/M bd ft for all sales.

Alternative 8. Sawlogs and Fuelwood

Under this management strategy, sawtimber is harvested as above described on a ten-year cutting cycle basis. Annual growth and stumpage prices are 300 bd ft/acre and \$88/M bd ft respectively. It is assumed that in the years after a timber sale fuelwood would be cut from the tops and unmerchantable parts of trees cut in the previous year's harvest and from material removed in conjunction with timber stand improvement. These two sources should yield five cords of firewood per acre every ten years for a delivered price of \$100/cord. This strategy would provide flexibility by making it possible to alter the product mix to suit market conditions at the time of harvest.

All volume estimates are as previously stated except for the volume of fuelwood removed after each timber harvest. This estimate (five cords per acre every ten years) is conservative; more fuelwood might be harvested depending on the quality of the sawtimber present.

A rotation age of 67 years was determined as before by using Duerr's financial maturity model, but since the initial stand was assumed to be 60 years old, no material will be removed until the seventh year of the analysis period. There are no expenses for timber stand improvement under this alternative, but these treatments (i.e., crop tree release and species selection) are assumed to be carried out by harvesting firewood.

RESULTS

Costs and revenues for each alternative were used to develop cash flows. The cash flows were then analyzed, using NC Return, to develop IRR, PNW, and B/C for each alternative.

Table 1 shows the number of years it takes for the sum of the revenues to be greater than the sum of the costs (i.e., payback period) for each of the alternatives analyzed. Table 2 ranks the alternatives analyzed by descending IRR, PNW, and B/C. Figure 1 shows a graph of the annual cash balance or undiscounted cash flow for each alternative.

DISCUSSION

When evaluating these alternatives, it is important to remember that IRR, PNW, and B/C are not necessarily indicators of the same thing. Each of these criteria have unique biases, and an alternative that looks good in terms of one criterion may not appear as attractive when evaluated on the basis of another.

As a general rule, PNW analysis tends to favor large expensive projects over smaller ones, but this may be a more important criterion to the individual concerned with building equity. On the other hand, B/C tends to favor smaller projects with a more immediate payoff. For an investor with many investment possibilities, IRR frequently is the most important criterion for efficiently

Table 1. Number of years before the sum of the revenues is greater than the sum of the costs based on an undiscounted cash flow analysis of the alternative

ALTERNATIVE	PAYBACK PERIOD
1. Row crops: corn, oats, and hay	8
2. Row crops: corn and soybeans	5
3. Pasture	15
4. Christmas trees	7
5. Fuelwood	3
6. Sawlogs	8
7. Sawlogs, unmanaged	8
8. Sawlogs and fuelwood	8

Table 2. Ranking of alternatives by IRR, PNW, and B/C

IRR		PNW (5% discount rate)		B/C (5% discount rate)	
Sawlogs and fuelwood mgt.	68.64%	Christmas trees	\$7714.85	Sawlogs, Unmanaged	3.846
Sawlogs, Unmanaged	63.91%	Row Crops: Corn and Soybeans	\$1348.27	Sawlogs	3.426
Sawlogs	62.22%	Row Crops: Corn oats, and meadow	\$ 616 .24	Christmas trees	2.998
Fuelwood mgt.	42.45%	Fuelwood mgt.	\$ 573.54	Sawlogs and fuelwood mgt.	1.732
Christmas trees	34.37%	Sawlogs and fuelwood mgt.	\$ 493.92	Row Crops: Corn and Soybeans	1.436
Row Crops: Corn and Soybeans	28.05%	Sawlogs	\$ 295.22	Fuelwood mgt.	1.302
Row Crops: Corn, oats and meadow	15.73%	Sawlogs, Unmanaged	\$ 260.83	Row Crops: Corn, oats, and meadow	1.210
Pasture	6.33%	Pasture	\$ 96.79	Pasture	1.117

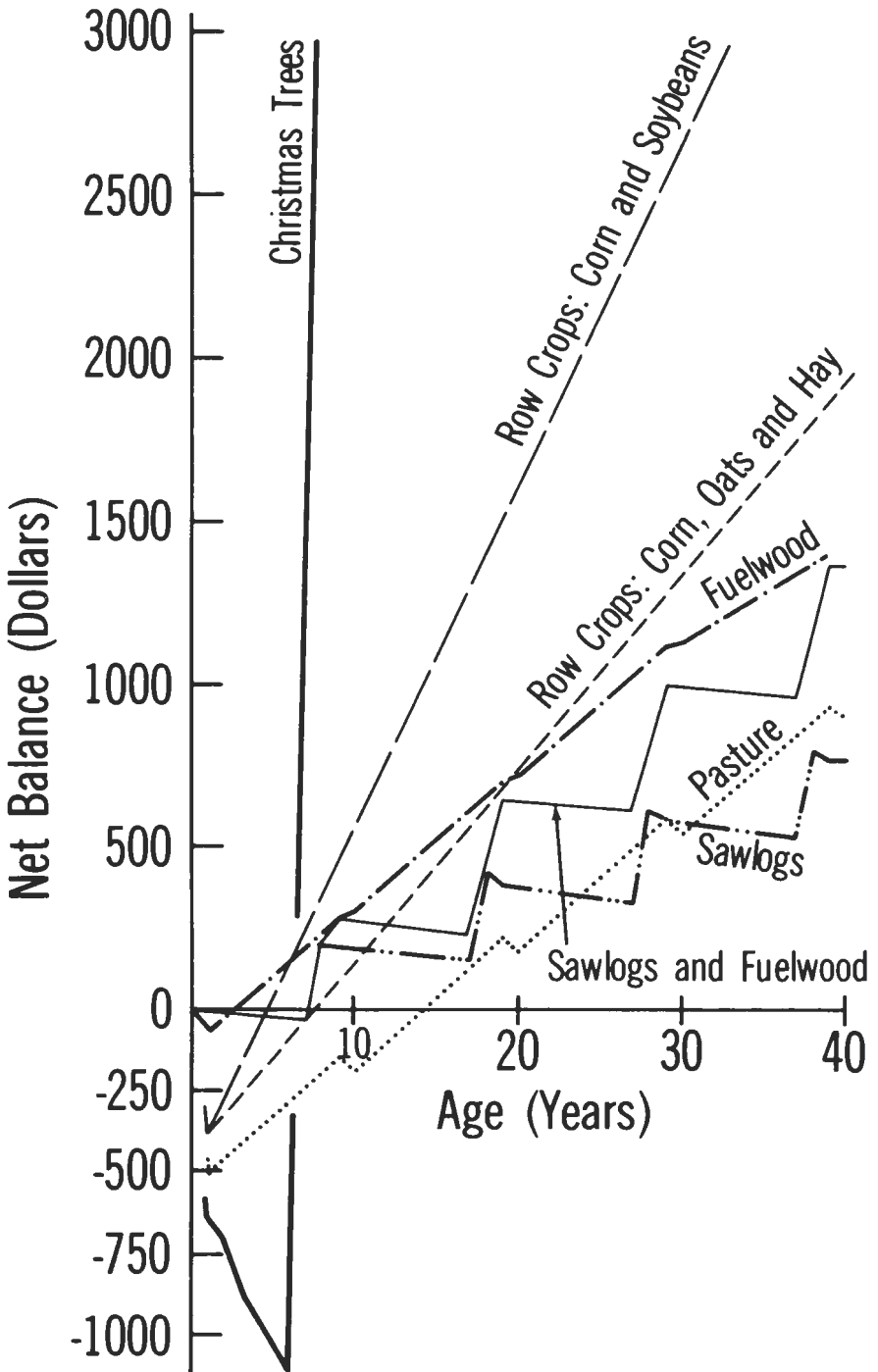


Figure 1. Undiscounted cash flow

distributing investment funds among various investment opportunities. However, the wise investor will consider all three and base any judgment on some combination of them.

In some situations (e.g., a young farmer first starting out, or one who is carrying a large debt load), cash flow is the single most important criterion considered in the decision process. Also, the investment opportunities and the constraints of factors such as availability of time and labor will vary from farm to farm.

All alternatives analyzed yielded positive economic returns, but some were obviously superior (Table 2.) The best five alternatives by IRR criterion are the forestry alternatives. The best four alternatives by B/C criterion are forestry alternatives. The best alternative by PNW criterion is a forestry alternative with the sawlogs and fuelwood, and fuelwood alternatives ranking reasonably well (Table 2). Including the effects of income taxes in the analysis would have made the forestry alternatives even more attractive because of the favorable capital gains treatment that timber income would have received.

Pasture is the worst alternative by all three criteria, yet it is one commonly selected by Iowa landowners. Even selling fuelwood or sawlogs before clearing would not have made pasture a better option than managing the timber stand for fuelwood production.

Even though many acres of forested land in Iowa have been converted to agricultural uses and this practice generates positive economic returns, it is not necessarily the optimal course of action by economic criteria. Additionally, this may not be the most efficient use of available investment capital. Clearly, there is an economic rationale for managing existing forest stands in Iowa for production of sawlogs and/or fuelwood.

Although the results of this study are compelling, it is important to remember that the figures will change with local market conditions. The point is, however, that this framework can be used by state and consulting foresters to provide specific and detailed economic information to private woodland owners.

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CHARLES E. BESSEY: BOTANIST, EDUCATOR, AND PROTAGONIST

Clarence T. Mertins and Duane Isely¹

ABSTRACT. Charles E. Bessey was Professor of Botany at Iowa State College, 1870-1884, and at the University of Nebraska, 1884-1915. A man of many roles, he was probably the most influential nineteenth-century botanist west of the Mississippi. He pioneered botany laboratory instruction, including use of the microscope. His textbooks broadened the scope of classroom botany beyond that of gross morphology and classification. Though a teacher rather than a leading research scholar, he proposed a phylogenetic classification of flowering plants that is the basis of modern interpretations. He was an evangelizer of a scientific agriculture based on research and was one of the proponents and authors of the Hatch Act of 1887, which established the federally funded agricultural experiment stations. He was an active proponent of improvements in secondary education. As an administrator at both Iowa State and Nebraska, he was influential in the development of the land-grant colleges as educational institutions.

Additional index entries: microscope, history of botany, history of agriculture.

INTRODUCTION

In certain ways, Charles E. Bessey was the most important American botanist during the latter part of the nineteenth century. No definitive biography of him presently exists. The only published primary-source research that has been conducted relates primarily to Bessey's roles in conservation and agriculture (Walsh, 1972b; Overfield, 1975). Accessible secondary-source published information is largely limited to postmortem eponymy (e.g., Pool, 1915), minor historical articles or accountings that refer to some of the activities in which Bessey was prominent (e.g., E. A. Bessey, 1935; Pool, 1935), and his listing in various scientific biographical encyclopedias. There is no significant summary of Bessey in his major role as a botanist in the broadest sense.

THE MERTINS MANUSCRIPT

In 1978-1979, C. H. Mertins, a botanist, undertook, as a "creative component" for a non-thesis Master's degree at Iowa State University, the preparation of a broad summary of Bessey's life and work derived from archival material in the libraries at Iowa State University and the University of Nebraska as well as the secondary sources. The time available for this endeavor

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did not allow extensive archival research so that Mertins' (1979) manuscript is in large part drawn from miscellaneous secondary sources. It is necessary then to regard his effort as a reasonably definitive essay about Bessey rather than the product of prolonged historical research. Nevertheless, because it is of broader context than any published material about Bessey, it deserves better than manuscript anonymity.

The content of the following is a rewritten summary derived from the Mertins manuscript with the exception of the "Abstract," this "Introduction," "The Botanical Scene, 1870," which immediately follows, and the last section of the paper, "Bessey in Publication," which have been prepared by Isely. One must turn to the Mertins manuscript (1979), available in the library of Iowa State University, for a detailed textual literature citation which is omitted in this revision in the interest of brevity. The "Literature Cited" herein consists mostly of papers cited by Isely that are not listed by Mertins.

The Mertins manuscript also contains several useful lists relating to Bessey. The first is a "Partial bibliography of materials concerning Charles E. Bessey." The second is a list of books written by Bessey. The third list contains "Published articles and notes of Charles E. Bessey." This, including about five hundred titles, is reasonably complete except that it does not include Bessey's allegedly numerous newspaper articles. The fourth is a list of "Unpublished letters, memoranda, manuscripts, and articles written by Charles E. Bessey." This enumeration is based on materials in the Archives of the Library at the University of Nebraska. The fifth is a "Bibliography of the published reviews of Charles E. Bessey of other published materials." This list, mostly of book reviews, contains over 600 titles. And the last is a bibliography of unsigned botanical notes, reviews and short articles that appeared in the *American Naturalist* and in *Science*, while Bessey was botany editor of these journals. Indirect evidence indicates that most of these were probably by Bessey, but this is not definitely established.

ARCHIVAL RESOURCES

The Library at the University of Nebraska possesses an extensive collection of Bessey's professional correspondence and other papers. These were exploited in part by Walsh (1972a, 1972b) and Overfield (1975) whose research, however, was limited to specific aspects of Bessey's professional activity. The material in the Iowa State University Library is more limited than that at Nebraska. Personal correspondence presumably still exists in the custody of Bessey's descendants, which to date has not been available for historical research (Mertins, pers. comm. 1981).

THE BOTANICAL SCENE

Bessey entered professional life at the time of a revolution in biology. It was then in the throes of emergence from the descriptive-classification-exploratory themes, with which it had been primarily concerned the preceding 200 years, towards the experimental; it was changing from philosophical to observational and from qualitative to quantitative. Chemistry, having developed beyond early adolescence, had opened the way for more precise studies in physiology than previously had been possible. The compound microscope,

though in existence for over 200 years, was only now being used to investigate the details of animal and plant structure, their development, reproduction, and life histories. The details of cell structure and function, including especially the intricacies of mitosis and meiosis were being unravelled. Above all, the mushroom cloud of Darwinian evolution was spreading about the world, its radiation permeating theoretical and argumentative discussion. It must be remembered, however, that the fruits of the science of genetics did not enter biological thinking and research until the twentieth century. While the center of botanical activity was still in Europe, it had partially diffused to the eastern institutions in the United States, but scarcely as yet to the hinterlands.

Nineteenth-century botany in the United States has been categorized by Ewan (1969) to include the Torrey and Gray epoch (1820-1860) and the Graduate Laboratory epoch (1860-1913). Another definition would be simply to call the years 1840-1880 as the Asa Gray epoch, for Gray, the foremost pioneer botanist of the New World and who dominated American botany as no one before or since, was primarily of the "old school," a nineteenth-century taxonomist. It is true that the "Graduate Laboratory" had its inception while Gray was still alive, but he and his botany remained preeminent until he passed from the scene.

Thus when Bessey started his professional life at Iowa State College, scholarly botany consisted primarily of the writing of manuals for identifying plants and the endless description of new species to go into the next editions. Textbooks supplied the educational background necessary to cope with such manuals; that is, how "to know" plants or be able to identify them. There was minimal treatment of "vegetable physiology." Botanical education in the United States was either primarily for the medical profession or for the genteel or the genteel; it was a world of its own with little relationship to the applied plant sciences of agriculture and horticulture.

Bessey had much to do with the revolution in American botany that would change the way botany was practiced.

ORIGIN AND INCUBATION

Charles Edwin Bessey was born May 21, 1845 in a log cabin home on his parent's farm near Wooster, Ohio. His early education was under direction of his parents, who apparently were responsible for his early interest in nature and agriculture. Formal education was interrupted by his father's ill health and death. The next few years included sporadic country school attendance, abortive attempts to prepare for college, and school teaching. In 1865 he moved to Michigan and worked as a surveyor, timber cruiser, and school teacher. He entered Michigan State Agriculture College in 1866. After initial enrollment in Civil Engineering, he changed to plant science, through the influence of Prentiss, Professor of Botany and Horticulture.²

² Conferences about this proposed change included President Abbot who, upon hearing of Bessey's decision, reportedly said, "Well, Bessey, I am glad of it, but you'll never be rich." The prediction proved more than usually true, even for a botanist, because when Bessey died in 1915 he was essentially penniless. The establishment of a fund, through action of some of Bessey's friends and the Nebraska legislature, was necessary to provide his surviving wife with a livelihood.

Bessey graduated from Michigan State with a Bachelor of Science degree in Botany and Horticulture in 1869, and this was essentially the end of his structured education. He subsequently accepted a fellowship (presumably for graduate work) and a position in the new college greenhouse. This arrangement was short-lived, for he was almost immediately offered a position as an instructor at the recently opened Iowa State College and came to that institution in February 1870 to begin the academic year.

Bessey was awarded the Master of Science degree from Michigan State in 1872. Because he had not been in residence at Michigan State 1870-1872, some arrangement crediting him for his work at Iowa State was evidently the basis of this degree. After he received this M.S., he was promoted to Professor of Botany, Horticulture, and Zoology at Iowa State.

Bessey had begun corresponding with Asa Gray, the reigning monarch of American botany, in the latter 1860s, and Gray had invited him to come to Harvard to study. Although Bessey accepted these invitations for the three month winter vacation periods in 1872-73 and again in 1875-76, he did not proceed in graduate study at Harvard. These early contacts with Gray (which continued until the latter's death), however, certainly provided Bessey with a view of the broader horizons of botany as they existed, both in the eastern schools in this country and in Europe.

His doctoral degrees were honorary: the Ph.D. from the University of Iowa in 1879 and the L.L.D. from Iowa College (presently Grinnell College) in 1898.

CHARLES E. BESSEY: THE MAN

Charles Bessey married Lucy Athearn on December 25, 1873. They had three sons. One of them, Ernst A. Bessey, followed his father's footsteps in botany and became one of the better known mycologists of the first half of this century.

Beyond these bare statements, there is presently little public information about the activities, joys, and tribulations of his personal life. The scope of his professional hyperactivity suggests that he was a slave of his institutional duties and his self-assigned roles as a man of "causes" so that his life was largely that of the public forum with the home providing but a secondary background.

Bessey's public postures, of course, shed some light on his personal attributes. The following example could probably be supplemented by archival search.

In 1877 at Iowa State, following a statement by President Welch's wife that dancing "was a harmless and desirable amusement," Bessey presented a resolution to the faculty, in part, as follows: "Whereas dancing is entirely foreign to the purposes of this institution and calculated to produce and promote an excitement which is injurious to the progress of the student . . . therefore be it resolved that it be forbidden. . . ." One might pass this statement as one entirely in tune with the times, but since the resolution was rejected by the faculty by a vote of eleven to three, Bessey seems to have been part of a reactionary minority. Alternatively, it may be suggested that Bessey better represented the conservative views of Iowa State's constituency than did his colleagues because in 1882 "the Board" ordered that "dancing by students on the College grounds is hereby forbidden" (Ross, 1942).

Bessey was a Congregationalist. He found no incompatibility between his religious beliefs and Darwinian evolution. His church ties, however, probably were not strong; otherwise they would have surfaced among his omnivorous extraprofessional promotional activities.

In personal appearance, Bessey has been reported as being a broad-shouldered, short (about 5 feet 6 inches), stocky man who weighed approximately 160 pounds. The few standard photographs of him are but stereotypes of the bearded nineteenth-century scientist and give no suggestion of personality. But, personality there was, at least professional personality. According to tradition, he was enthusiastic about everything and tirelessly committed to his work with a spontaneous self-forgetful devotion. An incessant talker with a heavy, round, cheery voice, he was ready to lecture on botanical or other subjects anywhere without reference to time or place. He was evidently a man who knew something about many things and who had an evident capacity for leadership. This conclusion is supported by the fact that he rapidly became president of nearly every organization with which he was affiliated from the local Phi Beta Kappa chapter to the national American Association for the Advancement of Science (AAAS). Bessey's philosophy of existence is perhaps summarized in one sentence of a charge that he gave the Nebraska graduating class in 1900: "You are to be, in a certain way, missionaries, whatever profession you may follow."

CAREER SUMMARY

Iowa State

Bessey arrived in Ames, Iowa on a "raw, wind-swept day," in February 1870, where he was immediately welcomed by President Welch. The president not only accommodated him in his home but spent considerable time acquainting him with the structure and operation of the college. At the first faculty meeting of the academic year, Bessey was named secretary of the faculty, a post he held for three years. Perhaps there was a planned relationship between these events. This initial and considerable responsibility (the faculty usually met once a week), however, gave Bessey an understanding of college metabolism that was to serve him usefully in administrative duties that followed him to the end of his career.

At Iowa State, Bessey was one of the first American botanists actually trained in botany and agriculture, his predecessors (as Asa Gray) mostly being fugitives from the medical profession. Apparently he was also the first professor of botany west of the Mississippi. His initial assignments, however, included botany, horticulture, zoology, entomology, comparative anatomy and human physiology. Later Bessey reflected that he had perhaps occupied an elongated settee rather than a chair.

Bessey promptly introduced teaching innovations. By 1873, there was a scheduled laboratory course in botany which included the use of the microscope. It was probably the first such undergraduate course in the country. Bessey also pioneered in graduate teaching. The master's degree of J. C. Arthur (later a major mycologist) was the first at Iowa State, and the subject of his thesis, a microscopic study of *Echinocystis lobata* (Wild Cucumber), was possibly the first investigation of this kind in the United States (Arthur, 1878, 1981).

Bessey supervised the laying out of walks and drives and the initial planting of trees and shrubs on the Iowa State campus. He collected plants first around Ames and then over the entire state, established the Iowa State Herbarium, and prepared the first checklist of the plants of Iowa. He was in charge of the college gardens where he conducted botanical, agricultural, and horticultural research and demonstrations.

Simultaneous with these institutional duties, Bessey held several administrative posts, which included a brief term as vice-president of Iowa State College in 1883. Within a year of his appointment at Iowa State, Bessey initiated a pattern of extra-institutional activity that was to continue for the rest of his life—that of activist participation in the scientific, agricultural, and educational communities.

Nebraska

The impetus for Bessey's move to the University of Nebraska was apparently political dissention between Iowa State College and the state government (Ross, 1942). However, in 1884, he rejected the first offer from Nebraska after finding that it lacked even the most rudimentary equipment for teaching botany. He was loath to build again as he had done at Iowa State. Only after a firm affirmation that money to purchase equipment, including microscopes, would be available did he accept the offer by Nebraska. He went to that institution as Dean of the Industrial College. During his career there he occupied this and other administrative posts (including that of acting chancellor) in addition to his teaching and self-assumed duties. His teaching load was well-nigh unbelievable. Evidently a charismatic teacher, he drew more and more students as the years went by so that in 1894 there were some 600 students taking botany courses, while Bessey was still the only fulltime instructor in the department. He received some relief in 1895 when Frederick Clements,³ one of his graduate students, was appointed laboratory assistant. In 1898, Bessey and Clements are said to have supervised some 8,000 hours of student work in 18 different courses.

Beyond his institutional responsibilities, Bessey continued his role as a scientific, educational, and agricultural protagonist by incessantly publishing both popular and professional articles in all of these fields. The nature of his interest in secondary education, for example, is suggested by his opening of the botany laboratories for two weeks in the summer of 1889 for the teachers in the Nebraska public schools. This was the informal beginning of summer sessions at the University of Nebraska. Bessey was also hyperactive in professional societies, as a botanical editor, and as the author of botany textbooks.

TEACHING: THE BOTANICAL LABORATORY AND MICROSCOPES

In the United States, Bessey possibly had more influence on the teaching of botany than anyone else of his era. He introduced the laboratory idea, complete with microscopes, and he probably taught botany to more students during the period 1880-1910 than anyone else in the country. And, in time he succeeded Asa Gray as the author of standard introductory textbooks in botany.

³The Clements of subsequent Clementsian ecology.



The Young Bessey
Undated, probably 1870s



Bessey, the elder statesman
1913



The early botany laboratory, Iowa State College, approximately 1890. Bessey was no longer at Iowa State when this picture was taken, but the scenerio is probably about the same as he left it.

Classically, botany in the educational system was restricted primarily to training for the medical profession. It faded from the medical curriculum after the middle of the nineteenth century following the emergence of the germ theory of disease and the development of bacteriology. In the middle nineteenth century, botany was an innocent subject for genteel and idle young ladies. It was one which could be added to their "accomplishments" along with needlework, elementary piano playing, and framing pictures with shell work. Most instruction was from *Gray's First Lessons in Botany* (1842a seq.), or his botanical textbook (Gray, 1842b seq.), or less worthy texts. Following assignments, the professor asked questions and the student responded. Those who memorized most accurately were considered the best students. Some adventurous professors, however, asked students to bring representative material for the lesson at hand, or even themselves brought specimens of plants into the classroom. Three-legged brass dissecting magnifiers were sometimes used for analysis of material. Compound microscopes, though widely used in Europe, were either non-existent or reserved for the use of the professor. Michigan State was one of the institutions that owned a microscope, and it was locked up away from the students. Bessey eventually persuaded Professor Prentiss to let him study the instrument and to use it to examine plant material.

The germs of Bessey's ideas about laboratory botany, probably were derived from several sources: his reading of European journals, his experiences in teaching about nature at Liberty Mills, Michigan while attending Michigan State, and certainly his use of the microscope at Michigan State. Botany, he believed, should be taught as a laboratory course, and the microscope should be available so the students could see for themselves the wonders of plant development and structure.

Iowa State owned no microscopes when Bessey arrived. He obtained a student microscope the year after his arrival, and this purchase was followed by that of an imported Beck (said then to be the most expensive piece of equipment owned by the University). By 1876 the botany department had acquired seven compound microscopes, and by 1883 there were 21 triple-objectives as well as two of the high quality Beck binoculars.

Bessey's initial teaching of botany included some opportunity for laboratory observation, and Ewan (1969) credits the beginning of Bessey's laboratory instruction to 1871. By 1873, lecture-laboratory instruction procedure was formalized in that lecture-question sessions were held in one room and the "botanical laboratory" was in another. In the laboratory were tables, a single microscope, reagents, and specimen materials. Each student was allotted a specific time for examining material, making drawings, and taking notes. Although the professor was available to answer questions, the student's work was largely that of individual study.

It has been stated that Bessey was the founder of laboratory teaching in botany in the United States, but the idea was also in the minds of others. Laboratory study at Harvard probably predated Bessey, but this evidently was for graduate students and was not a part of regular instruction for undergraduates until the middle 1870s. There were pioneer laboratory adventures at the University of Michigan, Illinois Industrial University (now the University of Illinois), and probably at other institutions. A review of catalog offerings of other colleges and universities, however, suggests that Bessey's laboratory instruction of 1873 was the first regularly scheduled, undergraduate student study of botanical material in the United States.

A related first for the Bessey laboratory was that of the microscopic study of fungi and other cryptogamic organisms and their relationship to plant diseases. The American pioneer in cryptogamic botany in the United States was, of course, Farlow at Harvard, but his first course was offered in 1875-76.

In any event, there is no doubt that Bessey was the Midwest's authority on the laboratory teaching of botany and that he was a vigorous exponent of his views of its importance. He stated in response to an inquiry from Dr. Beal from Michigan State, "A botanical laboratory is just as necessary for the proper teaching of botany as is a chemical laboratory for chemistry." In order to teach properly a summer botany course at the University of Minnesota in 1881, he took several Iowa State microscopes with him. The first edition of his textbook, published in 1880, includes laboratory exercises to supplement the text.

There is a general concurrence that while there may have been greater botanists than Bessey, he had no peer as a teacher in the latter nineteenth century. Believing that teaching was the "divine commission of service," he obviously put it ahead of research. He preferred to lecture to large classes of beginning students rather than to small classes of advanced students or graduates. Enthusiasm, even boyish enthusiasm, was the keynote rather than vast research knowledge, and he once stated "without enthusiasm the most learned man is well nigh powerless." The size of his introductory botany classes both at Iowa State and Nebraska probably considerably exceeded that in any other institution. Tradition credits him with the initiation of the training of more career botanists than any other teacher before his time or since. His approach was broader than botany because for him botany was the means of a kindling of a flame for life. He felt that no one could hope to master all of the available facts, but he could and should be taught to properly handle information. He opposed specialization.

BEYOND THE CLASSROOM

Administration

As seen in the foregoing summary of Bessey's career, he assumed several administrative posts, some briefly held, some evidently longstanding, at both Iowa State and the University of Nebraska. The fact that these assignments included the vice-presidency and acting presidency at these schools speaks for itself concerning his institutional status. We have no information about the proportion of Bessey's time that was consumed in these responsibilities, but it may be imagined that the role of chief executive officer required much of his energy for the intervals concerned.

Agriculture⁴

Until a hundred years ago, botany and agriculture had little to do with one another. The kind of botany taught had little to offer agriculture. The

⁴ The reader who desires a detailed review of Bessey's impact on American agriculture should turn to Overfield (1975) and Walsh (1972a).

latter, a world of its own, was a practice passed from father to son and had few roots in formal education. Its first substantive entrance into the educational system was in the "schools for the people" (the land grant institutions) in the United States. Working at two of such institutions, Bessey was a major figure catalyzing a link between botany and agriculture.

For Bessey, botany was indeed a science of intellectual beauty, and through agriculture it could also help provide the needs of the people. Having been born and reared on a farm and educated at Michigan State, Bessey had no problems identifying with the agrarians and their problems and needs. Thus in his botanical teaching he developed a role for applied botany in the land grant institutions. Almost immediately after his employment at Iowa State College, he initiated agricultural research and strove to stimulate it elsewhere. In addition he worked to facilitate the dissemination of plant science information useful to agriculture. For example, in the college garden he experimented with the use of manure to increase crop yields and the results of this work were included in the college's initial recommendations to farmers. He tested the usefulness of many (over 100) varieties of vegetable crops under Iowa conditions. He reported on insect pests of these plants and suggested methods of control. He wrote numerous semi-scientific and popular articles about plant diseases that were among the first prepared in the United States by a professional botanist. Soon he was writing about weeds and, after going to Nebraska, about problems relating to range management.

Bessey was an organization man. In the winter of 1870-71 he took part in Iowa's first Farm Institute held at Nevada, Iowa. Possibly this was the first meeting of this kind in the United States. In 1875, he was elected President of the Institute and was re-elected for several terms. This and the subsequently emerging institutes were agricultural organizations of farmers, college instructors, and other interested individuals who banded together to share information for the improvement of agriculture. These meetings, evidently combined some features of the agricultural extension service, which, however, did not come into existence until the Smith-Lever Act in 1914.

In short, Bessey rapidly extended himself beyond the Iowa State campus to the state and to some extent the nation. In 1874-75, the University of California at Berkeley invited Bessey to give lectures in agricultural botany. He became the center of an information network which included the students, farmers, fruit growers, teachers, and the members of agricultural and horticultural societies. He combined information derived from his scientific reading with that acquired through practical experimentation of his own and with that of the various agricultural organizations among which he circulated. In addition he acquired numerous correspondents whose field observations helped supplement his knowledge. Then through letter-writing, newspapers, and popular articles in agricultural journals, he disseminated this knowledge coupled with his own "how to do it" interpretations.

This activity continued, with only a change of scenes, following his move to Nebraska. With the help of Governor Furnas of that state, farmers' institutes were organized, and Bessey traveled to all parts of the state to speak at their meetings. He joined the state horticultural association and was its consulting botanist for many years. In 1880 a few other agricultural scientists and he established a Society for the Promotion of Agricultural Sciences (SPAS). The group, by intent limited to a small number of individuals, was specifically

concerned with the application of science to agriculture and the promotion of a respectable curriculum of agricultural training.

Perhaps most significantly at the national level, beginning in 1882, Bessey helped draft and promote legislation for the establishment of federally funded experiment stations at each of the land grant institutions. These efforts resulted in 1887 in the passage of the Hatch Act which provided the initial fiscal support for the agricultural experiment stations. Bessey became director of the Nebraska station and presided over its early growth.

Throughout his life a considerable portion of Bessey's publications related directly or indirectly to agriculture. The greatest number perhaps were about plant diseases. But he also wrote about weeds, the relationship of vegetation to stock production, and special topics such as "The demands made by agriculture upon the science of botany" and "The education of the farm boy." Most of these articles were short and of limited scientific significance. They were instead pioneer efforts in agricultural extension-type writing; based on knowledge that was immediately available, they made a pathway for more to come. Regarding this activity, Walsh (1972b) paid tribute to Bessey in the following vein: "The land-grant schools are a bridge between the intellectual community and the common man. It is incumbent, therefore, that land-grant faculty be committed to both academic excellence and altruistic public service . . . Charles Bessey is the epitome of the land-grant professor." This, of course, is a statement of Bessey's idealism rather than one of reality among the preponderance of land-grant institution professors. Rather than an epitome (a part which represents typically a whole), Bessey was more nearly a unique land-grant professor.

In the Service of Botany and Science

In science Bessey's promotional-evangelical nature found opportunity for expression primarily in two channels: his role as an editor and as a member and officer of scientific societies. He became botanical editor for the *American Naturalist* in 1881, changing to a similar role for *Science* in 1897, which he maintained until his death. He made the most of his editorial prerogatives. He wrote hundreds of book reviews. Being an exponent of the "new botany," one that went beyond collection and observation to experimentation, he urged botanists to find ways to improve the quality of botanical teaching, study, and research and to achieve academic standards equivalent to those in Europe. He was concerned about the attendance of botanists at professional meetings and the quality of the papers they presented.

He was a prodigal organization man. At the state level he was one of the founders of the Iowa Academy of Science and subsequently the Nebraska Academy of Science. In 1889, he became president of the Western Society of Naturalists, and in 1902, president of the American Microscopical Society. He was a charter member of the Botanical Society of America and its third president (1897). In the nascent American Association for the Advancement of Science, he sought for the professional identity of the botanists as a group. This initially took the form of the "Botany Club" of the AAAS, followed by the formal organization of Section G, the Botanical Section. Bessey was elected chairman of this section in 1883 and four more times in subsequent years. He was elected president of the AAAS in 1911, the first botanist west of the Atlantic Seaboard to receive this honor.

Activist for Anybody and Everybody

The fields in which Bessey had major impact have been noted above. But, his flair for involvement led him also into diverse peripheral activities.

Bessey was an early conservationist (Walsh, 1972b). He agonized over the destruction of the national forests. He became a member of the AAAS committee which concentrated its efforts in conservation of the Yellowstone Reserve in Wyoming. He was involved in the establishment of the Nebraska State Park and Forest Commission. In 1902 he was elected to the Board of Managers of the newly formed Wildflower Preservation Society of America and was active in an early movement (at that time unsuccessful) to save the *Sequoiadendron* groves in California.

In a completely different arena, Bessey was concerned with the quality of teaching in the public schools and the preparation of students coming to college. In Iowa, he was active in the Iowa State Teacher's Association. Among his papers is one presenting guidelines for curriculum changes in public schools. In Nebraska, as previously mentioned, he opened his botanical laboratories to schoolteachers in the summer. In 1908, he joined with a small group of school superintendents and other educators in chartering the Nebraska School's Masters Club. The objective of this group was to promote the intelligent discussion, independent of the pressures of politics, of major problems in education and to serve as a forum for innovative proposals. At the national level he was involved as a member of National Education Association, of which, in 1895, he was president of the Science Department and the following year vice-president for the entire organization. And, to round an even dozen, Bessey was a member of the Nebraska Art Association.

BESSEY IN PUBLICATION

The name "Bessey" is known to any present day plant taxonomist and to most reasonably educated botanists. This is not, however, because of the frenetic life that Bessey led. Neither was it because of his writing relating to these activities, nor his innumerable miscellaneous botanical publications. Despite all of these pioneering accomplishments, Bessey today would probably be little more than an archival figure of local interest to the institutions he formerly served and perhaps to historians of the endeavors in which he participated. Indeed, his name does not even appear in the multivolume *Taxonomic Literature* of Stafleu and Cowan (1976). Perhaps sadly, the facts give strength to the Shakespearean truism that "The evil men do lives after them. The good is oft interred with their bones" (*Julius Caesar* III.ii), because, seemingly, Bessey did no evil in support of his remembrance. Instead his scientific immortality is based almost entirely on his thinking in one area and largely there on a single publication, "The phylogenetic taxonomy of flowering plants" (Bessey, 1915)—the existence of which is almost an anomaly in his publication record and his career activities.

The Bessey Bibliography⁵

The Bessey bibliography compiled by Mertains (1979) contains approximately 500 titles and includes those papers and books accessible to routine bibliographical search. It does not include the innumerable newspaper releases Bessey allegedly prepared, an assembly which would require extensive effort. The Bessey book reviews, numbering upwards of 600, would present a kaleidoscopic view of the progress of botany as seen by their author during the several decades of his professional activity. It is alleged that many unsigned short notices in the *American Naturalist* and in *Science* during the years of his botanical editorship came from Bessey's pen. This is likely true, but judgment yet requires careful critical review.

Bessey's publications largely include: (1) short scientific articles and popular papers, and (2) botany textbooks. Study of the titles of the former leads to an impression of a man with a prolific pen but not necessarily that of an important scientist. It supports the view that Bessey's publishing impact was that of a critic and a stimulating influence rather than that of a first rate research scholar. These papers cover most aspects of his wide interests, which ranged from botany to agriculture and education. Many are semi-popular extension-type articles. Some concern the then current topics of botanical interest and controversy. The greatest number of botanical papers are notes about the flora of Iowa and Nebraska. It was only during the last 20 years of his career that a few contributions about the principles of plant classification began to appear.

Bessey's textbooks provide their author with more strength in posterity. During the early part of his career the most used and authoritative American texts were those of Asa Gray (e.g., 1842a seq.; 1842b seq.). Gray ultimately became disinclined to continue the chore of continuous revision and in 1878 suggested Bessey's name to the publishers. Bessey accepted the charge. The first edition of his *Botany for High Schools and Colleges* appeared in 1880 (Bessey, 1880 seq.). It went through four editions. *The Essentials of Botany* began its sequence of six editions in 1884 (Bessey, 1884 seq.). These books broke sharply with the tradition of the past (that is, of Gray and other authors) in introducing a much larger component of plant physiology and of cryptogamic botany.⁶ The next 20 years included *Elementary Botanical Exercises for Public Schools and Private Study* (Bessey, 1892), some three elementary

⁵ See also the earlier section, "The Mertins Manuscript," concerning bibliographies assembled by Mertins.

⁶ Ewan (1969) and Overfield (1975; derived from Ewan?) cite the influence of Sachs' multi-editioned *Lehrbuch der Botanik* (1870 seq.) on Bessey's textbook writing. Ewan's statement that Bessey's *Botany for High Schools and Colleges* (1880) "was an adaptation" of the Sachs' book even implies semi-plagiarism. We have not compared the two texts. It is evident, of course, that Bessey was deeply motivated by the thrust and breadth of German botany, for he was constantly urging his American colleagues to achieve the German standard of excellence. No doubt the genesis of many of Bessey's ideas trace to the German literature. However, we doubt the implication of Ewan's assertion. Bessey was too independent an individual to directly "adapt" from anyone else.

books directed towards use in Nebraska, and a co-authored *Elementary Agriculture* (Bessey et al., 1903). The final production of *Essentials of College Botany* was published jointly with his son, Ernst A. Bessey (Bessey and Bessey, 1914). These texts "reoriented botanical instruction" in this country (Ewan, 1969).

The Phylogenetic Classification of Flowering Plants

During the middle and latter years of Bessey's career, the multivolume, multi-authored German compilations *Das Pflanzenfamilien* (Engler and Prantl, 1887-1915) and *Das Pflanzenreich* (Engler et al., 1900-1953) came into existence. The classification of flowering plants was summarized at intervals in successive editions of the *Syllabus der Pflanzenfamilien*, the last one available to Bessey being Engler and Gilg (1913). The authors and editors of these monumental works seemingly regarded the family arrangement in the *Syllabus* as representing a presumptive phylogenetic classification in which, however, ideas of relationship were mixed with those of convenience. But, the *Syllabus* supported by the overwhelming documentation in *Das Pflanzenfamilien*, resulted in its well nigh universal acceptance as *the classification*, which expressed plant relationships. Practically all botanical manuals were arranged in the Engler-Prantl sequence. The arrangement of plant families in herbaria usually was the same as well. The strength of this tradition is indicated by the fact that its use was continued for some time after it was recognized that it was not a natural classification.⁷

Bessey's postulates upended the Engler-Prantl classification. The previous statement that this was essentially accomplished in one publication (Bessey, 1915) is true, but it should be qualified by noting that Bessey's latter publications include a few short papers about plant classification, which indicate that he was thinking about this topic and gradually assembling his data and ideas. Among these preliminary reports, however, only one, presented as an address of the retiring president of the Botanical Society of America (Bessey, 1897), has structured significance. It is likely, were it not for the 1915 capstone, his earlier observations would have sunk into oblivion.

The Besseyan system of classification is a taxonomic landmark not only in the nature of its proposals but in that it and a roughly contemporaneous system of Hallier (1905, 1912) are the first to be explicitly phylogenetic.

The first pages of Bessey (1915) constitute a defense of the use of the deductive method in those areas of science in which direct observation and experimentation are impossible. He follows with an enumeration of principles of classification which, "while generally accepted, have rarely if ever been formulated by taxonomists or others." These principles, 28 in number, given the title of "dicta," are divided into two groups: "General dicta" and those having special reference to the "structure of flowering plants," most specifically to that of flowers. The individual dicta are simply statements as to which of the two alternative conditions are to be considered primitive, e.g., that apetalous flowers are derived from petaloid ones, that hypogyny is the primitive

⁷ To this day, the junior author herein, whose botanical education dates from the 1930s and 40s, is more at home in an Engler-Prantl-derived manual than one in which family sequence follows a modern classification.

condition and epigyny derived, and that perfect flowers precede unisexual ones. Then there follows a brief discussion of the application of these dicta and a proposed diagrammatic phylogenetic tree (or more properly a shrub since it has three main trunks from ground level; it has also been called "Bessey's cactus"). The remainder of the paper is an enumeration of the classes, subclasses, orders, and families of flowering plants in a sequence, to the extent achievable in a linear system, dictated (in his view) by application of the subject dicta.

Our earlier reference to the "upending" of the Engler-Gilg system and sequence was simplistic in the sense that Bessey changed the older system in many ways. But "upending" remains a satisfactory verb. This is because the Engler-Gilg sequence starts with simple flowers and moves towards greater complexity in terms both of the number of kinds of parts and the number of each. The basic primitive group is the Amentiferae, the catkin-bearing trees (oaks, birches, willows, poplars, hickories, walnuts, alders, etc.), which have unisexual flowers which completely lack a perianth or which possess sepals only. The Besseyan system on the other hand regards the basic flower as a complete one with numerous free sepals, petals, stamens, and pistils all spirally arranged: that is, the strobiloid flower. It asserts that evolution has proceeded through changes from a spiral condition to cyclic, from an indefinite number of parts to a reduced and consistent number, and to coalescence and loss of floral members. The primitive order is the Ranales, which includes among woody plants the Magnoliaceae,⁸ and of the commonly herbaceous ones, the buttercup family, the Ranunculaceae. The members of the Amentiferae, according to Bessey, represent several groups of unrelated derivative types which have achieved similarity of floral aspect through parallel evolution. Bessey's view of the flowering plants was indeed a 180 degree rotation from that of Engler-Gilg.

Botanists found the Besseyan system interesting. Many agreed that it probably represented a truer picture of flowering plant relationship than that of Engler. But it stimulated no immediate outburst of excitement or activity. Indeed, except for the continuing interest of a few phyletic specialists, it might have been largely forgotten were it not for the text book *Flowers and Flowering Plants* by Bessey's student, Pool (1929). The frontispiece is a picture of Bessey accompanied by the statement: "Dr. Bessey proposed the outline of classification that is adopted in this book." The book went through two editions and was widely used over a 25 year period in the United States and to some extent elsewhere in the world until the latter 1950s. Teaching botanists and their students who succeeded them became familiar with the Besseyan system through this text.

Bessey thus was not forgotten, and his work became a focus for increasing interest in the classification of the flowering plants in the 1960s. Among several modern proposals about plant classification, those of Cronquist (1968, 1981), Takhtajan (1969), and Thorne (1976) are perhaps the best known. They are all plainly derived from Bessey: indeed, almost all of Bessey's dicta are yet regarded as valid except for the one (no. 11) that postulated the precedence of opposite over alternate leaves. Phylogenetic

⁸As to Bessey; the Magnoliales has since been segregated as a separate order.

arrangements, however, differ considerably from Bessey's "cactus" because much more data are available to present day botanists and because of individualistic interpretations of this information.

The most used current reference, at least in the United States, is Cronquist of 1968. Therein, as in Pool's book, the title page contains a picture of Bessey. The accompanying entry is: "Charles E. Bessey (1845-1915) author of a phylogenetic system and a set of dicta which profoundly influenced subsequent taxonomic thought."⁹

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⁹The more recent Cronquist (1981) is a massive descriptive documentation of the author's system in which his "views on evolutionary trends in the angiosperms . . . have undergone some relatively minor changes."

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ASSOCIATIONS OF GROWTH RATE WITH OTHER
TRAITS IN OATS (*AVENA SATIVA* L.)¹

D. B. Helsel and K. J. Frey²

ABSTRACT. Grain yields may be improved through several physiologically associated traits. Two important contributors to grain yield in oats are harvest index and growth rate. This study elucidates the associations, both genotypic and environmental, that exist between agronomic and physiological traits in oats. Phenotypic, genotypic, and environmental correlations among grain yield, harvest index, bundle weight, straw yield, growth rate and heading date are presented to indicate the feasibility of manipulating these traits in a breeding program. The results indicate that harvest index is genotypically independent of growth rate. Environmental correlations between growth rate and harvest index are negative, indicating that these traits may act compensatorily to make adjustments to minor environmental changes. Grain yield is strongly associated with vegetative development, both genotypically and environmentally. Associations with heading date are minimal; thus, improvement in grain yield or other traits does not necessitate later maturity.

Addition index words: genotypic correlation, environmental correlation, phenotypic correlation, *Avena Sterilis*, harvest index.

INTRODUCTION

Recently, much effort has been given to improving grain yield (GYD) of cereals via physiologically related traits. Numerous researchers have concluded that increased harvest index (HI) plays an important role in improving the GYD of cereal crops (Cannell, 1967; Donald, 1962; Nass, 1973; Rosielle and Frey, 1975a, 1975b; Sapra and Hughes, 1977; Sims, 1963; Singh and Stoskopf, 1971; Syme, 1972; VanDobben, 1962; Vogel et al., 1963). Another trait related to GYD variation is growth rate (GR) (Brinkman and Frey, 1977; Takeda and Frey, 1976, 1977; Takeda et al., 1979).

Grain yield of small grains can be quantified as follows: Grain yield (GYD) = growth rate (GR) x growth duration (GD) x harvest index (HI). In the Corn Belt of the United States, GD for oats (*Avena sativa*, L.) is restricted to 100 to 110 days by high mid-summer temperatures and foliar diseases; HI has been optimized at about 45%; thus, the remaining factor that can be manipulated to increase GYD is GR.

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GR during the first two-thirds of the oat growing season establishes the quantity of vegetative tissue available for photosynthesis and the number of florets that will be differentiated and sustained. Both factors are critical to obtaining high GYD.

GR, however, cannot be considered independently. Its degree of interrelationship with other traits, especially GD and HI, is critical to its manipulation through breeding to attain high yield. In this study, we evaluated the genetic and environmental associations between GR and other traits in populations of segregates from matings among lines and cultivars of oats.

MATERIALS AND METHODS

Genetic Materials

Twelve parental combinations (matings) involving six oat cultivars and five experimental lines were used in this study (Table 1). Parents were of two types with respect to origin: (a) lines containing introgressed *A. sterilis* germplasm (herein designated as *A. sterilis*-derived lines) and (b) *A. sativa* cultivars adapted to the midwestern United States. Some matings consisted of *A. sterilis*-derived lines backcrossed to their *A. sativa* recurrent parents; others were *A. sterilis*-derived lines mated with unrelated *A. sativa* cultivars; and still others involved two *A. sterilis*-derived lines. The parental cultivars were 'CI 8044', 'Clintford' (CI 7463), 'Grundy' (CI 8445), 'Dal' (CI 9159), 'Noble' (CI 9194), and 'Otter' (CI 8304). The experimental lines were derived from backcrosses involving either Clintford, CI 8044, or Grundy as the recurrent parent and *A. sterilis* accessions as donor parents. The five experimental lines had greater GYD than their respective recurrent parents (Frey, 1976). Y28653 came from Grundy*4/CI 9170; CI 9286 and CI 9273 came from Clintford*5/B443 and Clintford*6/B443, respectively; CI 9271 came from Clintford*5/B444; and CI 9277 was from CI 8044*6/B443. B443 and B444 were *A. sterilis* lines from Israel, and the "yield" gene in CI 9170 was intergressed from the *A. sterilis* line CI 8079 (Frey, 1972; Frey and Browning, 1971).

Experimental Method

F₁ seeds of the 12 matings were obtained in fall, 1975, and one F₁ seed from each mating was grown to obtain F₂ seeds. F₂ seeds were spaceplanted in the field, and when mature, F₂ plants from a mating were harvested and threshed individually. Four F₃ plants from each F₂ were spacegrown in a progeny row, and equal quantities of seeds from four F₃ plants were mixed to form an F₂-derived line.

Evaluation experiments, two per mating, were conducted in 1978 in randomized block designs with four replicates each. For each mating, one experiment was sown on a productive Clarion-Webster soil type at the Agronomy Field Research Center near Ames, Iowa, and a second was sown on a Kenyon soil at Nashua, Iowa. The two experiments for a mating contained between 30 and 100 F₂ derived lines, depending upon the mating, plus the parents, each entered several times. The same lines were tested in both experiments for use in evaluating a mating. A plot was a hill sown with 30 seeds, and the plots were spaced 30 cm apart in perpendicular directions. Plots were

Table 1. Parentages for the 12 oat matings, mating type, and numbers of F₂-derived lines and parents/samples tested for each mating.

Mating No.	Parents		Mating Type	No. of entries tested	
	Female	Male		F ₂ -derived lines	Parental lines
D237	CI 9273	Clintford	Backcross	17	23
D238	CI 9273	Grundy	Semibackcross	18	12
D239	CI 9277	CI 8044	Backcross	82	18
D241	CI 9271	Clintford	Backcross	33	27
D242	Y286-53	Grundy	Backcross	82	18
D245	CI 9273	CI 9271	Both <i>A. sterilis</i> -derived	41	19
D246	CI 9277	CI 9271	Both <i>A. sterilis</i> -derived	29	11
D248	CI 9268	CI 9277	Both <i>A. sterilis</i> -derived	82	18
D249	CI 9273	CI 9277	Both <i>A. sterilis</i> -derived	82	18
D250	Dal	CI 9268	Unrelated	48	22
D251	Noble	CI 9268	Unrelated	82	18
D252	Otter	CI 9268	Unrelated	82	18

hand-weeded, and a fungicide, Dithane (active ingredients Zn-Mn ethylene bis-dithiocarbamate) was sprayed on the plants at weekly intervals between anthesis and maturity to control foliar diseases.

Six traits were recorded for plants from each plot. Days to heading (HD), recorded as days after sowing when 50% of the panicles were fully emerged, was recorded only for the plants at Ames. When mature, the plants in a plot were harvested at ground level, dried, and weighed to obtain bundle weight (BWT) (g); subsequently, the bundle of plants was threshed, and grain yield (GYD) (g) was measured. Straw yield (SYD) (g) was computed as BWT-GYD, and harvest index (HI) (%) was calculated as (GYD/BWT) \times 100. Growth rate (GR) (g/da/plot) was calculated as SYD/HD. (The rationale for using HD instead of maturity date to compute GR has been given by Takeda and Frey [1976].) Heading dates were not recorded at Nashua, so the HD values from Ames were randomly assigned on a whole-replicate basis for use with the Nashua SYD values, thereby enabling GR's to be calculated for that experiment.

For purposes of summary, the data from the experiments at Ames and Nashua for a mating were combined for statistical analyses and presentation. All data were subjected to analyses of covariance. Genotypic and environmental variances and covariances were computed for all traits by equating expected variance and covariance components to the appropriate mean squares and cross products. In this type of analysis, environmental parameters are established from the error source of variation. Variance and covariance components were used to compute genotypic and environmental correlations by using the standard formula:

$$\text{Correlation} = \text{Cov}_{xy} / (\text{V}_x \cdot \text{V}_y)^{1/2}$$

where Cov_{xy} equals the covariance and V_x and V_y equal the respective variances for traits x and y .

RESULTS

On the average, *A. sterilis*-derived parents had about 10% greater GYD, BWT, SYD, and GR (Table 2) than *A. sativa* cultivars, but both *A. sterilis*-derived parents and *A. sativa* cultivars had similar averages for HI and HD. For all but one mating, D250, the parents reached anthesis within one to two days of one another. Within each mating, there was significant genotypic variation among F_2 -derived lines for all traits.

To give an overview of the interrelationships among traits, pooled correlations were computed across all 12 matings for each pair of traits. The phenotypic correlations among BWT, SYD, and GR were 0.95 or greater (Table 3), results that were expected because GR was calculated as SYD/HD, and SYD overall constituted 63% of BWT. These values represent cases of correlating a component with the whole. Phenotypic correlations of GYD with GR and SYD (0.59 and 0.58, respectively) underscore the importance of vegetative development on reproductive potential. GYD was significantly associated with HI but not with HD. The moderate phenotypic associations of HI with SYD, BWT, and GR were significantly negative. Generally, the lowest associations were those involving HD.

Table 2. Means for several traits measured on the *A. sterilis*-derived lines and *A. sativa* cultivars used in the 12 oat matings.

Trait	<i>A. sativa</i> cultivars	<i>A. sterilis</i> - derived lines
GYD (q/ha)	27.4**	30.3
HI (%)	37.4	37.0
SYD (q/ha)	51.9**	57.4
BWT (q/ha)	79.1**	87.4
GR (q/da/ha)	0.78**	0.86
HD	66.0	67.0

** Significant at the 1% level.

Table 3. Phenotypic correlations among six traits when pooled across 12 oat matings.

Trait	HI	SYD	BWT	GR	HD
GYD	0.31**	0.58**	0.79**	0.59**	0.04
HI		-0.39**	-0.18**	-0.38**	-0.05
SYD			0.95**	0.99**	0.13**
BWT				0.95**	0.12**
GR					0.06*

* and ** indicate values significantly different from zero at the 5% and 1% levels respectively.

As expected, BWT was highly correlated with GYD, both genotypically and environmentally (Tables 4 and 5). And generally, the genotypic (r_g) and environmental (r_e) correlations for GYD with HI, SYD, and GR also were high and positive. It is especially significant that GR and HI were not correlated genotypically. Further, the r_g 's involving HI with other traits generally were small in magnitude.

Genotypically, HD was negatively correlated with HI and positively with SYD, BWT, and GR. Rosielle and Frey (1975a, 1975b) found that GYD and maturity were significantly and positively associated, which differs from our results. Perhaps the lack of correlation between GYD and HD in our study resulted because the experimental materials had a limited range for HD's.

The r_g 's for GYD with HI and GR were sizable, which indicates that both GR and HI are important components of GYD. Since GR and HI were not correlated genotypically, it should be possible to combine high GR and a desirable HI into a common genotype. The negative r_e 's between HI and GR indicate that these traits reacted compensatorily to adjust to minor environmental variations. Because HI and GR can compensate for each other to adjust to environmental variations and because they are inherited independently, probably the best way to improve GYD via breeding for HI and GR would be with restricted selection; i.e., where one component (HI or GR) is held constant while the other is selected. Because the association of HI with GYD is curvilinear and HI is optimum at about 45%, best progress would be obtained by holding HI nearly constant while GR is increased. The r_g for HD with GR was moderately positive, but the r_e for these traits was virtually zero. Our genotypic correlations involving GR and those reported by Takeda and Frey (1977) for segregates from intraspecific matings and Takeda et al. (1979) for segregates from intraspecific matings of oats correspond closely. That is, r_g 's for GR with HD were moderate; those for GR with BWT, SYD, and GYD were high; and HI was genotypically independent of GR.

DISCUSSION

From our data and other published reports, one can develop a general understanding of how GR influences GYD in oats. Inasmuch as the genotypic association between HD and GR is zero to slightly positive, either increased GR or increased HD or both could give increased SYD. Greater GR could result from: (a) higher photosynthetic rate, (b) lower maintenance respiration, or (c) greater leaf area development.

Several *A. sterilis*-derived lines with greatly increased GYD have been studied in detail, but none showed a greater photosynthetic rate than its respective recurrent parent (unpublished data from D. B. Helsel). Also, other researchers have been unable to demonstrate an association between photosynthetic rates and GYD's for either barley or wheat (Muramota et al., 1965; Evans and Dunstone, 1970; Berdahl et al., 1972). Variability for maintenance respiration rates among small-grain species and genotypes have been difficult to demonstrate (Watson et al., 1963; Cannell, 1967). Thus, if photosynthesis and maintenance respiration rates are similar, greater GR must be due to development of greater leaf area (LA). Indeed, genotypic differences in SYD and GYD of cereals have been attributed to variability in leaf areas by Davidson (1965), Bunting and Drennan (1966), and Cannell (1967). Of course, increased

Table 4. Genotypic correlations among six traits when pooled across 12 oat matings.

Trait	HD	SYD	BWT	GR	HD
GYD	0.60	0.71	0.88	0.73	0.15
HI		-0.03	0.21	-0.02	-0.32
SYD			0.96	0.92	0.48
BWT				0.93	0.43
GR					0.35

Table 5. Environmental correlations among six traits when pooled across 12 oat matings.

Trait	HI	SYD	BWT	GR	HD
GYD	0.51**	0.55*	0.80**	0.53**	-0.03
HI		-0.30**	-0.01	-0.29**	0.00
SYD			0.94**	0.99**	-0.03
BWT				0.94**	-0.04
GR					-0.03

** indicates values significantly different from zero at the 1% level.

LA does not necessarily cause a simultaneous increase in GYD, but for genotypes with equal HI's, greater LA can produce increased GYD.

For a plant to initiate and develop greater SYD, extra LA must be present early in the growth cycle. Such a plant, when supplied with adequate nutrients, CO₂, and moisture, can develop additional LA at a compounding rate. In turn, the greater LA may result in the initiation of a larger number of reproductive primordia (i.e., spikelets and/or florets per spikelet). Because LA of small grains is completely developed at anthesis, having enough photosynthate to completely fill initiated florets is dependent upon the greater LA persisting after anthesis. Thus, greater leaf area duration (LAD), a measure of LA persistence, especially after anthesis, is required to give greater GYD (Fischer and Kohn, 1966; Welbank et al., 1966; Simpson, 1968; Helsel and Frey, 1978).

To insure high GYD, a proper division of the photosynthate resulting from the increased LAD is necessary. If a disproportionate share of the pre-anthesis photosynthate is used to produce stem tissue, either through greater tillering or plant height, a drain will be placed on the postanthesis photosynthates for vegetative maintenance, making it less available for grain filling; thus, GYD will not be increased concomitantly with SYD. Greater LA and LAD may be the actual morphological cause of greater SYD and GYD in the *A. sterilis*-derived lines that were used as parents. In this study, LA and LAD probably were assessed via GR; hence, the high apparent association between GR and GYD.

The explanation for GR causing increased GYD has been more or less proved already for oats. The *A. sterilis*-derived lines, CI 9268, CI 9271, and CI 9273, used in this study have greater LA and LAD than their recurrent parents (Helsel and Frey, 1978), and this likely is the source of their enhanced GR.

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SOME UNUSED SOURCES CONCERNING LITIGATION
OF SIR JOHN FASTOLF AND JOHN PASTON III

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ABSTRACT. Among the medieval manuscripts currently held in the collections of the libraries in the United States are a number which relate to the affairs of Sir John Fastolf (d. 1459) and his friends, the Paston family. Of these, three are printed here: two letters of Fastolf from the year 1451 and a deposition taken in June 1476 concerning an attack upon a property of John Paston III (d. 1504) in December 1475. The selection of these three is based upon their relationships to already published materials in the various previous editions of the manuscripts of the Paston family.

Index words: litigation, John Fastolf, Paston family.

Over forty years ago, Curt F. Bühler printed ten previously unknown documents relating to the Paston family from the manuscript collection of the Pierpont Morgan Library.¹ In the past decade the first two parts of Norman Davis' three volume new edition of the Pastons' fifteenth-century letters and papers have appeared.² Because of the large number of Paston documents—over one thousand pieces—the availability of this material in print for the last two hundred years, and its uniqueness, being one of four large accumulations of private correspondence surviving from late medieval England, the Paston material has been fundamental for the understanding of fifteenth-century English history and English language development. Not surprisingly, the Paston manuscripts have undergone three different editions in the past two centuries. Each has added newly discovered manuscripts to the published materials.³ Printed below are three hitherto unpublished and previously unused manuscripts located in three different libraries in the United States. They are printed here in order to make them more readily available to scholars and because they illuminate matters which are only partly known to us regarding the Pastons and their friend, Sir John Fastolf. The first two are letters from Sir John regarding affairs in the first half of 1451, and the third is a deposition concerning a forced entry into some property of John Paston III in 1475.

The identification of the hands in these documents is based upon an examination of the plates in Davis' edition of the *Paston Letters* and of related manuscripts containing the hands of Sir John Fastolf and William Worcester, his secretary, found in the Department of Manuscripts of the British Library. As far as possible, these manuscripts have been transcribed as they stand. Punctuation, though, has been modernized with the intention of making the extremely long sentences somewhat more intelligible. With regard to the description of the manuscripts and to abbreviations, Norman Davis' practices have been followed as much as possible.⁴ However, the superscript "a" has been rendered either as "au" or "a" depending on individual scribal preference and as "ia" in the name "William." And, on occasion, the final "n" with a bar

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above has been seen as representing an "i" in the letter combination "coñ" which is the equivalent of "cion." Mid-sentence capitals have been silently reduced. Interlineations are placed in half-brackets. Each document is introduced with a discussion of the context in which it appeared.

I. Sir John Fastolf to John Berney II, Sir Thomas Howes, Walter Shipdham, and Geoffrey Spirling, 3 January 1451

In the confusion of the aftermath of Cade's rebellion, the indictment of many of Henry VI's courtiers and officials by juries in various counties of southeastern England, the loss of Normandy to the French, and the return of Duke Richard of York from Ireland—all of which occurred in the summer of 1450—several of the gentry of Norfolk had begun to move against several of the king's favorites in the law courts. This first letter (Document I) by Fastolf falls in the middle of his litigation against the favorites led by Sir Thomas Tuddenham and John Heydon, esquire.⁵ The four recipients are maintainers of Fastolf's interests in Norfolk while he resided in London. John Berney II is a distant relative of Fastolf as well as of several other Norfolk families such as the Pastons, Mundfords, and Yelvertons, all of whom held grievances against Tuddenham, Heydon, and other royal officials or friends. The other three are employees of Fastolf: Howes was at this time parson of Castle Combe, co. Wilts., and steward of Fastolf's manor of Caister, co. Norfolk; Shipdham acted as one of Fastolf's auditors; and Spirling often served as a messenger.

Some understanding of Fastolf's lawsuits may be obtained from an examination of the already published letters of Fastolf and the Pastons.⁶ On 16 April 1450 in the midst of the outcry against the royal officials led by William de la Pole, duke of Suffolk, John Fastolf asked Thomas Howes for all the available information about the "grievances" caused him by John Heydon. This request began the legal confrontation Sir John was to have with Heydon and Tuddenham during the next year or so.⁷ Although Fastolf had started to move against the royal favorites who had harassed him and who now were the subject of public criticism, he stood by the king and advised the government during the spring and summer on how to oppose Cade's supporters.⁸ Through the late summer and autumn various individuals including Fastolf sought legal remedies for disputes with their neighbors before the sessions of oyer and terminer in September, November, and December. Of the defendants mentioned by Fastolf in this letter, three, Thomas Brampton, John Wood, and Robert Wood, were not involved in litigation with him; three, Sir Thomas Tuddenham, John Heydon, and William Prentice, were so with him and other plaintiffs; and three, John Ulveston,⁹ William Dynne, and Margaret Brigge,¹⁰ were apparently solely his concern. By the beginning of the Christmas season, some or all of the nine had been indicted in Norfolk before either sessions of the peace¹¹ or of oyer and terminer. But in December various, if not all, of the defendants were attempting to have their cases removed to London before the court of King's Bench, which they felt would be more friendly toward their side. From Fastolf's letter of 3 January it would appear that Heydon, Dynne,¹² Ulveston, Prentice, and Brigge had been able to have their cases transferred from the Norfolk commission of the peace to the King's Bench. They had achieved this by appearing at the King's Bench and obtaining a writ *certiorari*. Fastolf, nevertheless, intended to keep all these cases before the justices of the peace

through a general writ *procedendo*, which not only would return the “escaped” five from King’s Bench by saying insufficient ground existed for them to leave the JPs’ court but also would order the justices to proceed in all nine cases. However, Sir John Fortescue, the chief justice of the King’s Bench, doubted that Fastolf’s plan was possible. In any event, Fastolf hoped to get at least a *procedendo* against the four who had not appeared in King’s Bench. In the meantime he would discuss the situation further with the chancellor, John Kemp, cardinal-archbishop of York, who at this time was refusing to act on a writ *supersedeas* issued by the king for all sessions of oyer and terminer in Norfolk. A reason for Kemp’s hesitation regarding the *supersedeas* is that on 27 December, he, and subsequently the king and various other lords, had been told that if the recent oyer and terminer did not run its course, there would be a major rising against the government with over five thousand men from Norfolk marching on London.¹³ While possibly aware of this report, Fastolf thought that the king had been injured already by the granting of the *centiorari*. Many people in East Anglia wanted the activities of Tuddenham and the others examined in court, and in this period neither the King’s Bench, which acted too slowly, nor the justices of the peace, who could be intimidated, could effectively deal with cases involving the mighty as could commissions of oyer and terminer.¹⁴ The local population, no doubt, saw the transferences to the King’s Bench as a loss of the cases, because if those lawsuits were kept before the local justices some influence could be exerted on them. And, if the king’s order of a stay of the commission of oyer and terminer took effect, the best judicial route for Fastolf and his friends then would be blocked. The situation surrounding these cases had become very complex. Two of the leading peers in the region, the duke of Norfolk and Lord Scales, had split over which side to support, while both of them remained loyal supporters of royal policies in other areas. Aware of the legal maneuvering in London, the earl of Oxford, who had presided over the sessions of oyer and terminer in November and December and would again do so in January, wrote on 2 January to John Jermyn, the sheriff of Norfolk, and to Fastolf. While asking Jermyn how he purposed to proceed at the coming sessions at Lynn, Oxford told Fastolf to talk to the king’s council, and especially to Kemp, and to inform him how he was expected to proceed. Although by the seventh Fastolf had received a *procedendo* regarding Tuddenham, Brampton, and the two Woods, he feared that little could be done against Heydon. However, five days later his spirits in this regard improved, and he suggested that some proof supporting Heydon’s indictment might be obtained.¹⁵

Source: MS.xq822.33/DF26d, University of Illinois Library, Urbana-Champaign.¹⁶ 30x22 cm. Hand unidentified, and signature autograph.

Dorse: In upper left-hand corner in a column: zicss[?]/tcss/xq822.33/Df26d/Ms4122

To my right trusty and welbeloued John a Berney Squire Ser Thomas Howes Walter Shipdham and Geffrey Spirlyng dd¹⁷

In the upper left-hand margin of the letter in a later hand similar to that of the marginal date of Document II the incorrect date: 3 Jan. 1450.

Right trusty and welbeloued frendes I grete yow weel and certifie yow I haue receivid *your* *lettre* and weelvnderstand it. And as for a *procedendo* to be grauntid vp-on the *certiorari*, the chief iuge thinkith it may not be doon by lawe in as moche as *certein* of hem haue apperid in the kynges benche and pledid. Wherupon the *certiorari* now cam downne by vertu¹⁸ of a *certiorari* be-fore this hadde owte of the Chauncerye the laste terme to remeve *certein* enditementes vp-on hem in Norffolk & in Norwiche by-fore the justices of the peas. Vp-on whiche enditementes whan thei were come inne in-to the kynges benche *certein* of hem apperid as Heydon, Dynne, Vluston, Prentys, and Brigge and pledid. Vp-on whiche apperaunce the seid *certiorari* was¹⁹ made owte of coors²⁰ of þe place and ex officio &cetera. But as for Tudenham, Brampton, Woode, Woode,²¹ and others þat apperid not²² I shal haue a *procedendo*. And otherwise I am answerid of þe iuge I may not, nevertheles I shal labour to my lord Chaunceller, if I may ghethe on of hym in generall spede if I may &cetera.²³

Item where as the kyng hadde grauntid supersedies to a come downne for to surcese of all the oyer [and] *determiner* that is lettid, for suche shal noon passe as yette, as my lord Chaunceller grauntith &cetera.

Item Cousyn Bereney and parson in as moche as the Lord Scales is at Lynne and as I am enformed wille be there bygge of his men and tenautes in mentinyng the seid Tudenham and Heydon and perauenture speke grete wordis²⁴ whiche is noo grete hurte if he doo noo more. Yit *certein* of my frendes and weelwillers²⁵ haue counsellid me that for suche materes as I haue there in processe that I haue good counsell and other men of worship to be present in my materes forseid pursuyng as my cousyn Paston whom I trist moche I wete weel wil be there and also my frendes William Jenney, John Jenney, and Lomnour.²⁶ And if ye thinke it to be doon I pray yow cousyn be ye there. I suppose the seid Lord Scales wille not be opynly *parciall* seyng he [is] a *commissionere* and a²⁷ knyght of the gartier &cetera.

Item I shal sende the *procedendo* by Brayn and Bokkyng²⁸ whiche shal be with Yeluerton²⁹ on Saterday at nyght next comyng and also the *procedendo* generall if I may ghethe hit. This *certiorari* hurtith the kyng gretely but not the parties saf for tho[se] that exigences ben awardid ageinst hem and yet process of outlawery shal procede ayenst hem neverthe latter. As for all other materes *particuler* that ar or may be to my aduaile and profite in that parties, I pray yow tendirly to solícite hem to my grettest profite, as I trist fully ye will &cetera bryngyng with yow Ser Thomas all manere [of] evidences concernyng my billes at this oyer and *determiner* &cetera.

Item as for tendernesse of lordship to be shewid to Tudenham and Heydon by my lord of Norffolk fere yow not ther-of in noo wyse &cetera. And³⁰ our lord haue yow in kepyng. Writen at London the iij day of Januare Anno xxix *Regis Henrici Sexti* &cetera. I haue hadde grete sute and labour that I shuld entrete with Ser Thomas Tudenham and Heydon. And I haue answerid non otherwyse, but in cas thei will appere in *propre persone* or by attorney and plede the materes tried and founden for hem—I agre me. And if thei be founden for me, I wille surcesse of execucion suyng and put my materes in comprimis³¹ of my Lord Chaunceller and other men of conciens and lerned. And otherwise thei ghethe noon agrement of me, for I haue leuere it were knowen in the contre howe I haue be done too thanne to be recompensid of all my losses þat I haue hadde by them, for me thinkith it more my worship

by whiche I sette more than by ought all. And so I wille the contre knewe &cetera.

Item my shippe with stuff is come this nyght and hathe be longe hiderward.

[signed] Ser J ffastolfe

II. Sir John Fastolf to Sir Thomas Howes, 24 June 1451³²

Fastolf's second letter (Document II) pertains to the aftermath of the decisions reached at the sessions of oyer and terminer of January, March, April, and May 1451 regarding the activities of Tuddenham and Heydon, the state of several other of his lawsuits before the courts, and the management of his estates. For the purpose of maintaining continuity with the material in Document I, rather than examining the contents of Document II in their exact order, the litigation with Tuddenham and Heydon will be discussed first. Apparently, despite Fastolf's apprehensions, his causes had made some headway in January before the commissioners of oyer and terminer at Lynn. Sometime before the next sessions, which would begin on 2 March 1451, the duke of Norfolk, president of the sessions, asked that those having complaints against Lord Scales, Tuddenham, Heydon, and Sir Miles Stapleton³³ present their grievances in writing to him.³⁴ As the sessions opened, rumors circulated in Norwich that Tuddenham and his friends had had various justices and plaintiffs indicted in Kent. Although seven of Scales' retainers were indicted, members of the Paston family, throughout the month of March, were convinced that Tuddenham and Heydon were on the way again to assuming control of the county. In mid-April Fastolf reported from London that Tuddenham and Heydon with a large group of followers were expected to come to the sessions at Norwich at the end of the month. When these sessions met under William Yelverton and John Prisot,³⁵ the latter moved them to Walsingham where Lord Scales joined the commission, which then continued to sit. Even though Scales, Tuddenham, and Heydon had a sphere of political influence centered on Walsingham, Thomas Howes thought that of the cases presently before the oyer and terminer Fastolf's had the best chance of continuing to a verdict. What exactly happened is not recorded in the surviving correspondence, but it appears that Fastolf won some sort of decision. In Document II he asks Howes to apprise him of the amount which his struggles with Tuddenham and Heydon have cost so that he may inform either the arbiter or the judges, none of whom he names, of the expenses. Ten days later, however, Henry VI pardoned Tuddenham, "*his heirs and executors*, of all amercements incurred by him before any justices in Norfolk and Norwich after St. Peter's Chains last [1 August 1450], and chattels and issues forfeit and fines made after that day, saving to the king 200*l.* thereof to be paid at the Exchequer. By p.s. etc."³⁶ As Fastolf makes references to other legal battles of the past year, the significance of the pardon for him is not known.³⁷

By 23 November 1450 Fastolf had begun to move against John Ulveston and John Andrew³⁸ who allegedly had forged the office—that is, having created fraudulent documents from a supposed inquisition taken by the escheator—with regard to the manors of Beighton, co. Norfolk, and Bradwell, co. Suffolk. This, presumably, had happened at the duke of Suffolk's instigation during Ulveston's tenure as escheator of Norfolk and Suffolk in 21 Henry VI.³⁹

In addition, in the case of Bradwell, according to Fastolf, a Sir John Shipton,⁴⁰ had forged a quittance, for which Fastolf wanted him indicted if possible. By late April 1451 Sir John had sued for and obtained two writs *venire facias* to have examined the documents regarding the inquests into Beighton and Braewell. In early May Howes had presented the writs to the sheriff and waited for advice concerning Shipton. By late June Fastolf had become uneasy about keeping his supporters in line until the matter of these two manors could be settled. From his reference to the attaint, it would appear that he had acquired another writ based upon a claim that a jury—possibly in Ulveston's escheatorship—had issued a false verdict concerning the manors. In time Fastolf would recover his lands within Beighton and Bradwell.⁴¹

The reference to Higham's lands has to do with Fastolf's interest in buying the property of an unnamed member of the Higham family who had apparently died in 1450. Late that year Fastolf was concerned with Margaret, née Higham, the wife of John Brigge, an adherent of several of his opponents. It would appear his interest in the Higham property was being made more complicated by Margaret Brigge, who probably was either the sister or daughter of the deceased and who had sued a writ of attaint against Fastolf to protect her interest in the property. By the summer of 1451 Fastolf and Howes were working out the financial arrangements with Higham's widow, although things had still not been settled as late as September. Several years later, William Worcester, secretary to Fastolf, remarked that the defense against Margaret's suit had cost Sir John one hundred marks—the exact amount Howes, in the summer of 1450, had told Fastolf for which Higham's land could be purchased.⁴²

Within the two paragraphs concerning the information needed to settle Fastolf's affairs with Tuddenham and Heydon are several items of note. In addition to Walter Shipdham various others of Fastolf's agents are also mentioned: Thomas Sweyn, John Intwood, a surveyor, and Richard Conerey. Bishop's appeal had to do with the payment of 100*l.* by Fastolf that for some unknown reason had never been made. The seizure of his sheep at Drayton, co. Norfolk, had bothered Sir John so much that it had been included in a petition to parliament, probably made in early 1450 against the duke of Suffolk, Tuddenham, and Heydon.⁴³ Now, Fastolf wanted Wormegay,⁴⁴ his agent for Drayton, to be replaced by John Emond, one of his tenants at Taverham, co. Norfolk. The matters to which Fastolf alludes had to do with Emond knowing about "the one who pretended title to Dedham."⁴⁵ Apparently the problem of Fastolf's rights in Dedham, co. Essex, was the result of claims by the Pole family, whose head was the duke of Suffolk. From this time until his death in 1459, Fastolf would have to fend off the Poles, led by Alice, née Chaucer, the widow of Duke William who had been murdered in May 1450. In any case, he wanted Howes to supervise the property and rights of the widowed duchess. After Fastolf's death in 1459, Duchess Alice and her son, Duke John, would lay claim to Hellesdon and Drayton in Norfolk and to Cotton in Suffolk. Besides these concerns, the Poles were also raising questions about Fastolf's wardship of the daughter of his nephew, Sir Robert Harlyng, who had died in 1435. The traverse of Haryng's land, no doubt, was part of a defense of Sir John's authority in his nephew's estates. By 1456 even Fastolf's payment for the wardship was being challenged by the Poles, who were to drop their interest in the Harlyng properties by 1459.⁴⁶

The reason for Fastolf's concern in June 1451 about the whereabouts of the royal license allowing him to found a collegiate church at Caister is unknown. Nor are the identities of the individuals mentioned in this part of the letter known. Thomas Ovy and the Lady Berdeston (Bradeston?) are not mentioned in the currently published Paston/Fastolf documents, and they do not appear in the Chancery calendars of the Public Record Office. Master Thomas Ludham, on the other hand, was a cleric apparently in Fastolf's service and one of the purchasers of his employer's lands in the manors of Runham, co. Norfolk, and Dedham in 1449 and 1450 respectively.⁴⁷ Later these properties must have been re-sold to Fastolf, as he was in possession of them at his death. Fastolf ends his letter by asking Howes again to check into his legal expenses by consulting⁴⁸ Walter Shipdham and William Cole, who like Shipdham was one of his agents.⁴⁸ Unfortunately for Fastolf, his quarrel with Tuddenham did not cease in the summer of 1451, and throughout the remainder of the decade the disputes with the Poles would involve him with Tuddenham as well.

Source: MS.xd.274, The Folger Shakespeare Library, Washington, D.C.⁴⁹
28.5x41 cm. Hand of William Worcester, signature autograph.

Dorse To my trusty & welbelovyd frende sir Thomas Howys, Stuard off
Castre

In the left-hand margin of the letter in a later hand similar to that of the marginal date of Document I the incorrect date: 24 June 1450.

Ryght trusty frendz I grete you well. And for asmoch as the next terme ye ryght short but of xiiij dayes, wherfor I pray you and charge you that ye sende vpp to me in all goodly haaste by such commers betwene as be of your knoulege that such materes as most be avysed or remedied heere may be doon be tyme soo as none damage or inconvenient fall in the vacacion tyme of the processe for Beyton & Bradwell or the atteynt,⁵⁰ for yt ys to deme that my aduersaries wolke wyrk all the vntrouth that they can ayenst me.

Item sendyth me wrytyng of all my wryttes sent home, how they been executed, and the namys of hem that ye have for be put in processe for arre & debt thys term, and such as make ende wyth you there that yee take vpp the costes of the processe whych Rauiyms myne atourney can sey yow.

Item as for the wryt I sent you by Piers Plowman for Hygham-ys landz in Suffolk, ye most see that the shyreff of Suffolk retourn the wryt and kepe the day of retourn t[o] ⁵¹ be sent vpp & not lost, for at the next wryt hyr lond shall been executed, but yff ohe make ende wyth me and hyr goodz also, for now the shyreff may retourn, but that he ys deede.

Item y⁵² hafe well vndrestand that ye sent me a⁵³ rolle of papier of certeyn chargeable costes that I have expended and payd for the deffence of the greete yniuries don to me thys x or xij yeer day. But ye most remembre in Shypdam bokes and Thomas Sweyn accomptes with Intewoddz beyng yn the andyt⁵⁴ at Castre for the costes of the trauers⁵⁵ that was payd for my nefeu Harlyng londz. Also I hafe not the costes here that was payd at Donwyche & at Norwyche for the appele of Bysshop. Also Rychard Conerey⁵⁶ bokes most be sought of dyuers yeeres for costes & dammages of parkyng of my sheepe at Saxthorp in lykewyse Haylysdon & Drayton bokes for distreynyng

at Drayton &cetera. And serchyth as many officers tymys as ye can by lyklynnesse conceyve only extorconn or dammage or costes doon to me, for I hafe serched to the vtmost heer of all maner costes in pleez or processes. And so I pray you to doo there & sende it me be tyme to thentent I may cast the sommes payd out by you & by myne officers there to the costes that y hafe payd heere that y may shew to the arbytrar or to the juges ⁵⁷ how that y hafe be ruled by Ser Thomas Tuddenham and Heydon.

Item sende ye all the coostes, charges & expenses payd and boorn by you & my seruantes all the tymes of oyer [and] terminer kept to my counsell in expenses or othyrwyse, for all such materes ys vntrestand a dammage to me. And there as hath be made expenses in hors or intaille at Heylysdon or Castre or any othyr place of my proinsion,⁵⁸ it is reson that it be valued.⁵⁹ Item the costes leyd out in Norffolk in defenses of my processes, drawyth but clxij li. iiij. by your takyng owt. But & ye serche well the bayllyffs of Blyclyng, Saxthorp, Drayton, Castre & Haylysdon besyde Shypdan bokes & youres. Ye shall synde more money, also the costes of expenses of my seruantes rydynges, the expenses vpon the maners for that causes oonly valued wolles be valued & cast vnto. I sende you the said rolle to corrigge it.

Item y have wryten to yow that for my proffyt in the maner of Drayton, be-cause that Wyemegey hath ouer manye charges and offices to approwe well my londz in his office, that my wille ye that John Edmond my tennaunt in Trauerham be as my baylly and officer in Drayton takyng⁶⁰ for hyr ffee as gode shepe as ye can entrete hym¹ yeerly, but I wolle he have ouersyght of my wareyn in Drayton aswell as the ouersyght of my bookz in Trauerham & Haylysdon. And forasmoch the seid Emond hath been wylling to me ward in certeyn materes that ye knou off, as Worcestre hath crediblye enformed me for esy reward yevyn, reson wolle that y owe hym better wille to resseyve hym to my seruauunt. And also he hath certeyn evidenses that may do me case whych that y may the better & esyer com bye hem when he ys my man. And I vndrestand well concienst & tone; and be thyn a yeer or twoo, we shall press it. And therfor sende ye for hym and go throw wyth hym as ye shall conadre⁶¹ best for my mooste proffyt and avayle.⁶²

Item I pray you and charge you that notwythstandyng I have officers & bayllyffs vppon my maners of Castre, Haylysdon, Drayton, Blychyng, Saxthorp, & all such othyr placys where as onye money ys growed & owyng for rent, ferme corn, or for conyes wolles,⁶³ or chatell & wodd & such commoditeez of a manerr that ye do your part to resseyve my Dcwtecs of Such commoditees your-sylf quarterly & dayly as it is ronne and not to suffre my officers resseyve it & delyuere it you but it be in your absense. For ye knou well of experrence that when it commyth in theyr handz they woll make work & sett it out in itemys nedlese and not esye to hafe owt of her handz. For they have a reson & seyn that when they resseyve my money, they wolle accompt for it at the yeer-ys eende and so marchaunt wyth my money or all pay it in petitions of itemmys to my grete dammage & hurt and a grete cause of the dimminussyng of my lyvelode. And wold Ihc myne andnours⁶⁴ wold take thys mater well to hert and counsell you thereafter. And thynk ye in your soule whethyr that I sey reson or not and take ye i[tt]⁶⁵ to hert. And myne officers may be aswell discharged off a lyuer⁶⁶ lyuerey of money that to whych her charge made to your hand as to delyuere vppon the accompt for it ys not so redy payd then, ye knou well. And for deffault of thys ouersyght it

makyth my bayllyffs be yn gretter arre then they ought or wold bee, & thys mater were tymely awayted vppon by yow.

[signed] Ser J ffastolfe

Item. Wolle ye hafe in knoulege that the xix yere of the regne of thys kyng, I put a⁶⁷ bille of supplicion to the kyng sent by Thomas Ovye of the Lady Berdeston ye counsell⁶⁸ to the kyng beyng at Cambrygge then. And the s[u]bstaunce of my bill was that it lyked the kyng of hys speall grace to graunt and licence me to founde a college of certeyn preestes clerkes & pore⁶⁹ men at my place in Castre. Whych [bill of] supplicion was graunted and signed wyth the kyng-ys hand. And the seid Ovye brought the bille to London. And now y hafe doo serched amonges my wrytynges for the seid bille signed wyth the kynges hand, and y can-not fynde it. So y suppose that the seid Ovye can tell to whom the bille was delyuered to⁷⁰ thentent I myght inquire & demaund for it. Y suppose Maister Thomas Ludham can sey where that bille be-come & he bee in that contre, yff the said Ovye can-not remembre. I pray you therfor serche at home at Castre and inquirye in all haast goodly of the seid Ovye asswell as off Maister Thomas Ludham whate remembraunce they can sey you of thys bille where it shuld bycom & sende me woord.

Item I sende you a rolle of the grete parte of costes in money leyd owt & payd here in London owt of myne prevy cofurerys to lerned men & for counsell to diffe[re]nd the malycious⁷¹ & fals processes pursued ageynst me thys x yere day by myne aduerse comfort &⁷² meynテナunce of Norfolk. And y sende you your rolle of costes; also to corrige it after more serchys made as ys specified before in bokys of myne accomptantes payng you to do serche of the new the said officer bokys by avice of Watkyn Shypham & William Cole yff he be at Castre; and put it in your papyr or a part that y may cast euery cost of euery processe to othyr. As to the trauers of Horlyng landz and the deffence of the appele for Byssop, dooth it cost iij li.? Where-euere it be wryt and the bokes be not here off it [but of Intewod last⁷³ accompt,] ye must inquire there. And betyme to labour it for my worshyp & proffyt that y make none demaund⁷⁴ [to] my party aduerse of euery p[ar]ticler [cost beside the] damage. But as the trouth ys and that I may fynde record & wrytyng off it and nede bee. I pray you pondre these maters betyme to be sent me word. And god haffe you in hys kepyng. Wryt at London the xxiiij day of June. Anno xxix⁰ regni regis Henrici vj.

III. Deposition of John Wellys, mayor of Norwich, William London, William Peper, Hamo Claxton, and Robert Wellys concerning an attestation by William Wisbech, 16 June 1476.

Since the publication of Gairdner's editions of the Pastons' letters, several letters, in which a quarrel between John Paston III and a Nicholas Derby is mentioned, have been known to scholars. Knowledge of this dispute has been limited to Paston's request that one of the family's attorneys "swe forthe the axions a-yenst Darby and other for Byskley" and to Margaret Brews' attempts to bring Derby and Paston together as a part of her plan to marry her daughter to Paston.⁷⁵ From this deposition (Document III) one learns that the cause of the trouble was Derby's armed entry into Paston's property in Bixley Trowse on 23 December 1475. Unfortunately, William Wisbech, one of Derby's accomplices, does not explain in his statement to John Wellys and

his fellow citizens of Norwich the reason for the trespass. Whatever the cause, the resultant litigation was great enough to cast a shadow over Paston's marriage negotiations with the Brewses for his future wife's hand during 1476 and 1477.

Of the known members of Derby's gang, information appears to exist only for Nicholas Derby and his chief supporter Henry Lancaster. While the former was pardoned for nonappearance regarding a debt in 1471, the latter, on the other hand, since 1473 had been receiving the issues from the king's part of the honor of Chester in the county of Suffolk at an annual farm of 17s. 8d. Lancaster later sued one Seman Ryvers for nonpayment of a debt. From the designations of esquire and gentleman and Margaret Brew's references to Nicholas as her cousin, Derby and Lancaster evidently were numbered as members of the East Anglian gentry. When Lancaster died holding lands of the crown, he was considered to be of enough importance to have an inquisition *post mortem* ordered regarding his wife and himself.⁷⁶ As for William Wisbech and William Waldey's identities, there remains only Wisbech's representation of them being yeomen.

John Wellys and his associates were and continued to be the political leaders of Norwich. Less obvious, however, is the association of the Paston family with several members of the panel. As early as 1462 Wellys provided the latest news from London to the Pastons in Norfolk. In 1469 Richard Calle, the family's bailiff and who in 1470 became the brother-in-law of John II and John III, borrowed some money from Wellys in order to discharge several of the obligations owed by the Pastons.⁷⁷ In addition, various members of the Paston family, John Wellys, and Hamo Claxton acted jointly in the arrangement of several enfeoffments.⁷⁸ As Wisbech's testament injures the cause of Nicholas Derby and aids that of John Paston III, Wellys and the others may have had more than an impartial interest in certifying its truthfulness.

Source: MS. Eng. 824, Houghton Library, Harvard University.⁷⁹ 36x13.7 cm. Hand unidentified.

In a different hand in the upper left-hand corner is written "1458" and below it is written and crossed out "1475."

To alle cristen peple to whom this present writyng shall come to see & here. John Wellys maire of the Cite of Norwich, William London, William Peper, Hamon Caxton citezens and aldermen of the seid Cite, and Robert Wellys of the same, mercer, due reuerence and gretyng after every estate attordyng⁸⁰ in our lord Jhu and lastyng ffor als moche as it is ineritory⁸¹ to testefie the trouthe in every mater to the honour and laude of hym that is essennall trouthe. It⁸² was that the xvj of June the xvj yeer of the reigne of oure soueraign Lord Kyng Edward iiijth come one William Wesbiche of the parish of Seynt Petre of Mancroft in Norwich yoman seyng these woordes in effecte, maister maire, I pray yow to testefie these woordes in writyng vnder youre seal of office the whiche I shal seye by-fore you and my maisters here present. That on Cristemas evenys even the whiche was the Saterdag by-fore Cristemas day last passed⁸³ I was one of those persones that was with Nicholas Derby of Shelfangre in the shire of Norffolk, Esquier, Herry Langcastre of the same town, gentilman, William Waldey late of the same town, yoman, with others dyuers riotous felaship there whan we entred in-to a place londys and

and tenementis⁸⁴ in Biskeley Trows and other wwnys⁸⁵ there abowte in the whiche John Paston, Esquyer, was seased er we come. And for suernesse of ones persones we were defensibly arrayed. I am weel remembred we had v long bowes, v sheefz arwes, ij sperys wherof one of them with-out an hed, j jakke of salettys, a trussyng doublet of defense, and an-other trussyng doublet of defense with-out sleves. What harneys or wepen we had elles I am not remembred. And these wordes arn true as I wole answer a-fore god at my most nede. And so I require yow to witnesse what I seye. Whervpon of the maire a-fore named witnessyng the seid William Wesbyche thus to haue seid no-thing added nor mynused that myght chaunge the effecte of the rehersell of the same William Wesbyche, the seal of myne office of mairaltie of the seid cite haue do to be appendent and we, William London, William Peper, Hamon Claxton,⁸⁶ and Robert Wellys, a-fore named oure seales to these presentz haue set to at Norwich the seid xvj day of June the xvj yeer aforeseid.⁸⁷

NOTES

¹ Curt F. Bühler, "Some New Paston Documents," *Review of English Studies*, 14 (1938), 129-42. Unfortunately, until recently this little collection has not been widely noticed. This has allowed R. L. Storey's conspiracy theory to stand as the explanation of the abortive rising of Duke Richard of York at Dartford in 1452, as set forth in his *The End of the House of Lancaster* (New York: Stein and Day, 1967), pp. 94-101. In an as yet unpublished essay, "An Itinerary of a Rebellion: Richard of York's Path to Dartford Field," this writer has challenged this theory on the basis of an examination of the relevant letter published by Bühler and its importance for the opening phase of the so-called Wars of the Roses.

² Norman Davis, *Paston Letters and Papers of the Fifteenth Century* 2 vols. (Oxford: Clarendon Press, 1971 and 1976).

³ For a history of the Paston manuscripts and their publication, see Davis, I, pp. xxiv-xxxiii. See my review of *Paston Letters*, by Norman Davis, *Speculum*, 54 (1979), 361-64, for a discussion of the relationship of the Davis edition to that of James Gairdner and of the new documents published by Davis.

⁴ Davis, I, pp. lxxx-lxxxv.

⁵ For basic biographical information on Heydon and Tuddenham, see Josiah C. Wedgwood, *History of Parliament, Biographies* (London: HMSO, 1936), pp. 452-53 and 880-81.

⁶ James Gairdner, *The Paston Letters, A. D. 1422-1509*, 6 vols. (London, 1904; rpt. New York: AMS Press Inc., 1965), II, nos. 103-205, *passim*. One must use Gairdner's last edition here rather than Davis' because Davis has not seen fit to edit most of the "Fastolf Papers" which Gairdner had already published. Below, where possible, all references to Paston and Fastolf papers will be provided from both editions for the convenience of the reader. For a detailed discussion of one of these suits in this period, but one not mentioned in Documents I and II, see P. S. Lewis, "Sir John Fastolf's Lawsuit over Titchwell 1448-55," *The Historical Journal*, 1 (1958), 1-20.

⁷ Gairdner, II, no. 107. Within East Anglia, itself, the clamor against Henry VI and Suffolk had begun in March and was accompanied by the suggestion that Richard, duke of York, should have the rule of the country (Public Record Office, London, Court of King's Bench: Crown Side, Indictments, Ancient, KB 9/118/1, no. 30 and KB 9/271, no. 117).

⁸ Gairdner, II, no. 126, or Davis, II, no. 692, and P.R.O., Exchequer, Treasury of Receipt, Council and Privy Seal, E 28/80/74.

⁹ For biographical data on him, see Wedgwood, p. 895. For a discussion of the litigation of Fastolf against Ulveston, see the introduction to Document II.

¹⁰ The identity of "Brigge" is not really known. Most likely this "Brigge" is Margaret Brigge, who at this time was involved in litigation with Fastolf regarding some property of one of her relatives (see the discussion of Document II). Margaret, née Higham, was the wife of John Brigge, who supported the interests of Tuddenham and Thomas, Lord Scales, in late 1450 and early 1451 (*Calendar of the Patent Rolls, 1446-1452*, p. 391, and Gairdner, II, nos. 154 and 172, or Davis, II, nos. 877 and 472 respectively). "Brigge" could be John and not Margaret, but nowhere in Fastolf's correspondence is mentioned a suit against John Brigge.

¹¹ A commission of the peace was named on 9 October 1450 for Norfolk, see *Cal. Pat. R., 1446-1452*, p. 592. Excluded from this panel of justices were Tuddenham, Heydon, and Thomas Daniel, all of whom had served as JPs since late 1447.

¹² By early January Fastolf, though, was less interested in going against William Dynne because Dynne had supplied his agents with useful information (Gairdner, II, nos. 151 [Davis, II, no. 467] and 164).

¹³ Simon Blake, the bailiff of Swaffham, co. Norfolk, whose town was a plaintiff against Tuddenham, was the source of this information (Gairdner, II, no. 170, or Davis, II, no. 471).

¹⁴ On the value of these three courts for dealing with the powerful, see John Bellamy, *Crime and Public Order in England in the Later Middle Ages* (London: Routledge & Kegan Paul, 1973), pp. 95-99.

¹⁵ This summary is derived primarily from Gairdner, II, nos. 103 (Davis, II, no. 131), 141 (Davis, II, no. 459), 142 (Davis, II, no. 460), 145 (Davis, II, no. 463), 146 (Davis, II, no. 461), 151 (Davis, II, no. 467), 154 (Davis, II, no. 877), 156, 159, 160, 164, 167-169, 170 (Davis, II, no. 471), 171, 172 (Davis, II, no. 472), 173, 175 (Davis, II, no. 880), and 186; and III, no. 346 (Davis, II, no. 566). Because of the mention of indictments in Document I, Gairdner and Davis' dating of John Osbern's "Memorandum on Prosecutions" (Gairdner, no. 175 and Davis, no. 880) and of the "Petition to Parliament by the Town of Swaffham" (Gairdner, no. 185 and Davis, no. 881) may be incorrect. Rather than dating from the spring of 1451, both of these items probably date from September 1450 to, at the very latest, the first half of January 1451.

¹⁶ Published with the permission of the University of Illinois Library. This letter is noted in C. U. Faye and W. H. Bond, *Supplement to the Census of Medieval and Renaissance Manuscripts in the United States and Canada* (New York: The Bibliographical Society of America, 1962), p. 172. With the letter is a typed transcript, whose origin is unknown according to Carline B. Stottlar, Graduate Assistant, The Rare Book Room, University Library (personal communication to the author, 15 February 1978). Although some minor differences occur between the typed transcript and mine, I have made no reference to them in my notes. The anonymous transcriber noted, however, that the date appearing in the upper left-hand margin of the manuscript is incorrect.

¹⁷ This "dd" may stand for *dedite*, i.e., "give to."

¹⁸ "wherof" canceled. All canceled words appear after the word to which a superscript has been attached.

¹⁹ "gra" canceled.

²⁰ "coors" is a somewhat unusual spelling of the word "course." See the *Middle English Dictionary*, ed. Hans Kurath and Sherman M. Kuhn, Part C (Ann Arbor: University of Michigan, 1959-1960), p. 669, no. 11 and *The Oxford English Dictionary*, ed. James A. H. Murray *et al.* (Oxford: Clarendon Press, 1933), II, 1087, no. 19.

²¹ Above the first "o" is a superscript "c" whose meaning is unclear.

²² "w" canceled.

²³ In the left-hand margin opposite the paragraph is the letter "a" in a later hand and which is similar to the two "a"s so appearing in Document II; see notes 57 and 62.

²⁴ "as" canceled.

²⁵ "w" canceled.

²⁶ For William and John Jenney, see Wedgwood, pp. 498-501. William Lomner was a friend and agent of the Paston family.

²⁷ "c" canceled.

²⁸ The identity of Brayn is unclear; he may be either Matthew Brayn, an employee of Fastolf (Gairdner, II, no. 126, or Davis, II, no. 692) or the clerk of the sessions of oyer and terminer in this period. John Bokking was one of Fastolf's clerks.

²⁹ William Yelverton, justice of the King's Bench. See Leslie Stephen and Sidney Lee, ed. *Dictionary of National Biography* (London, 1900), LXIII, 318. Yelverton served on all the sessions of oyer and terminer in Norfolk from November 1450 through April 1451.

³⁰ "as for" canceled.

³¹ The phrase "putten in compromis" meant "to subject to arbitration."

³²In my review of *Paston Letters* by Norman Davis (*Speculum* 54, p. 361), I gave the correct date as 24 June 1452 which is, in fact, wrong. Internal evidence regarding the litigation concerning the manors of Beighton, co. Norfolk, and Bradwell, co. Suffolk, and the existence of a small check-mark which represents the number one and which is attached to the first cross-stroke of the third "X" of the regnal year indicate 24 June 1451 is the correct date for this letter. (See also note 49.)

³³For his career, see Wedgwood, pp. 804-05.

³⁴Gairdner, II, no. 210, where Norfolk's proclamation is dated as 1452, probably in April. However, as these men were subject to judicial proceeding in the first half of 1451 and not in 1452, this proclamation must date from early 1451, most likely in February. The business before the sessions and the duke in the spring of 1452 concerned the doings of the gang led by Robert Ledeham, Charles Nowell, and Roger Church. I intend to examine the gang's exploits elsewhere.

³⁵Justice of Common Pleas; for him, see *Dict. Nat. Biog.*, XLVI, 402.

³⁶*Cal. Pat. R.*, 1446-1452, p. 455, emphasis added. The granting of the pardon to his descendants and also to his executors is most unusual. In the four-year period bracketing this pardon, this writer has found no similar provision in the published calendars of the patent rolls (*Cal. Pat. R.*, 1446-1452, pp. 287-585, and 1452-1461, pp. 1-125). This phraseology may have come directly from Tuddenham's written petition to the king who, upon granting it, had issued a privy seal writ based on the wording. If true, Tuddenham was taking no chances that the decisions which had gone against him might plague his family in the future. Regarding the administrative procedures resulting from an approved petition being issued under the great seal through a warrant from the privy seal, see A. L. Brown, "The Authorization of Letters under the Great Seal," *Bulletin of the Institute of Historical Research*, 37 (1964), 131-40.

³⁷For the most part the summary in this paragraph has been derived from Gairdner, II, nos. 174, 178-182, 184, 186, and 192, or Davis, II, nos 473 and 474, I, no. 137, II, no. 475, I, nos. 138 and 139, respectively, except for the first and the last two references.

³⁸At this time he was an associate of Heydon; for his career, see Wedgwood, p. 11.

³⁹He was appointed on 6 November 1442 and served until 4 November 1443; see *Calendar of the Fine Rolls, 1437-1445*, pp. 241 and 285.

⁴⁰His identity is something of an enigma, as he does not appear in the published Chancery calendars between 1435 and 1461. He may be the John Shipton of London, gentleman, who is mentioned in regard to some property near St. Paul's cathedral in 1440-1441 (*Calendar of the Close Rolls, 1435-1441*, pp. 431-41, and *Cal. Pat. R.*, 1436-1441, p. 541).

⁴¹The information in this paragraph comes from Gairdner, II, nos. 156, 159, 160, 162, 188, and 192; III, nos. 276 (Davis, II, no. 518) and 310.

Fastolf had continually to renew with the crown the keeping of Bradwell between 1449 and 1452 and that of Beighton from 1449 to 1454 (*Cal. Fine R., 1445-1452*, pp. 112, 116-117, 148, 156, 175, 199, 206, 252, and 257, and *1452-1461*, pp. 17, 19, 66, and 114-115).

⁴² Gairdner, II, nos. 144, 159, 186, and 205, and III, no. 346, or Davis, II, no. 566. For John and Margaret Brigge, see note 10, *supra*. For Worcester's relationship with Fastolf, see K. B. McFarlane, "William Worcester: A Preliminary Survey," in *Studies presented to Sir Hilary Jenkinson*, ed. J. Conway Davis (London: Oxford University Press, 1975), pp. 196-221; and for his research for Fastolf's lawsuits, see *idem*, "The Investment of Sir John Fastolf's Profits of War," *Transactions of the Royal Historical Society*, 5th ser., 7 (1957), 113, n. 1.

⁴³ Gairdner, II, nos. 104 and 153.

⁴⁴ Later Wormegay apparently entered the service of the Yelverton family (Gairdner, III, nos. 330 and 402, or Davis, II, nos. 548 and 705, respectively).

⁴⁵ Gairdner, II, no. 159, and III, no. 337, or Davis, II, no. 555.

⁴⁶ Gairdner, III, no. 337, or Davis, II, no. 555.

⁴⁷ *Cal. Pat. R., 1446-1452*, pp. 300-01 and 314.

⁴⁸ Gairdner, II, nos. 104 and 153.

⁴⁹ Published with the permission of the Folger Shakespeare Library. For the provenance of this letter, see Seymour De Ricci, *Census of Medieval and Renaissance Manuscripts in the United States and Canada*, 3 vols. (New York: The H. W. Wilson Company, 1935-1940), I:361, where it is incorrectly dated as 1450.

⁵⁰ An attain was the conviction of a jury of having given a false verdict or an attempt to reverse the verdict of a jury as false. See *O.E.D.*, I, 545.

⁵¹ A blot of ink appears after the "t" and may cover an "o."

⁵² No space between the "y" and "hafe."

⁵³ No space between the "a" and "rolle."

⁵⁴ The meaning of "andyt" is not clear. It may be a variant spelling of "indit" or "indict" meaning here "indictment." On the other hand, it may be "andyit" which meant "instruction" or "explanation" (*M.E.D.*, Pt. A, p. 269). A better possibility is that it derives from "enditen" meaning to write a book or a letter and, therefore, stands for the word "writings" (see *M.E.D.*, Pt. E, pp. 127-28).

⁵⁵ A traverse in this context could have been either a survey of Harlyng's lands or the denial of an allegation of fact in a lawsuit. Because the reference appears with a request for information about other lawsuits, the latter definition is probably the relevant one here.

⁵⁶ The reading of this name may also be: "Couerey" or "Coidey."

⁵⁷ In the left-hand margin opposite this paragraph appears the letter "a." See note 23.

⁵⁸ Most likely "prouision" is meant here.

⁵⁹ "beyn" canceled.

⁶⁰ "xl. s. & his lyuey" canceled.

⁶¹ "Conadre" is derived from *conari*, meaning "to endeavor" or "to undertake."

⁶² See notes 23 and 57.

⁶³ The phrase "conyes wolle" became "coney-wool" (1714) and "coneywooll" (1723); see *O.E.D.*, II, 957. The *M.E.D.*, Pt. C, 512, does not note this development.

⁶⁴ A variant spelling of "annoyers;" that is, Fastolf's own officers.

⁶⁵ This "i" is followed by an ink blot which has evidently the elements of two "t's" beneath it.

⁶⁶ The third letter of this word has been written over thereby confusing what letter it was; therefore, Worcester rewrote the word but neglected to cross out his first attempt.


⁶⁷ No space.

⁶⁸ "at th" canceled.

⁶⁹ No space.

⁷⁰ No space.

⁷¹ This word reads as "malȳcou̅se." However, the meaning of the bar over the letters "ycou" is not clear, as it may signify one of two possibilities. First, it may indicate that an "n" should be present in this combination of letters. But, an "n" does not fit unless the "c" becomes a "g" making the word "malignious" (of malicious speech [1578]; see *O.E.D.*, VI, 86). Second, a bar over "con" at the end of a word can equal an "i" thus reading "cion" or in this case "ciou." Therefore, the word evidently is "malicious."

⁷² The reading of the manuscript :  with a blot of ink covering the right half and with a bar above.

⁷³ The preceding two words are not written clearly.

⁷⁴ "for" canceled.

⁷⁵ Gairdner, V, nos. 885, 894 and 895, or Davis, I, no. 369, and II, nos. 789 and 790, respectively.

⁷⁶ *Cal. Pat. R.*, 1467-1477, p. 257, and 1476-1485, p. 85, and *Cal. Fine R.*, 1471-1485, pp. 54 and 176. The relationship, if any, of Henry Derby,

one of the mainpernors for the commitment of the honor's issues to Lancaster, to Nicholas Derby is unknown to the author.

⁷⁷ Gairdner, IV, nos. 510 and 531, and V, no 712, or Davis, I, no. 170, and II, nos. 676 and 759, respectively.

⁷⁸ *Calendar of Inquisitions Post Mortem, Second Series, Henry VII, I*, no. 1229, and II, nos. 605 and 700.

⁷⁹ Published by permission of the Houghton Library, Harvard University. For provenance, see Faye and Bond, p. 227, where they incorrectly state it was written in 1458.

⁸⁰ Presumably a form of "attorn." For the various medieval meanings of "attorn," see both the *O.E.D.*, I, p. 553 and the *M.E.D.*, Pt. A, pp. 492-94.

⁸¹ This derives from "eneritour," "enheritour," "inheritour," and means "inheritable." See *M.E.D.*, Pt. E, pp. 155-57.

⁸² This word is very indistinct in a fold in the manuscript.

⁸³ The date indicated here is 23 December 1475. Because the phrase "evenys even" could be taken to mean "eve's evening," the relative clause mentioning "the Saterday by-fore Christemas day" was included to remove any possible ambiguity here.

⁸⁴ The other possible expansion is "tenentis."

⁸⁵ This comes from the verb "wunien," "to dwell" or "to inhabit" and here means "dwelling." See Francis Henry Stratmann, *A Middle-English Dictionary*, new ed., ed. Henry Bradley (1891; rpt. London: Oxford University Press, 1940), p. 700. The actual spelling is "wWnys" with the "W" most likely signifying "uu."

⁸⁶ The first time this William is referred to his name is spelled as "Caxton;" however, judging from the spelling in the published calendars of the Public Record Office, "Claxton" is the usual way this name was spelled.

⁸⁷ The author wishes to acknowledge the Iowa State University's University Research Grant and the Sciences and Humanities Research Institute Grant which allowed him to examine material relevant to these manuscripts in the British Library and the Public Record Office, London, during the summer of 1979.

REVERSION FROM VARIEGATED TO GREEN
LEAF BLADES IN *OPLISMENUS HIRTELLUS*
(L.) BEAUV. (GRAMINEAE: PANICEAE)¹

Richard W. Pohl²

ABSTRACT. A single branch of a plant of *Oplismenus hirtellus* which bore longitudinally white-striped leaf blades reverted to producing all-green blades. The green branch greatly outgrew the striped parental form.

Oplismenus hirtellus is a common trailing tropical grass, spreading widely by stoloniferous rooting stems. A variegated-leaf form of this species, with alternating longitudinal white and green-striped leaf blades, is often cultivated under the name of "basket grass." While individual leaf blades of the variegated strain of *Oplismenus hirtellus* show wide variation in the relative amounts of green and colorless tissue, I had never previously seen individuals with entirely green leaf blades in our cultivated strain.

In fall of 1980 a plant in the Iowa State Botany greenhouse, which had variegated blades, produced a single branch with green blades. A portion of this plant, including the interconnected branch with green leaf blades, was washed free of soil to determine that the two strains were parts of a single individual, and it was replanted in a single pot. This plant was observed over a period of four months, after which the aerial parts were cut off and the green and variegated branches separately measured and dried to constant weight. While both the green-blade form and the variegated form continued to grow after transplanting, the green type far outstripped the variegated form in mean internode length, length of the longest branch, and dry weight of the vegetation produced (Table 1). The aspect of the colony was dominated by the green-blade form, and the striped-blade form became increasingly suppressed as growth proceeded (Figure 1). Other differences between the two forms included:

1. Blades of the green form were longer and wider than those of the variegated form. However, the length/width ratio was greater for the variegated blades.
2. Mean internode length for stems of the green form was nearly twice as great as that of the variegated form.
3. As an index of the greater vegetative vigor of the green form, the longest branch was 135 cm, whereas the longest branch of the variegated form was only 50 cm.
4. The green blades showed a prominent transverse rippling of the lamina, not evident in the variegated form.

¹ Journal Paper J-10430 of the Iowa Agriculture and Home Economics Experiment Station, Ames, Iowa 50011. Project 1833.

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Figure 1. *Oplismenus birtellus*. Interconnected variegated-leaf and green-leaf strains, showing overgrowth of the green form. Photo by H. T. Horner, Jr.

Table 1. Growth of green and variegated leaf forms of *Oplismenus hirtellus*

Strain	Length	Leaf Blade Width	L/W	Internode Length	Longest Branch	Dry Weight Entire Stems & Leaves (g)
	(mm)	(mm)	Ratio	(mean mm)	(cm)	
Variegated	48-72	8.5-16	5.4	21.5	50	6.0
Green	57-90	15-21	4.4	42.4	135	45.2

Variegated leaf forms with longitudinal leaf striping occur in a number of monocots, including *Agave*, *Sanseveria*, *Tradescantia* (Küster, 1927), and the grasses *Arundo donax* L., *Stenotaphrum secundatum* (Walt.) O. Kuntz, *Phalaris arundinacea* L. Such forms are often grown for ornament. Küster has previously reported reversions from variegated to green leaf forms in *Tradescantia*, *Zea*, and *Phaseolus* and called the phenomenon *regressive Panaschierung* (regressive mosaicism). I have observed apparent reversions to all-green forms in *Arundo donax* in Central America and *Stenotaphrum secundatum* in the greenhouse. The variegated leaf form of *Oplismenus hirtellus* would probably be strongly selected against in nature because of its inferior vigor. I have repeatedly observed this species in the wild in Central America and have never seen variegated forms, although they are commonly observed in cultivation in greenhouses.

LITERATURE CITED

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SCIENCE IN THE *JOURNAL DES SÇAVANS*, 1665-1666

Charles S. St. Clair*

ABSTRACT. The *Journal des sçavans*, the first scientific and literary journal was initially published in January 1665. It contained book reviews, articles, news notes, and editorial comment on a wide range of subjects. Natural science predominated. This paper describes representative reviews and articles dealing with natural science and ancillary subjects which were published in the *Journal* in 1665 and 1666. This sample of mid-seventeenth century science suggests a predominate interest in astronomy, human biology, and medicine.

Index words: periodical (seventeenth century), natural science (seventeenth century), physical science (seventeenth century), biological science (seventeenth century), Denys des Sallo (1626-1669), and Abbé Jean Gallois (1632-1707).

INTRODUCTION

The *Journal des sçavans*¹ is often characterized as the parent of scientific and literary journals. Founded during the seventeenth century at a time when existing means of disseminating information were generally inadequate, the *Journal*—neither book nor newspaper—was a new communication medium which soon was widely accepted. Denys de Sallo (1626-1669), who originated the idea, defined the *Journal's* purpose in the first issue. It was to catalog and summarize the most important books printed in Europe, to eulogize distinguished men, to report new discoveries and experiments in science as well as in the arts, and to report the decisions of secular and ecclesiastical tribunals. The value of such a publication, as de Sallo urged, was that the man of letters could use the *Journal's* pages to solicit comments on proposed works, the book buyer would be guided in his selection of books, and the man who could not afford to buy books would be able to learn about what transpired in the republic of letters.²

The first issue of de Sallo's *Journal* appeared on Monday, January 5, 1665 at Paris (Figure 1). It was published under a pseudonym but had full approval of the state. A new issue followed each Monday for twelve weeks. Following the issue of March 30, however, after a month-long dispute, the state suppressed the *Journal*. By expressing his opinions too freely, de Sallo had antagonized influential people who retaliated by silencing him.

The *Journal* resumed publication on Monday, January 4, 1666 under the editorship of Abbé Jean Gallois (1632-1707), who had worked with de Sallo the previous year. The only interruption³ of the weekly schedule during 1666 was Gallois' ten-week vacation in the fall.

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LE
JOURNAL
DES
SCAVANS.

De Lundy V. Janvier | M. DC. LXV.

Par le Sieur DE HEDOVVILLE.



A PARIS.

Chez IREAN CUSSON, rue S. Jacques, à l'ima-
ge de S. Jean Baptiste.

M. DC. LXV.

AVEC PRIVILEGE DV ROY.

Figure 1. Title page of the first issue of the *Journal des sçavans*, January 5, 1665. Photo courtesy of the History of Science Collections, University of Oklahoma, Norman, Oklahoma.

GENERAL CONTENT

The fifty-five issues of the *Journal* published between January 5, 1665, and December 20, 1666, contain 265 book reviews, sixty-one articles, and one eulogy. The books reviewed deal with a variety of subjects, and the articles vary considerably in content from one issue to the next. Articles, as used here, include news notices, extracts from letters or some other periodical, and editorials. The letter extracts may have been written to the editor or sent to him by a third party. The common practice of anonymity was an expedient way of avoiding entanglements. Book reviews usually consisted of summaries which presented the author's main point or purpose, followed by the reviewer's commentary. The greatest number of reviews was of books on natural science; reviews of theology were a close second with those of history, literature, and law following.⁴ Articles serving to inform readers of other activities in the arts and sciences drew their information from various sources. Most of them during the first two years were devoted to natural science.⁵

PHYSICAL SCIENCE CONTENT

During its first two years, the *Journal* reviewed thirty-three books dealing with physical science. Twelve of these books are about astronomy. A book by the Italian astronomer Guiseppe Campani (c. 1620-1695), according to one review, reported the confirmation of Christian Huygens' (1629-1695) observations of the rings of Saturn and the determination that Jupiter turns on an axis.⁶ Books dealing with comets received some attention after European astronomers observed a bright comet from December 1664 to February 1665. In discussing these books, the reviewer used astronomical terms such as celestial longitude and celestial latitude as if they would be well understood by his readers.⁷

During this period the *Journal* also published thirteen articles dealing with some phase of astronomy. Three articles concerning the '64-'65 comet appeared in 1665. The most extensive of these reports is of a meeting held January 10, 1665, at the College of the Jesuits in Paris, at which the causes and effects of comets were discussed. Giles Persone de Roberval (1602-1675) spoke in support of the opinion of Copernicus concerning the place and movement of the earth. He also thought comets were exhalations of the "sphere elementaire." Some of René Descartes' (1596-1650) ideas on comets were explained, and Adrien Auzout (d. 1691) suggested that the path of the comet was a circle oriented obliquely with respect to the ecliptic and the celestial equator. Finally, Father Jacques Grandami (1588-1672) expanded views, initially expressed nearly fifty years earlier, and shared by others, that comets are parts of the sky condensed by the action of stars. He reported the position of a comet on various days, measurements of its apparent motion, and presented a description of charts on which the course of the comet was plotted.⁸

Comets drew less attention in 1666. The single article about them dealt with a dispute over the comparative value of different sets of observational data.⁹ The astronomical attention (four reviews and two articles) instead concerned solar and lunar eclipses, in particular an eclipse of the moon on June 16, 1666, and of the sun on July 2, 1666. One review noted the extraordinary occurrences of an eclipse of both the sun and the moon only fifteen days apart

observed from the same place on earth. The other reviews dealt with the observation and presumed mechanics of eclipses.¹⁰ The articles about the eclipses are extracts from letters. The first was from Pierre Petit (1598?-1677), who described the eclipse of the moon as seen from Paris.¹¹ The second article is an extract from a letter written by Antoine François Payen (b. 1610?) in which he described the eclipse of the sun.¹²

Other astronomical articles include two observations, extracted from another periodical, made by Robert Hooke (1635-1703). The first concerns the faces seen in Mars and a description of their movement, which is said to imply axial rotation.¹³ The second extract concerns the planets Jupiter and Saturn.¹⁴ There was also a letter written by Johannes Hevelius (1611-1687) about a new star discovered in the constellation of Cygnus.¹⁵

Several other books on astronomy were reviewed. The astronomer Giovanni Domenico Cassini (1625-1712) reported the discovery of the rotation of Mars.¹⁶ In the April 19, 1666 issue, the *Journal* had carried a review of an ephemerides in which the author stated that celestial tables based on Johann Kepler's (1571-1630) hypothesis and Tycho Brahe's (1546-1601) observations are to be preferred over all others.¹⁷ Subsequently another book discussed the conjunctions of Saturn and Jupiter in 1663 and Saturn and Mars in 1666 and the fact that predictions of times of conjunction were incorrect by as much as six days.¹⁸ The anonymous author explained that the erroneous predictions were a result of incorrect observations about the motions of the sun and Saturn in the various tables. He concluded with the statement that celestial phenomena such as conjunctions are important because they provide astronomers with opportunities to verify tables by observation.¹⁹

Physical science material otherwise is miscellaneous. There were reviews of two books on the Nile River, one concerned with the source of that river²⁰ and the other one an explanation of the overflow of the Nile.²¹ A book which discusses the "stone" hematite²² is reviewed, and there is an article about mercury mining in Frioul, an area in the foothills of the Julian Alps.²³ Two articles²⁴ and one review were concerned with chemistry. The book reviewed was perhaps the equivalent of an elementary chemistry text. Suggesting that it facilitates elucidating the obscure terminology of chemistry, the reviewer says the book promises to define chemical terms, to set forth the principles of chemistry, and to explain the operations necessary for producing and transmuting metals.²⁵ In physics, there is a review of a treatise arguing that light is a substance²⁶ and an article about experiments performed with a large burning mirror.²⁷ Another review of a treatise intended for the instruction of ships' pilots contains a discussion of the variation of the magnetic needle.²⁸

BIOLOGICAL SCIENCE CONTENT

Reviews of thirty-four books dealing with biological science appeared during the *Journal's* first two years. These included both technical and popular reference treatises and a few general biological works.

Human biology was the most popular subject. Concerning a book in Latin by Martin Schoock (1614-1669) on sneezing, the reviewer said that the book is an explanation of the nature and function of the olfactory nerves.²⁹ Another review dealing with Descartes' *L'homme* summarizes his idea that the human body is a machine. Descartes included a section on the formation and

the development of the foetus. In this, says the review, Descartes expresses his opinion that the two sexes contribute to the formation of the foetus, which develops from the heart, the heart being the first part to form. The review declares that the book would have been unintelligible to most people if its editor had not added many explanations and diagrams.³⁰

A review of a medical text reports that the author, John Rogers (1627-1665?), believes that our bodies contain five *coctions*. These *coctions* serve both to maintain the individual and to propagate the species. The first *coction* is *chylose*, a preparation of chyle that is found in the stomach.³¹ The second, *chymose*, found in the lymph circuit, is said to be impure *chylose* in the process of being renewed. The third is *haematose*, a mixture of blood and vital spirit from the heart. The fourth is *pneumatose*, which is made in the brain and is used to generate the animal spirit and nervous juice. The fifth *coction* is *spermatose*; it is the reproductive *coction*. Roger, saying that many illnesses are brought about by some fault of these *coctions*, devoted much of his book to the causes and cures of illnesses caused by bad *coctions*.³² The influence of Galenic ideas is clear.

Some major medical problems of the 1660s can be inferred from the review of a book entitled *Questions of These Times* by the medical doctor Jacques Chaillou (1636?-1720). The review does not present the author's thoughts and conclusions on the problems; it just lists those considered in the book, namely, (1) the place of origin of blood,³³ (2) the circulation of the blood, (3) the different kinds of fevers, (4) the heart and its ducts, and (5) the production of milk.³⁴

Anatomical inquiry in the middle 1660s apparently followed many avenues. A book concerned with foetal development, a review said, explains conception, differentiation of the various parts of the body, nourishment of the embryo, and finally how the embryo can live for about seven months within the mother without breathing.³⁵ Other books include a treatise on the valves in the blood vessels,³⁶ a report on numerous animal dissections,³⁷ and a study of the nature and uses of pancreatic juice (said to be based largely on experiments performed on dogs).³⁸ A treatment of the thoracic canal and the origin of blood³⁹ are the subjects of a book which mentions a secret method for embalming bodies and discusses the dissection of living animals.⁴⁰

Some medical works claimed to be drawn largely from classic authorities as Avicenna (980-1037) or Hippocrates (c. 460-c. 377 B.C.).⁴¹ One book, equivalent of a pharmaceutical treatise, is on theriacs (antidotes) and nostrums (medicines).⁴² One disparaging review is of a book concerning the deleterious effects of tea and tobacco.⁴³

Four of seven articles published dealing with the biological sciences are medically oriented and concern the delights and ill effects of chocolate,⁴⁴ the poisonous nature of medicines made with antimony,⁴⁵ a post-mortem performed on a person who had been struck down by lightning,⁴⁶ and a report of an abnormal birth. The latter, an extract of a letter written in November 1664, begins: "About three weeks ago . . . the wife of a groom . . . gave birth . . . to a child which had two diametrically opposed heads, four arms, and as many hands, one abdomen and two feet. For a long time they were at a loss how they must baptize this creature. At last they decided she was double, and they gave her the names Martha and Mary. She took food by both heads, and excreted in the ordinary way. . . . This monster lived only about two days." A doctor

performed a post-mortem, the article continues, and "he found the two heads and the two chests very perfect but the belly was not. There was only one intestine, one bladder, and one womb. But it had two livers, two spleens, and two stomachs. They have embalmed this monster, and preserved it carefully."⁴⁷

Beyond the natural interest in human beings, biology as otherwise represented in the subject year of the *Journal* is miscellaneous in scope. Of such, the major work reviewed is a two-volume comprehensive treatment of both plants and animals.⁴⁸ The other reviews included one on vipers,⁴⁹ one on butter,⁵⁰ and one on the newly introduced substance called chocolate.⁵¹ Other articles deal with whales,⁵² ship-worms,⁵³ and glow-worms.⁵⁴

CONTENT IN AREAS ANCILLARY TO NATURAL SCIENCE

In 1665-1666 the *Journal* carried eight articles describing new inventions and new uses of existing devices. Included are descriptions of Huygens' pendulum clocks⁵⁵ and of Robert Boyle's (1627-1691) experiments with a mercury baroscope which he had used in predicting the weather.⁵⁶ The last *Journal* of 1666 has an extensive, illustrated review of Robert Hooke's well-known *Micrographia*.⁵⁷

Several reviews are of books that are related to science, although they do not deal with science. One example is the review of John Graunt's (1620-1674) now well known *Natural and Political Observations Made Upon the Bills of Mortality*. Among other things, the review gives Graunt's estimate of the birth and death rates for London, as well as the estimated population. The review ends noting that on the average four children are produced from each marriage, and the average London family has eight members.⁵⁸ Finally, there is a review of a book on science that proposes to explain physics, but includes also logic, metaphysics, mathematics, and biology.⁵⁹ It seemed to be an unsuccessful attempt to explain all aspects of science.

IN SUMMARY

This sample of discourse about mid-seventeenth-century science suggests that in the physical sciences, interest in astronomy was predominant, whereas in biology, it was of the human body and its ailments. Otherwise, people wrote about the unusual and uncommon, of distant places, and of exotic things.

THE JOURNAL AFTERWARDS

From 1667 to 1674 publication of the *Journal* was sporadic; only forty-seven issues appeared during the final eight years of Gallois' editorship. From 1675 for nearly fifty years, a number was published weekly or bi-weekly with greater regularity. One exception was the suspension of publication from December 24, 1686 to November 16, 1687. Beginning in 1724 the *Journal* adopted a monthly publication schedule. From its beginning, an edition was also published in Amsterdam, and at various times other editions of the *Journal* were published at Lyons, Cologne, and Leipzig.⁶⁰ The *Journal* continues today under the name of *Journal des savants*.

NOTES

¹ The original typography, *IOVRNAL DES SÇAVANS* (see Figure 1), is not followed for the title of this journal because it is usually rendered *Journal des sçavans*. In all other cases, however, titles are rendered faithful to the original typography except where words appear in all capital letters.

² "L'imprimeur au lecteur," *Journal des sçavans*, [I] (January 5, 1665), [iii-iv]. Hereinafter the *Journal des sçavans* is cited as *Jds*. On the early history of journals and the periodical press see Sherman B. Barnes, "The Editing of Early Learned Journals," *Osiris*, I (1936), 155-72; Harcourt Brown, *Scientific Organizations in Seventeenth Century France (1620-1680)* (New York: Russell & Russell, 1967); [Denis François Camusat], *Histoire critique des journaux. Par M. C **** (Amsterdam: J. F. Bernard, 1734); David A. Kronick, *A History of Scientific and Technical Periodicals: The Origins and Development of the Scientific and Technical Press 1665-1790* (New York: The Scarecrow Press, Inc., 1962); and Betty Trebelle Morgan, *Histoire du Journal des sçavans depuis 1665 jusqu'en 1701* (Paris: Les Presses Universitaires de France, 1929).

³ [Camusat], I, 29-33.

⁴ The total number of books reviewed in the *Journal* in 1665-1666 by subject is: natural science, 67 (biological, 34; physical, 33); theology, 57; history, 39; literature, 23; law, 14; areas ancillary to science, 13; biography, 10; philosophy, 9; political science, 9; memoirs, 8; and other areas, 16.

⁵ The total number of articles in the *Journal* in 1665-1666 by subject is: natural science, 37 (biological, 10; physical 27); areas ancillary to science, 10; political science, 2; law, 1; theology, 1; and other areas, 10.

⁶ "Ragguaglio di nuove osservazioni, da Giuseppe Campani. in 12. In Roma," *Jds*, [I] (January 5, 1665), 3-5.

⁷ Examples of reviews of books about comets are found in "Le cours de la comete, avec un traité de sa nature, de son mouuement & de ses effets. Présenté à Monseigneur le Prince par le Pere Grandamy, de la Compagnie de Iesus. A Paris chez S. Cramoisy, ruë S. Iacques. In 4," *Jds*, [XII] (March 23, 1665), 137-38; "Le courier de traverse, ou le tricomete obserué à Oxfort. Traduit de L'anglois de Monsieur de Fortfischer. A Paris chez Iacques Bouillerot, au Palais," *Jds*, [XIII] (March 30, 1665), 147-48; "Ioh. Hevelii prodromus cometicus. In fol. Gedani 1665. Et se trouue à Paris chez Piget," *Jds*, [IX] (March 1, 1666), 110-113; and "Dissertation sur la nature des Comets, par M. Petit Intendant des Fortifications. In 4. A Paris chez L. Billaine, au Palais, 1665," *Jds*, [XII] (March 22, 1666), 142-46 [misnumbered 242-46].

⁸ "De la comete," *Jds*, [IV] (January 26, 1665), 41-48.

⁹ "Extrait du Iournal d'Angleterre. Sentiment des Astronomes d'Angleterre sur la contestation arriüée entre deux sçauans hommes, touchant vne obseruation faite de la premier des deux dernieres Cometes," *Jds*, [XIII] (March 29, 1666), 160.

¹⁰“Aenigma astronomicum, adulterium Solis & Lunae visibile in Hemisphaerio Parisiensi anno 1666. Die 16. Iunii. In 4. Parisiis, apud L. Billaine, & Ioann. Cusson via Iacobaea,” *Jds*, XXII (May 31, 1666), 254-55; “Deux eclipses en l’espace de 15. iours dechiffrees par le P. Grandamy de la Comp. de Iesus. A Paris chez Seb. Mabre-Cramosy. In 4,” *Jds*, XXIII (June 7, 1666), 269-70; “Emblema astronomicum, sol larvatus anno 1666. die 2. Iulii, hora 6. matutina. In 4. Parisiis apud Lud. Billaine in Aula Palatii, & Ioan. Cusson, via Iacobaea,” *Jds*, XXV (June 21, 1666), 291-92; and “Relation de l’eclipse horizontale de Lune obseruée en l’isle de Gorgone le 16 Iuin 1666. par l’ordre du Serenissime Prince Leopold: avec les reflexions de M. Payen. In 4. A Paris chez L. Billaine au Palais. & I. Cusson ruë S. Iacques,” *Jds*, XXXVI (September 6, 1666), 426-30).

¹¹“Extrait d’une lettre de Monsieur Petit Intendant des Fortifications, à Monsieur Galloys Prestre, sur l’Eclipse de Lune du 16. Iuin, & sur vn passage de Pline restitué à ce propos,” *Jds*, XXV (June 21, 1666), 295-98.

¹²“Extrait d’une lettre de M. Payen Aduocat au Parlement à M. de Montmor premier Maistre des Requestes de L’Hostel du Roy: touchant l’Eclipse arriüée le 2. Iuillet. 1666. A Paris chez L. Billaine au Palais, & I. Cusson ruë S. Iacques,” *Jds*, XXVIII (July 12, 1666), 332-34.

¹³“Extrait du Iournal d’Angleterre, Contenant les particularitez de quelques obseruations qui ont esté faites à Londres au mois de Fevrier & de Mars dernier touchant la planette de Mars,” *Jds*, XXXIV (August 23, 1666), 403-06.

¹⁴“Extrait du Iournal d’Angleterre, Contenant quelques nouuelles Obseruations faites à Londres touchant la Planete de Iupiter,” *Jds*, XXXV (August 30, 1666), 416-18.

¹⁵“Extrait d’une lettre de Monsieur Heuelius écrite à Monsieur Payen Aduocat au Parlement, touchant l’Obseruation de la nouvelle étoile découuerte dans la constellation du Cygne,” *Jds*, XLI (December 13, 1666), 486-90.

¹⁶“Martis circa axem proprium reuolubilis Obseruationes. Bononiae à Io. Dominico Cassino habitae. Romae, 1666,” *Jds*, XXII (May 31, 1666), 259-62.

¹⁷“Iohan. Heckeri motuum celestium Ephemerides ab anno 1666, ab annum 1680. ex obseruationibus correctis Tychoonis Brahei, & Iosephi Kepleri Hypotesibus Physicis Tabulisque Rudolphinis. In 4. A Paris chez Piget, ruë S. Iacques, 1666,” *Jds*, [XVI](April 19, 1666), 192-93.

¹⁸“Monopolion caeleste conjunctionis Saturni & Iouis anni 1663. & coniunctionis Saturni & Martis anni 1666. Parisiis, Apud Ioannem Cusson,” *Jds*, XXXVIII (November 22, 1666), 453-54.

¹⁹The conjunction of Saturn and Jupiter preceded the prediction based on the tables of Andrea Angoli (1570-1657) by six days, those of Lorenz Eichstadt (1595-1660) by five days, those of Kepler by three days, those of Father Giovanni Battista Riccioli (1598-1671) by three days, and the conjunction was a day later than predicted by the tables of Philips van Lansberge (1561-1632).

²⁰“Isaacus Vossius de Nili et aliorum Fluminum origine. In 4. Hagae-Comitis. Et se trouue à Paris chez Seb. Mabre-Cramoisy,” *Jds*, XXXIII (August 16, 1666), 383-88.

²¹“Discours sur les causes du débordement du Nil, par Monsieur de la Chambre. In 4. A Paris chez Claude Barbin au Palais,” *Jds*, XXV (June 21, 1666), 287-91 [pp. 287-90 misnumbered 283-86].

²²“Ioh. Laur. Bauschi schediasmata bina de Lapide haematite & aetite. In 8. Lipsiae. Et se trouue à Paris chez Piget,” *Jds*, XXXVII (November 15, 1666), 437-38.

²³“Extrait du Journal d’Angleterre, Touchant vne Mine de Mercure qui est dans le Frioul, & la maniere de faire du vent par la cheute de l’eau,” *Jds*, [XIV] (April 5, 1666), 169-72. The mining area of Frioul (or Friuli) is more commonly referred to by the town of Idria (once Italy, now Yugoslavia), which is the world’s second largest producer of mercury.

²⁴“Extrait du Journal d’Angleterre,” *Jds*, [V] (February 1, 1666), 65-66; and “Extrait du Journal d’Angleterre, Touchant vne nouvelle maniere de produire en vn moment vn degré considerable de froid, sans se servir de neige, de glace ou de nitre, & cela en quelque temps de l’année que ce soit, communiquée par M. Boyle,” *Jds*, XXXIII (August 16, 1666), 391-94.

²⁵“Ioannis Ioachimi Becheri Oedipus Chemicus. Amstelodami,” *Jds*, [I] (January 4, 1666), 12-13.

²⁶“Physico-mathesis de lumine, Coloribus & iride. Auct. Franc. Maria Grimaldo Soc. Iesu. Bononiae. In 4, Et se trouue à Paris chez Sim. Piget,” *Jds*, XXXV (August 30, 1666), 407-12.

²⁷“Extrait d’une Lettre écrite de Lion, touchant vn Miroir Ardant fait par M. Villette,” *Jds*, [X] (March 8, 1666), 125-26; and “Autre Extrait d’une lettre écrite de Paris à Londres sur le mesme miroir,” *Jds*, [X] (March 8, 1666), 126.

²⁸“Traitté de la variation de l’aiguille aimantée, par Guillaume Denis. A Dieppe. Et se trouue à Paris chez Seb. Mabre-Cramoisy. In 4,” *Jds*, XXVII (July 5, 1666), 315-16.

²⁹“Martini Schoockii de sternutatione. Amstelodami,” *Jds*, [I] (January 5, 1665), 7-8.

³⁰“L’homme de René Des Cartes, avec vn traité de la formation du Foetus du mesme Auteur. A Paris,” *Jds*, [I] (January 5, 1665), 9-11.

³¹The stomach and intestines were probably included in the one term.

³²“Analecta inauguralia, seu disceptationes Medicae Doctoris Ioannis Rogersii. Londini. In 8,” *Jds*, [VI] (February 9, 1665), 65-67.

³³The controversy was whether the blood originated in the heart or in the liver.

³⁴“Questions de ce temps. Par Maistre Jacques Chaillon, docteur en medecine. In 8. A Angers, & se trouue chez Solly, ruë S. Jacques,” *Jds*, [IX] (March 2, 1665), 105-06.

³⁵“Genesis microcosmi, seu de generatione fetus in utero. Authore Antonio Dusingio. Amstelodami. in 12,” *Jds*, [XVII] (April 26, 1666), 199-202.

³⁶“Frederici Ruysch doctoris medici dilucidatio Valvularum in vasis lymphaticis & lacteis. Hagae-Com. 1666. In 12,” *Jds*, XX (May 17, 1666), 237-39.

³⁷“Laurentii Bellini exercitatio Anatomica de structura & vsu Renum. Amstelodami. In 12,” *Jds*, XXII (May 31, 1666), 255-57 [p. 257 misnumbered 267].

³⁸“Traitté de la nature et de l’usage du Suc Pancreatique, par Regnier de Graef Medecin Hollandois. In 12. A Paris chez Oliuier de Varennes dans la galerie des Prisonniers,” *Jds*, XXXI (August 2, 1666), 367-70.

³⁹The author believed blood was formed in the liver.

⁴⁰“Iac. Henr. Paulli anatomiae Bilsianae Anatome, cui accessit Io. Iac. Wepferi de dubiis Anatomicis Epistola cum Responsione. In 8. Argentorati. Et se trouuent à Paris chez Piget,” *Jds*, XXXVIII (November 22, 1666), 448-49.

⁴¹For example, “Petri Michaelis de heredia regis Catholici Archiatri Opera Medica. Lugduni. Et se trouuent à Paris chez Seb. Cramoisy & Seb. Mabre Cramoisy. In fol. 2 Volumes,” *Jds*, XXVII (July 5, 1666), 316-19.

⁴²“Remarques curieuses sur la theriaque. avec vn excellent traitté de l’Oruietan, par I. Riollot Docteur en Medecine. In 8. A Bordeaux. Et se trouue à Paris chez Fred. Leonard,” *Jds*, XLI (December 13, 1666), 485-86.

⁴³“Simonis Paulli medici regis Daniae Commentarius de abusu Tabaci & Herbae Théae. Argentorati. In 12. Et se trouue à Paris chez Piget,” *Jds*, XXIX (July 19, 1666), 335-39.

⁴⁴*Jds*, [IV] (January 25, 1666), 54.

⁴⁵“Decret de la faculté de medecine & Arrest du Parlement touchant l’usage de l’Antimoine,” *Jds*, XXIII (June 7, 1666), 271-74 [pp. 273-74 misnumbered 73-74].

⁴⁶“Extrait d’une lettre escrite d’Oxford le 12. May 1666. par Monsieur Vvallis, & inserée dans le Journal d’Angleterre, touchant la visite d’un corps mort frappé du tonnerre,” *Jds*, XXIX (July 19, 1666), 343-46.

⁴⁷“Extrait d’une lettre escrite d’Oxford, le 12. Nouembre 1664,” *Jds*, [I] (January 5, 1665), 11-12.

⁴⁸“Honorati Fabri Soc. Iesu theologi Tractatus duo, quorum Prior est de Plantis & de Generatione Animalium, Posterior de Homine. In 4. Parisiis apud Franc. Muget viâ Citharae,” *Jds*, XXXIV (August 23, 1666), 395-400.

⁴⁹“Osservazioni intorno alle vipere, fatte da Francesco Redi, in Firenze. in 4,” *Jds*, [I](January 4, 1666), 9-12.

⁵⁰“Martini Scoockii tractatus de Buthiro. Accessit eiusdem diatriba de auersatione casei. In 12. Groningae, & se trouue à Paris chez R. Ninuile, ruë de la Harpe,” *Jds*, [XIII](March 30, 1665), 153-55.

⁵¹“Francisci Mariae Cardinalis Brancatii de vsu Chocolatis diatriba. Romae. In 4,” *Jds*, [III](January 18, 1666), 29-32.

⁵²“Extrait du Iournal d’Angleterre,” *Jds*, [VI] (February 8, 1666), 76-78.

⁵³“Extrait d’une lettre escrite d’Amsterdam,” *Jds*, [VII](February 15, 1666), 89-90.

⁵⁴“Extrait d’une lettre de M. Auzout à M. de la Voie, du 31. Mars. 1666,” *Jds*, [XV](April 12, 1666), 181-82.

⁵⁵Three articles on pendulum clocks appeared in the *Journal* in 1665: “Extrait de deux lettres. L’une escrite de Londres, & l’autre de la Haye, touchant l’vsage des Pendules, pour trouuer les longitudes sur la mer,” *Jds*, [VIII] (February 23, 1665), 92-96; “Extrait d’une Lettre écrite de la Haye le 26. Fevrier 1665,” *Jds*, [XI] (March 16, 1665), 130-32; and “Observation à faire sur le dernier article du precedent Iournal, où il est parlé de la Concordance de deux pendules suspenduës à trois ou quatre pieds l’une de l’autre,” *Jds*, [XII] (March 23, 1665), 143-44.

⁵⁶“Extrait du Iournal d’Angleterre, contenant quelques obseruations faites par Monsieur Boyle, & tirées d’une de ses lettres touchant le Baroscope & le moyen de peser l’air,” *Jds*, [XVII](April 26, 1666), 205-08.

⁵⁷“Micrographia, or some physiological descriptions of minute Bodies made by magnifying glasses, with obseruations and inquiries thereupon, by R. Hooke fellow the Royal Society. In fol. London,” *Jds*, XLII (December 20, 1666), 491-501.

⁵⁸“Natural and Political Observations made vpon the Bills of Mortality, by Iohn Graunt. London. In 4,” *Jds*, XXXI (August 2, 1666), 359-64 [pp. 363-64 misnumbered 369-70].

⁵⁹“Placita philosophica Gvarini Guarini Clerici Regularis, vulgo Theatini, In fol. Parisiis, apud Dionys. Thierry,” *Jds*, XXXIX (November 29, 1666), 461-62.

⁶⁰I am grateful to Professor Thomas M. Smith and the history of science seminar at the University of Oklahoma and to Jean Busfield at Michigan State University for their valuable comments on this paper.

ESTIMATION OF TOTAL-PLANT LEAF AREA IN GRAIN SORGHUM¹

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ABSTRACT. Relationships between the area of individual leaves and leaf area of the whole plant in grain sorghums (*Sorghum bicolor* (L.) Moench) were examined by using correlation and regression procedures. Our objectives were to identify the individual leaf or leaves most closely associated with total-plant leaf area and to establish the appropriate prediction equation for estimation of total-plant leaf area from the area of that leaf. The results indicate that the fourth leaf from the top of the plant serves best for estimating total-plant leaf area. Commonly the largest leaf, it showed moderately good coefficients of determination with total-plant leaf area across diverse environments and genotypes. The regression coefficient of the prediction equation seemed the most useful parameter for estimating total-plant leaf area, i.e., the multiplication of the area of this leaf by the coefficient $b = 5.06$. This procedure will be useful for investigations that require primarily a relative ranking among entries for total-plant leaf area. No single-leaf measurement, however, can accurately predict total-plant leaf area because both genetic and complicating environmental influences are manifested in the development of individual plants. No single leaf accurately reflects these influences. Precise data for total-plant leaf area is presently attainable only by the measurement of all leaves.

Additional index words: *Sorghum bicolor* (L.) Moench, vegetative growth, plant architecture.

INTRODUCTION

Fast and reliable estimation of actual leaf area is an objective sought by many investigators. Studies of plant development and growth may require the determination of leaf areas at several stages of growth. Plant breeders and crop physiologists, however, are often interested primarily in the leaf area of fully developed plants as a crop community. A simple procedure that provides a reliable estimate of total-plant leaf area will be most useful.

Total-plant leaf area in grasses can be obtained by summing estimates of the areas of all leaves of a plant, or the areas of alternate leaves may be estimated and the summation doubled. Both procedures are laborious and time consuming. In sorghum (*Sorghum bicolor* (L.) Moench), multiplying the length of a leaf by its maximum width and then by the factor 0.75 has been suggested for estimating the area of an individual leaf (Stickler et al., 1961). Measuring leaves from early vegetative stages to completion of plant growth, Bueno and

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Atkins (1981) concluded this procedure estimates the area of most leaves with reasonable accuracy but tends to overestimate the area of small leaves.

More rapid methods for the estimation of total-plant leaf area in grasses have been proposed. McKee (1964) developed the leaf-area coefficient of 6.67 in maize (*Zea mays* L.) by dividing the total-plant leaf area by the accumulated length of all leaves. Francis et al. (1969) suggested that a leaf-area coefficient should be developed by dividing the total-plant leaf area by the area of the largest leaf. This procedure would likely result in different leaf area coefficients for different maize genotypes and for different environments.

Pearce et al. (1975) found that the area of the eighth leaf from the top in maize was highly correlated with total-plant leaf area. This leaf also had one of the largest mean areas when measured over a number of genotypes. The regression of total-plant leaf area on the area of leaf number eight was computed, and the regression coefficient ($b = 9.39$) was considered a reliable leaf-area coefficient for the estimation of total plant leaf area in maize. Their procedure is rapid and requires length and width measurements from only one leaf per plant using one to several plants per genotype and/or experimental treatment.

Five methods for estimating plant leaf area in maize were compared by Fakorede et al. (1977). They found that the method developed by Pearce et al. (1975) differed significantly from the other four and suggested that one should not use a single leaf area coefficient unless it was developed from data obtained over several years and locations.

We have seen only a simple comparable study for sorghum. Krishnamurthy et al. (1974) found that leaf number four from the top of the plant for two genotypes and number six from the top in a third were the most highly correlated with total plant leaf area. The regressions of total-plant leaf area on the areas of leaves four and six were computed, and regression coefficients of 4.11 and 5.05 for leaf four and 5.87 for leaf six were obtained. They concluded that there is no single sorghum leaf which can be used as the basis of leaf area estimation and proposed that different leaf-area coefficients should be developed for each specific situation.

The usefulness of a leaf-area estimation procedure that requires the measuring of only a few leaves on each plant is obvious. The objective of our research was to identify the individual sorghum leaf or leaves most closely associated with total-plant leaf area and to establish the appropriate prediction equation for estimation of total-plant leaf area from the area of that leaf.

MATERIALS AND METHODS

To study the growth pattern of a community of plants, growth parameters need to be calculated several times and leaf area measurements are required at several stages of plant development. The results presented in this paper were obtained from such experiments conducted over a three-year period at the Iowa State University Agronomy Research Farm near Ames, Iowa. Sorghum for Experiments One and Two, grown in 1976 and 1977, respectively, was planted somewhat after the usual time (July 2 and June 15). However, conditions for growth were favorable; the plants developed rapidly and assumed normal stature. Sorghum for Experiment Three was grown in 1978 and was planted at a more normal date, May 26.

Experiments One and Two were arranged in split-plot designs, with row spacing as whole plots and a 2 x 2 factorial combination of hybrids (tall and short) and plant densities (low and high) randomized as subplots, with three replicates of each plot type. Rows were spaced 51, 76, or 102 cm apart, and plant densities were 128 and 256 thousand plants/ha. The genotypes tested each year were near-isogenic hybrids. In 1976, the "tall" hybrid was 'A Combine Kafir 60' x 'Redbine 60' and the "short" hybrid was 'A Tx616 Kafir' x 'Redbine 60.' In 1977, the female parents again were 'A CK60' and 'A Tx616 Kafir,' while the male parent was 'Tx7078.' Each experimental unit (plot) consisted of three rows 6.1 m long, and each unit was replicated three times.

Eighty days after planting (soft dough, stage seven, Vanderlip and Reeves, 1972), leaf length and maximum leaf width were measured in the field on all leaves of all plants of Experiment One. Leaves were stripped and numbered in descending sequence from the plants, placed on marked boards, and length and maximum width were measured to the nearest cm and mm, respectively. Leaf areas were later calculated by using the formula $A = L \times W \times 0.75$, as proposed by Stickler et al. (1961).

Leaf-area measurements were made in Experiment Two from early vegetative stage until plants were approaching maturity. Beginning at 30 days after planting (seedling, stage two⁺; Vanderlip and Reeves, 1972) and continuing each ten days thereafter until 70 days after planting (half bloom, stage six; Vanderlip and Reeves, 1972), ten consecutive plants in each plot were pulled from the soil, and the roots discarded. Five plants per plot were sampled at the 80-, 90-, and 100-day intervals (dough stage to physiological maturity, stages seven through nine; Vanderlip and Reeves, 1972). Only normal and competitive plants were sampled. Leaves from each plant were first detached, stacked, and numbered in ascending order of occurrence on the plant. They were then secured with rubber bands and wrapped with wet paper towels. Each bundle of plants was identified by plot number, placed in a styrofoam box, and stored in a cold room (ca 4.5C) to prevent wilting. Areas of individual leaves were measured to the nearest mm² by using a Licor Model LI3000 portable area meter. In Experiment Two the first true leaf which developed after the cotyledonary leaf was designated number one, but it was never measured because it was very small and was no longer attached to most plants at the first sampling date.

The entries in Experiment Three were ten commercial hybrids that had been tested extensively in Iowa. This group spans the range of commercially available sorghum hybrids for agronomic traits and for diversity of commonly used male and female parents. The row spacing was 102 cm; plant density was 128 thousand plant/ha; and the entries were arranged in a randomized complete block design with three replicates. Plots were single rows 4.3 m long, with data recorded from plants in the center 3.0 m. The leaf area measurements presented in this paper were taken at 80 days past planting (stage seven) in the manner described for Experiment Two, but ten plants were sampled from each plot and leaves were numbered in descending sequence. The mean grain yield for the ten hybrids in an adjacent three-replicate test was 75 q/ha.

RESULTS AND DISCUSSION

For a leaf-area estimation procedure to be useful practically in a breeding program, a single coefficient that provides estimates that do not deviate significantly from the actual plant leaf area seems necessary. To satisfy this requirement, the regression equation that is developed should have an intercept value not significantly different from zero and a large coefficient of determination.

Areas estimated for the individual leaves in Experiment One were pooled over row spacings, plant densities, and height genotypes (hybrids), because areas were not influenced appreciably by these variables. Average areas ranged from 110 cm² for the flag leaf to 312 cm² for the fourth leaf from the top. Leaves five (300 cm²) and three (285 cm²) were the next largest. Regression of total-plant leaf area on the area of leaves three, four and five were computed from the pooled data and the parameters from these equations are presented in Table 1. The intercept values of the equations are large, and they are significantly different from zero. Regression coefficients ranged from 4.43 to 5.65. Data recorded for all leaves showed a clear trend for the larger leaves to have a closer association with total-plant leaf area. But the coefficients of determination for the largest leaves were only moderate, ranging from 0.60 to 0.76.

Data obtained from the periodic samplings of Experiment Two provided an opportunity for further evaluation of the utility of different sorghum leaves as indicators of total-plant leaf area. Coefficients of determination for the area of each leaf with total-plant leaf area are shown for Experiment Two in Table 2. The values listed are for the data pooled over row spacings, plant densities, and hybrids since these variables did not influence leaf area appreciably. Leaves were numbered from the base of the plant; therefore, leaf 16 was the flag leaf. Leaves two, three, four, and five were fully extended at 30 days after planting; leaves seven, eight, nine, and ten had reached their maximum area by 40 days after planting; and leaves 11 through 16, as well as the total-plant leaf area, attained maximum area by 50 days after planting.

At 30 days after planting, the leaf with the highest coefficient of determination was number seven from the base of the plant. This leaf while the largest leaf at that time was not fully extended. At 40 days past planting, the leaf most highly associated with total-plant leaf area was number 11, which was the second largest leaf, and again it was not fully extended. At 50 through 100 days after planting, leaf 13 (i.e., the fourth leaf from the top of the plant) had the highest coefficient of determination with total-plant leaf area. This leaf was the third largest on the plant, and it was fully developed at 50 days after planting.

Table 3 presents data from the regressions of total-plant leaf area on area of the most highly correlated leaf for Experiment Two. The values were computed from the data pooled over row spacings, plant densities, and hybrids at each of the sampling intervals. The intercepts for all equations are significantly different from zero, and most have a rather large positive value. As one might expect, the values for each parameter are similar from 50 through 100 days past planting because total-plant leaf area changed very little during that

Table 1. Sorghum leaf area, Experiment One. Y intercepts (a), regression coefficients (b), standard errors of the intercept (sd_a), standard errors of the regression coefficient (sd_b), and coefficients of determination (r^2) obtained by regression of total-plant leaf area on area of leaves three, four, and five from the top at 80 days after planting, Ames, Iowa, 1976.

Leaf Number	a ⁺	b	sd_a	sd_b	r^2
3	197.89	4.43	26.77	0.091	0.60
4	-221.99	5.39	25.55	0.080	0.74
5	-220.43	5.65	25.28	0.082	0.76

⁺ All intercept values are significantly different from zero ($P < 0.01$)

period. The regression coefficients were appreciably smaller at 30 and 40 days after planting indicating that at these vegetative stages of development different leaf-area coefficients would be required for estimation of total-plant leaf area.

The regression coefficients obtained at 50 through 100 days after planting (Table 3) are similar to those obtained for leaf four in Experiment One (Table 1). This is not surprising inasmuch as the genotypes used in the two experiments are similar and planting arrangements were alike. However, there is a marked difference in the complete prediction equations because of a striking divergence in the intercept values in the two years. This suggests that the regression coefficients may not change appreciably over different environments but that the prediction equations may change because of differences in the intercept value. It seems, therefore, that use of a single regression equation as a leaf area factor would not estimate plant leaf area similarly over different environmental conditions.

The results from Experiments One and Two indicated that regression coefficients of the prediction equations were relatively constant over a range of environmental conditions. Data obtained in Experiment Three serve similarly for an evaluation of the variability of regression coefficients over a diverse group of genotypes. Average areas for individual leaves of each hybrid differed widely, and areas of the largest leaf ranged from 377 to 533 cm² among hybrids. The largest leaf on two hybrids was the third from the top, on five hybrids it was the fourth, and on three hybrids the fifth from the top was the largest. Although this shows that position of the largest leaf varies with genotypes, the fourth leaf from the top was the largest when the areas for each leaf were averaged over all hybrids (Table 4). Coefficients of determination between the area of individual leaves and total-plant leaf area across all hybrids also are shown in Table 4. Leaves four, five, and six combine a large average leaf area and a fairly good association with total-plant leaf area.

Table 2. Sorghum leaf area, Experiment Two. Coefficients of determination for total-plant leaf area and the area of individual leaves, computed from data pooled over row spacings, plant densities, and hybrids at each sampling interval, Ames, Iowa, 1977.

Leaf Number	Days after planting							
	30	40	50	60	70	80	90	100
2	0.13	—	—	—	—	—	—	—
3	0.13	0.08	—	—	—	—	—	—
4	0.11	0.13	—	—	—	—	—	—
5	0.13	0.08	—	—	—	—	—	—
6	0.37	0.20	0.18	—	—	—	—	—
7	0.81	0.27	0.21	0.14	0.14	0.09	0.11	—
8	0.70	0.10	0.14	0.07	0.07	0.06	0.09	0.11
9	0.49	0.11	0.20	0.12	0.19	0.10	0.13	0.25
10	—	0.58	0.30	0.26	0.21	0.22	0.23	0.22
11	—	0.87	0.60	0.54	0.56	0.51	0.50	0.45
12	—	0.75	0.87	0.84	0.82	0.81	0.83	0.79
13	—	0.39	0.92	0.89	0.87	0.84	0.86	0.86
14	—	—	0.89	0.85	0.85	0.80	0.82	0.82
15	—	—	0.79	0.72	0.74	0.65	0.68	0.67
16 (flag)	—	—	0.49	0.30	0.40	0.27	0.50	0.26

Table 3. Sorghum leaf area, Experiment Two. Y intercepts (a), regression coefficients (b), standard errors of the intercept (sd_a), standard errors of the regression coefficient (sd_b), and coefficients of determination (r^2) obtained by regression of the total-plant leaf area on area of the most highly correlated leaf at each sampling interval, Ames, Iowa, 1977.

Days after planting	a ⁺	b	sd_a	sd_b	r^2	Leaf Number
30	56.99	2.95	10.51	0.107	0.81	7
40	591.23	3.01	19.77	0.088	0.87	11
50	568.31	5.05	40.36	0.157	0.84	13
60	578.22	5.08	32.42	0.119	0.91	13
70	576.99	5.17	41.09	0.148	0.87	13
80	659.39	4.82	41.80	0.155	0.84	13
90	597.73	5.05	39.89	0.150	0.86	13
100	429.24	5.11	42.24	0.154	0.86	13

⁺ All intercept values are significantly different from zero ($P < 0.01$)

Table 4. Sorghum leaf area, Experiment Three. Average area (cm^2) at 80 days after planting for individual leaves, their coefficients of determination (r^2) with total-plant leaf area, and number of observations computed from data pooled over ten sorghum hybrids, Ames, Iowa, 1978.

Leaf number	Average leaf area	r^2	Number of observations
1 (flag)	167	0.01	300
2	316	0.03	300
3	408	0.19	300
4	443	0.64	300
5	421	0.78	297
6	367	0.81	290
7	304	0.77	271
8	246	0.63	233
9	179	0.51	191
10	138	0.39	91
11	135	0.60	21
12	117	0.22	5

Table 5. Sorghum leaf area, Experiment Three. Y intercepts (a), regression coefficients (b), standard errors of the intercept (sd_a), standard errors of the regression coefficient (sd_b), and coefficients of determination (r^2) obtained by regression of total-plant leaf area at 80 days after planting on area of leaves four, five, and six from the top of the plant, Ames, Iowa, 1978.

Leaf number	a ⁺	b	sd_a	sd_b	r^2
4	-41.69	6.27	122.96	0.271	0.64
5	329.69	5.76	77.07	0.177	0.78
6	837.39	5.28	58.72	0.152	0.81

⁺ Intercept value not significantly different from zero

Parameters from the regressions of total-plant leaf area on leaves four, five, and six from the top, for the data pooled across all hybrids, are presented in Table 5. Only leaf four had an intercept value that was not significantly different from zero, but it also showed the largest standard errors for the intercept and the regression coefficient and the smallest coefficient of determination. Although the average areas of these leaves were fairly comparable, their regression equations differed considerably due to large differences among the intercept values and smaller differences among the regression coefficients.

The relationship between the area of the fourth leaf from the top of the plant and total-plant leaf area was determined for each of the ten hybrids (Table 6). Coefficients of determination ranged from 0.51 to 0.79. Regression equations for the hybrids differed considerably because of large variation in the intercept values. The regression coefficient among this diverse group of hybrids averaged 5.06, but they ranged from 3.97 to 6.59.

The primary objective of our research was to identify the individual leaf or leaves whose area is most closely associated with total-plant leaf area. Collectively, our results suggest that the area of the fourth leaf from the top of the plant is most closely related to total leaf area. This leaf was most often the largest leaf, and it showed moderately good coefficients of determination with total-plant leaf area across diverse environments and genotypes. The third and fifth leaves from the top, reasonably related to total leaf area, also might serve for estimation purposes if leaf four was damaged and not suitable for measurement.

Another objective of our study was to establish the appropriate procedure for estimation of total-plant leaf area from the area of the selected leaf.

Table 6. Sorghum leaf area, Experiment Three. Average areas (cm^2) of the fourth leaf from the top and for the total plant, Y intercepts (a), regression coefficients (b), standard errors of the intercept (sd_a), standard errors of the regression coefficient (sd_b), and coefficients of determination (r^2) obtained by regression of total-plant leaf area at 80 days after planting on area of the fourth leaf for ten sorghum hybrids, Ames, Iowa, 1978.

Hybrid	Area of the fourth leaf from top	Total- plant leaf area	a ⁺	b	sd_a	sd_b	r^2
NB 505	398	2208	247.55	4.23	45.31	0.113	0.62
RS 506	336	2028	418.32	4.19	28.70	0.084	0.73
RS 610	404	2724	655.71	4.44	48.99	0.118	0.63
RS 628	443	3736	620.66	6.44	58.86	0.130	0.76
RS 633	438	3102	731.11	5.16	71.83	0.163	0.51
Tx 680	504	3402	464.16	5.45	77.98	0.151	0.63
RS 690	489	3167	693.24	4.82	52.17	0.106	0.72
KS 692	415	2639	632.54	5.29	41.35	0.097	0.79
Warner W832	517	3476	-241.94	6.59	74.54	0.142	0.73
Warner W866	486	2910	853.97	3.97	51.49	0.105	0.63

⁺ All intercept values are significantly different from zero ($P < 0.01$)

The parameter that seems most useful for estimating leaf area in sorghum on the basis of our experiments is the regression coefficient of the prediction equation. The coefficients presented seemed to vary less over the years and for different planting regimes and genotypes than did the complete prediction equations. The pooled data of different experiments revealed remarkable consistency. The average regression coefficient for the fourth leaf from the top for the diverse group of hybrids listed in Table 6 is $b = 5.06$. The average b -value for leaf 13 (fourth from the top of plant) from 50 days after planting and afterwards in Experiment Two (Table 3) is 5.05. And Krishnamurthy et al. (1974) reported a b -value of 5.05 for the regression of total-plant leaf area on area of the fourth leaf from the top for one of the three genotypes that they evaluated. This then suggests that a practical way to estimate total-plant leaf area in sorghum is to multiply the area of the fourth leaf from the top of the plant by the leaf area coefficient, $b = 5.06$. Such a procedure requires deferment of determination until the last leaves have developed, but it simplifies the measuring procedure, and it does not require destruction of the subject leaves. For investigations that require only a relative ranking among entries for total-plant leaf area, this procedure may be useful. Additionally, one can improve precision by including in the index the areas of either or both the third and fifth leaves from the top. The fact that limits the value of this procedure is variation among individual hybrids and treatments. The use of this coefficient would probably overestimate the total-plant leaf area of genotypes and/or experimental treatments that involve plants with small leaf area. And it would underestimate total-plant leaf area of genotypes and treatments with very large leaf areas. In addition, in our work, the errors of estimate for the intercept and the regression coefficient were larger in many instances than seems acceptable in the development of a precise estimator of leaf area.

We concluded, therefore, that there is no single-leaf measurement that can accurately predict total-plant leaf area in sorghum. Both genetic and environmental influences are manifested strongly in the development of individual plants and no single leaf accurately reflects these influences. Precise data for total-plant leaf area seems attainable only by the measurement of all leaves.

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EMOTIONALLY DISTURBED AND NORMAL CHILDREN'S PERCEPTIONS OF THEIR PARENTS¹

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ABSTRACT. The purpose of the present study was to examine emotionally disturbed (ED) and normal (non-ED) children's perceptions of their parents' behaviors. Pairs of children (N=56) were matched on age, sex, and socioeconomic status. Two measures were used: Children's Report of Parental Behavior Inventory (CRPBI) which is an objective paper and pencil inventory; and Kinetic Family Drawings (K-F-D) which is a projective picture instrument. The main variables investigated were: acceptance versus rejection, psychological autonomy versus psychological control, and firm control versus lax control (CRPBI); and high versus low control and acceptance versus rejection (K-F-D). The results indicated that ED children perceived more psychological control from parents than the non-ED children (CRPBI), but the K-F-D measures were neither related to the CRPBI measure nor to group differences. The non-ED children drew significantly more actions of individual figures, actions between individual figures, and characteristics of individual figures than the ED children. The results of the investigation seemed to indicate that two different sources of children's perceptions of parents were tapped: the socially desirable and the more hidden perception.

Additional index words: emotionally disturbed, children's perceptions of parents.

INTRODUCTION

Parental behaviors, attitudes, expectations and their effect on children have been studied extensively. The results are diverse. Although findings generally indicate that children's behavior is associated with parental practices, it is the children's perceptions of the parents rather than practices *per se* that have the most effect on the child's psychological development (Van der Veen and Novak, 1971). Researchers postulate that the child's perceived world is his or her reality or frame of reference and an influential contributor to emotional adjustment.

Research relating age, sex and socioeconomic level to children's perceptions of various aspects of parental behaviors has been extensively reviewed by Goldin (1969), Armentrout and Burger (1972), and Becker (1964). The results are diverse. However, very few studies have compared emotionally

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disturbed children's perceptions with those of normal children. Data currently available indicate that emotionally disturbed children perceive their parents as more rejecting, harsh, and non-loving than do normal children (Knoblock, 1971; Rogers, 1969; Novak and Van der Veen, 1970; Van der Veen and Novak, 1971).

In most instances information consciously available to the child is obtained by using paper-pencil questionnaires. Many authors advocate the use of two or more instruments and coordination of indications gained from a multiple approach (Kagan and Lemkin, 1960; Goodenough, 1946; Knoblock, 1971). Projective devices are considered as more direct measures to assess unconscious perceptions and to reveal the sometimes well-guarded private world of children. The dual approach allows for detecting discrepancies as well as providing additional clues to sources of anxiety leading to emotional problems.

The present study employed two different measures to assess children's perceptions of their parents. The Kinetic Family Drawing (K-F-D) (Burns and Kaufman, 1970-72), a projective technique, was used to tap the children's unconscious perceptions of their parents. The Child's Report of Parental Behavior Inventory (CRPBI) (Schaefer, 1965a), a paper and pencil test, assessed children's unconscious perceptions of their parents on the conscious level. Brief descriptions of these instruments are included in the instrument section of this paper.

Beyond the primary purpose of the study, we also investigated: (a) determination of level of agreement between children's perceptions of parents on similar factors on the two instruments, (b) comparison of the total number of emotional indicators delineated by Burns and Kaufman in drawings of the two populations, and (c) comparison of completion time for the two measures and between the two populations. It was hypothesized that children with emotional problems (ED) would perceive their parents differently than children with no emotional problems (non-ED). It was also anticipated that the ED children will perceive mothers and fathers differently than the non-ED children.

METHOD

Subjects

The subjects were 56 children (44 boys, 12 girls) 7 through 13 years of age with a mean age of ten years and five months. They were selected from two populations—public schools and clinical treatment centers for emotionally disturbed children. Half of the subjects ($N=28$) were in treatment for emotional disturbance in one of the three existing children's clinics in Iowa. Each child admitted to these clinics had been evaluated by a team of staff members and diagnosed by an examining child psychiatrist as experiencing moderate to severe emotional disturbance. The children in these centers are diagnosed on a continuum rather than grouped in specific categories (e.g., moderate, medium, severe).

The normal children ($N=28$) were students in two Iowa urban communities who were judged by their teachers as well-adjusted and who were receiving no known clinical treatment for emotional disturbance at the time. The pairing of children from the two populations was on the basis of age, sex, and socioeconomic status.

Instruments

The shortened version of the CRPBI questionnaire was used to measure the children's reported perceptions of parental behaviors (Schaefer, 1965b). Factor analyses of the CRPBI consistently have yielded three separate orthogonal factors: (a) acceptance versus rejection, (b) psychological autonomy versus psychological control, and (c) firm control versus lax control. Based on Burger et al. (1973) analyses of the CRPBI, the two best scales for each of the factors were employed.

K-F-D (Burns and Kaufman, 1970-72), which requires the child to draw his/her family members in "action" (doing something), is a projective technique developed to facilitate assessment of the personal reality of troubled children. The theoretical framework proposed by Burns and Kaufman (1970-72) states that kinetic element facilitates children's expression and projection of their perceptions of family members and family relationships. A Gestalt interpretation based upon both the separate indicators and their meanings plus the overall intuitive impression portrayed in the drawing has usually been employed (Johnston, 1975; Levenberg, 1975). We felt, however, for the purposes of the present study, the projected perceptions in the pictures would not discriminate between psychological control versus psychological autonomy and firm control versus lax control. Therefore, pictures were rated only on the variables high control versus low control and acceptance versus rejection.

Procedure

Subjects were tested individually in two separate sessions. Prior to testing, the researcher spent time with each child in order to establish rapport. The testing of emotionally disturbed children was done in an office or interview room at the subject clinic. Testing of the normal children was done in an unused classroom.

The drawing data (K-F-D) were obtained at the first session. The instructions were: "Draw a picture of everyone in your family, including you, doing something. Try to draw whole people and not cartoon or stick people. Remember, make everyone doing something—some kind of action. Take as long as you need and tell me when you are done." After the child stated she/he was through, the child was asked to tell who the figures were and what they were doing. The child's comments were recorded on the drawing next to the figure. Drawing time ranged from 7 to 55 minutes with a mean of 16.13 and standard deviation of 8.19.

The CRPBI was administered on a separate day. To facilitate understanding, four sample questions were completed first. The children were told that there are two forms, one for each parent, and that there were no right or wrong answers. Each questions was read by the researcher together with the child to maintain uniformity and understanding. Individual testing with the CRPBI took from 10 to 55 minutes with a mean time of 20.07 and the standard deviation of 10.59.

Scoring of K-F-D drawings

Preparation (training) of the judges was necessary. Since the K-F-D book (Burns and Kaufman, 1972) provides guidelines for analysis of pictorial

data not required for this investigation, a directly germane Training and Analysis Manual was prepared.⁴ The six characteristics to be rated on each child's drawing were: styles (e.g., edging, underlining figures), symbols, actions of individual figures, actions between figures, characteristics of individual K-F-D figures (e.g., arms, elevated figures, omission of body parts), and K-F-D Grid (e.g., size of figures, central figure placement, distance of self from others).

The two step training and analysis process was followed to prepare the judges. Drawings by 7- to 13-year-old children were analyzed first jointly by all three judges and differences of opinion arbitrated. Secondly, judges independently scored another set of drawings. At the end of every practice session, the amount of agreement was calculated. Finally, three prepared judges independently scored the 56 drawings gathered in the study. The judges rated the mother and father figure in each K-F-D on the two factors. These two subjective ratings were made after each judge studied the drawings and rated them on six other directly observable characteristics. To minimize bias due to practice, pictures were scored in different order by each judge. Judging was completed within a two week period.

Analysis

The reliability of the judges for judging the content of the drawings was evaluated by correlating their response for mothers and fathers separately and for acceptance versus rejection and high control versus low control separately. This resulted in four 3 x 3 correlation matrices.

Dummy variables, representing sex groups were intercorrelated along with age, socioeconomic status, K-F-D and CRPBI factors, K-F-D and CRPBI time measures, and the number of K-F-D emotional indicators.

Rather than using a repeated measures analysis of variance, two linear combinations of the mothers' and fathers' scores for both the CRPBI and the K-F-D were formed: mothers' plus fathers' scores and mothers' minus fathers' scores. Each of these scores was analyzed as a function of group, sex, age, and their interactions. Since the numbers in the eight cells formed by the combination of these three factors varied, an overall F statistic was computed as well as the seven single degree-of-freedom comparisons. This procedure recognizes the fact that these single-degree-of-freedom comparisons could be uniformly not significant even though the overall F may indicate there are differences between the eight groups.

RESULTS AND DISCUSSION

The Spearman-Brown reliability based on 56 observations and three judges were: $r = .72$ for mothers, acceptance versus rejection; $r = .75$ for mothers, high control versus low control; $r = .72$ for fathers, acceptance versus rejection; and $r = .71$ for fathers, high control versus low control.

Of the ten ANOVAS, there was only one significant overall F statistic. However, this was significant beyond the .001 level ($F_{7,48} = 3.223$). The

⁴ Manual and Scoring procedure available from Jane O'Brien, 2726 Witmer, Des Moines, Iowa 50310.

single degree-of-freedom comparison for group differences for mother plus father on the CRPBI factor of psychological autonomy versus psychological control was also significant beyond the .001 level ($F_{1,48} = 15.67$) indicating that the ED children perceive more psychological control by parents than the non-ED children. This supports Rogers' (1969) conclusions that children who receive treatment for emotional disturbances see their parents as excessively demanding of achievement and dependence. Age differences were also significant beyond the .05 level ($F_{1,48} = 4.63$) indicating decreased control with age. Burger et al. (1975) and Armentrout and Burger (1972) also have found children consistently reporting decreasing psychological control from parents as age increases.

The remaining "significant" single-degree-of-freedom comparison (conditional on a non-significant over-all F) occurred sporadically and were basically not interpretable.

Ancillary findings through correlations

Pearson Product Moment Correlations were computed to ascertain existing agreement between like factors as measured by the CRPBI and K-F-D. No significant agreement was found for any of the factors measuring children's perception of fathers. An apparent trend was shown, however, in the relationship between children's perceptions of a mother's behavior in the K-F-D and CRPBI.⁵

Examination of the correlational matrices (Table 1) revealed that the scoring of the three K-F-D judges was in significant agreement. All judges saw the projections from the K-F-D as being opposite in meaning for those reports from the CRPBI. These correlations taken together give no basis for convergent validity for the two measures. The trend might be said to be toward divergence.

The computed correlations of total numbers of emotional indicators found by judges on the K-F-D drawings indicated that the non-ED children included significantly more actions of individual figures ($r = .39$, $p < .01$) actions between figures ($r = .31$, $p < .05$) and characteristics of the individual K-F-D figures ($r = .45$, $p < .01$) than the ED children. This was not expected since Burns and Kaufman (1970-72), Johnston (1975), and Jacobson (1973) have said these drawing characteristics are indicative of emotional problems. However, McPhee and Wegner (1976) and the present study found significantly more styles of K-F-D's present in well-adjusted children rather than among emotionally disturbed children.

Our data shows that the boys included significantly more actions of individual figures than did the girls in both populations ($r = -.26$, $p < .05$). This finding is in agreement with Burns and Kaufman (1972) frequency tables for this drawing characteristic. Time for completing the CRPBI correlated significantly with the variable representing the two groups ($r = -.50$, $p < .01$). The non-ED children took less time to answer CRPBI statements than did the ED children. No such differences were found in completion time for the K-F-D drawings.

⁵ The complete correlation matrix is available from the authors.

Table 1. Correlations among the three independent judges on characteristics of K-F-D drawings

Acceptance versus rejection Mother				Acceptance versus rejection Father			
Judge	1	2	3	Judge	1	2	3
1	1.000			1	1.000		
2	.347**	1.000		2	.408**	1.000	
3	.659**	.393**	1.000	3	.535**	.437**	1.000
High control versus low control Mother				High control versus low control Father			
Judge	1	2	3	Judge	1	2	3
1	1.000			1	1.000		
2	.542**	1.000		2	.325*	1.000	
3	.415**	.556**	1.000	3	.512**	.511**	1.000

* $p < .05$ ** $p < .01$.

SUMMARY

The results of the present investigation indicated that the ED children perceived more psychological control by parents than the non-ED children and that this control is perceived to decrease with age. The non-ED children were judged to draw more "action" pictures than the ED children. This finding was contradictory to some research reports, since more "active" pictures are declared to be indicative of emotional problems (Burns and Kaufman, 1970-72; Jacobson, 1973). Furthermore, even though children's drawings of family members are accepted as good indicators of their attitudes and feelings in clinical settings (Di Leo, 1970), it is possible that the meanings of K-F-D characteristics may be meaningful only in context of other indicators of disturbance in interpersonal relations.

The results failed to show congruency of children's perceptions for the projective (K-F-D) and non-projective (CRPBI) measures used. One might speculate that the nonprojective test measured perceptions which the children were consciously willing to show whereas the projective measures tapped more hidden feelings and perceptions about their parents. Partial support for this interpretation is to be found in the results of research done with college students by Holtz et al. (1980). They found no relationship between Kinetic Family Drawings for distance between the self and other family members and two other interpersonal distance scales. They postulated that factors such as social desirability or "social schema" could have acted as interviewing variables on the obtained measures. On these bases the noncongruent findings were to be expected. That is, the results suggest that two different sources of children's perceptions of parents are tapped: the socially desirable and the more hidden perceptions. Of course, these points are moot, because it appears that neither instrument (the CRPBI and the K-F-D) is well validated for distinguishing between the ED and the non-ED children.

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DETERMINING IN-SERVICE NEEDS OF VOCATIONAL TEACHERS

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ABSTRACT. The purpose of this study is to develop a professional profile of the educational needs and accomplishments of the post-secondary vocational-technical teachers in Iowa. The published results provide (1) a current professional profile of the vocational-technical teachers of Iowa and (2) a survey instrument which can be used to maintain and update this bank of information. The profile was obtained by developing and administering a survey instrument to 417 practicing vocational-technical teachers in Iowa. It includes such factors as the occupational and educational background, educational goals, and the means by which these teachers plan to achieve these goals.

The study shows that about one-half of the vocational-technical teachers in Iowa have less than professional certification and that they have fewer than five years of teaching experience. About one-half of the non-degree teachers desire to complete the baccalaureate degree. This instrument and subsequent study should provide data and direction for their development.

Additional index words: post-secondary; vocational-technical education; trade and industrial education.

INTRODUCTION

The improvement of classroom instruction which is the main goal of in-service programs includes four phases: (1) assessment of needs, (2) implementation of responsive programs, (3) utilization of results of in-service experiences, and (4) evaluation. Efforts by administrators and educators of teachers to promote the professional growth and development of vocational-technical teachers must be based on some assessment of the current competencies and needs of practicing teachers. Professional growth or staff development programs can be planned more effectively if the assessment of needs precedes any formal in-service planning. Based upon the identification of needs and the above stated phases, the following research model was developed and administered.

During the past three decades, several studies about the professional profile of vocational-technical teachers have been published, e.g.: *A survey of trade and industrial teachers* (Barlow and Moore, 1953); *A study of trade and technical teachers who received first credentials* (Allen, 1963); *Profiles of trade and technical teachers* (Barlow and Reinhart, 1968); and *The report*

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of the Michigan study of industrial teacher competency (Ford and Silvius, 1965).

Iowa, like many other states, has developed a large system of post-secondary community colleges and vocational schools. These schools are divided into 15 areas covering all counties in the state. Thirteen of these post-secondary "area" schools are classified as community colleges, and two are classified as vocational schools. Because of this rapid expansion, these schools have had to recruit many new vocational teachers. Information about the qualifications, educational needs, and aspirations of neither the incoming nor practicing teachers has been or is readily available. It is also important to maintain current records of needs, because active in-service programs must constantly meet a variety of changing needs.

The objective of this study, therefore, was to determine the characteristics, deficiencies, and professional needs of practicing post-secondary vocational-technical teachers in each area school district and collectively for the state of Iowa. Professional information concerning these teachers was obtained by means of a survey instrument. This information includes such factors as the occupational and educational background, educational goals, and the means by which these teachers plan to achieve these goals.

PROCEDURE

A survey instrument was developed and administered in order to obtain a current professional profile of the post-secondary vocational-technical teachers in Iowa. Question content and questionnaire format were developed from several similar studies (Allen, 1963; Barlow, 1953; Carroll, 1969) and from consultation with vocational personnel in Iowa. The questionnaire, consisting of 35 questions employs a short, quick answer, programmed format. Instruction arrows → and ↓ were used to guide the informant through the questionnaire. These arrows, plus the use of overlapping, shortened questionnaire pages, reduced response sheets to two small pages. In addition, when a series of questions did not pertain to a particular individual, the individual was instructed to move ahead to the next relevant point. This format facilitated the initial as well as subsequent updating surveys.

The instrument was distributed to all 547 Iowa post-secondary teachers in the trade and industrial, technical, health occupation, and related instructional fields. Distribution was arranged through the directors of the 15 area schools. Following a second mailing, the return was 417 or 66.9 percent.

After the questionnaires were returned, the information was coded for computer computation. The computer printout was then transferred to tables and subsequently to figures for quick reference and analysis.

FINDINGS

The type of information obtained can be illustrated by the question concerned with work towards a baccalaureate degree. Table 1 illustrates the response to this question. The columns marked "0" include 190 teachers who already have a baccalaureate or masters degree. The results of this study can be classified in two ways: (1) information concerning a profile of each area school district and (2) information concerning a professional profile of the state.

Table 1. Typical Survey Question

Do you plan to complete work for a baccalaureate degree?

(0) have a degree or no response

(1) yes

(2) no

	0	0	1	1	2	2
AREA	F	P	F	P	F	P
I	8	53.3	3	20.0	4	26.7
II	11	64.7	4	23.5	2	11.8
III	11	61.1	2	11.1	5	27.8
IV	9	40.9	5	22.7	8	36.4
V	13	52.0	5	20.0	7	28.0
VI	5	35.7	6	42.9	3	21.4
VII	29	53.7	11	20.4	14	25.9
IX	22	71.0	6	19.4	3	9.7
X	24	61.5	6	15.4	9	23.1
XI	16	42.1	14	36.8	8	21.1
XII	19	46.3	8	19.5	14	34.1
XIII	15	46.9	8	25.0	9	28.1
XIV	5	45.5	2	18.2	4	36.4
XV	15	39.5	9	23.7	14	36.8
XVI	18	81.8	3	13.6	1	4.5
TOTAL	220	52.8	92	22.1	105	25.2

F: Frequency

P: Percentage

In terms of professional status, it was found that 45 percent of the vocational-technical teachers are teaching with a pre-professional certificate. Sixty-five percent have four to ten years of occupational experience. For the majority this experience was gained within the last six years prior to becoming a teacher. In addition, 45 percent have had up to five years of supervisory experience. Seventy-two percent have had six years of teaching experience or less; 36 percent four to six years; and another 36 percent but one to three years.

The majority of vocational instructors are teaching in the area of prior experience rather than moving into new areas. Most of those with little teaching experience have come directly into vocational-technical teaching whereas instructors with considerable teaching experience have taught prior to entering vocational-technical education.

The study has provided some positive and realistic information for the preparing and upgrading of vocational-technical teachers. In the area of workshops, 91 percent of the teachers are interested in workshops directly related to their specialty, whereas only 55 percent would consider a workshop outside their specialty. Skill-based courses are of interest to 65 percent of the teachers, and some interest was expressed in returning to industrial employment as a means of obtaining updating experiences.

In order to successfully conduct workshops and courses, sufficient enrollment is essential. To best serve the teachers, the study shows that the key option is quarter-term evenings (one night a week for ten weeks) with the second option being one-week summer courses and workshops. When considering distance for weekly meetings, the majority considered 25 miles to be a maximum, however, about 25 percent of the teachers indicated they would be willing to travel 50 miles.

In terms of academic attainment the survey shows that 48 percent of the teachers currently hold a college degree and of these, 31 percent have a baccalaureate and 15 percent have a masters. Only three percent indicate the holding of an associate degree. Currently, 44 percent of those who do not hold a degree are planning to complete a baccalaureate degree (Table 1). Of these, about 24 percent have 97 or more quarter hours of credit and thus have completed half the requirements for a degree.

The occupational competency examination for college or university credit is a developing concept. The survey indicates that less than half of the non-degree teachers were aware of this opportunity; the information provided by the questionnaire indicated only 38 individuals have taken such examination. One hundred five persons, slightly more than 50 percent of the non-degree teachers, do express the desire to take a competency examination for university credit.

DISCUSSION

Relevant data concerning the professional profile of vocational-technical teachers has been obtained, tabulated and put into usable form. This survey was published by the State Department of Public Instruction and distributed to the teacher training institutions and area schools. This report provided basic information and a profile concerning the professional status of the Iowa vocational-technical teachers in the trade and industrial, technical, health

occupations, and related instructional areas. The information will be useful in short- and long-range planning of course work and updating needs of teaching staffs. Presumably some of the information such as that concerning workshops, scheduling, and distance traveled will become quickly dated. The professional status of the teachers will constantly be changing as they progress in their studies and as others enter and leave the teaching profession. Therefore, it is recommended that the State Department of Public Instruction, or similar group, periodically repeat this survey, perhaps each September, in order to maintain and update this bank of information. Responsive in-service programs can then be based on recent information, and teacher educators' efforts and appropriations of financial resources may be utilized maximally for the benefit of instructors and students in our post-secondary schools.

Finally, it appears that the vocational-technical teachers of Iowa have academic aspirations. It can be anticipated that as these teachers meet their goals, 75 percent of the future area school faculties will have baccalaureate degrees and professional certification.

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STUDENT-PERCEIVED USES OF A FOREIGN LANGUAGE: SPANISH

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ABSTRACT. Student perceptions of future use of a foreign language naturally affect enrollment. This study, based on a survey of all Spanish classes at Iowa State University, Spring Quarter 1980, indicates that students relate the Spanish language primarily to usefulness in traveling in a Spanish-speaking country. Students in advanced classes give a higher priority to possible professional use of the language than do beginning students. This type of data, if replicated by other institutions and for other languages, could be of importance in guiding curriculum preparation and course content.

The President's Commission on Foreign Language and International Studies espoused the view that more people in the United States should acquire ability in a second tongue. Many universities ostensibly support this view in that curricula contain language requirements which are, however, usually minimal. Beyond this, student perceptions of future use of a foreign language are probably the major factor contributing to enrollment.

A knowledge of such perceptions should have a bearing upon the teaching materials and methods used in classes as well as upon the language curriculum as a whole. In the spring quarter of 1980, a survey was taken by all Spanish classes at Iowa State University. One of its aims was to discern why students enroll in foreign language courses. The questionnaire was an adaptation of one surveying student-perceived communication needs in first year French classes at Purdue University.¹

Table 1 describes the survey population, and Table 2 contains the survey questions. The students were given a list of ten uses of Spanish. They were asked to indicate the likelihood of their employing the language for that purpose by choosing among the probabilities listed in Table 2.

Table 3 gives the survey results broken down into three categories: the total survey population, the first year students, and the second year and advanced students. The items are listed by rank. The mean and the standard deviation are indicated for each.

Interpretation of the following from Table 3 must take into account the limited population size and its geographical homogeneity as well as the differences between some contiguously ranked items.

The survey results for the total population show that the students perceive their primary future use of Spanish to be for travel to a Spanish-speaking country. The three least likely uses (the eighth, ninth, and tenth ranked items) were working, living, and studying abroad. Thus, of the four categories which specifically involve being in a Spanish-speaking country, the

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¹Linda L. Harlow, W. Flint Smith and Alan Garfinkel, "Student-Perceived Communication Needs: Infrastructure of the Functional/Notional Syllabus," *Foreign Language Annals*, 13 (February 1980), pp. 11-22.

Table 1. Survey Population of Spanish Classes, Iowa State University, 1980

	Number of students	Percentage of total
First year students	118	67
Second year and advanced course students	59	33
Total	177	100

Table 2. Survey Questions

Do you think you may use Spanish in the future:

1. To travel to a Spanish-speaking country?
2. To study in a Spanish-speaking country?
3. To work in a Spanish-speaking country?
4. To work in this country with Spanish speakers from other countries?
5. To work or associate with Spanish speakers of this country?
6. To correspond with people in Spanish-speaking countries?
7. To read books and articles in Spanish for research or other job-related purposes?
8. For leisure/pleasure activities: reading, watching TV in Spanish, seeing Spanish language movies?
9. To understand Hispanic culture as it applies to our country (history, language influence, cuisine, etc.)?
10. To live, for other than work or study purposes, in a Spanish-speaking country?

Students responded to these questions using the following choices:

- 1 = Definitely
- 2 = Most probably
- 3 = Maybe
- 4 = Probably not
- 5 = Never

Table 3. Survey Results for the Total Population and Course Level Categories (Ranked by \bar{x})

Total (N = 177)				First Year (N = 118)			Second Year/Advanced (N = 59)		
Rank	Language Use	\bar{x}	s	Language Use	\bar{x}	s	Language Use	\bar{x}	s
1	Travel	1.88	0.93	Travel	2.14	0.97	Travel	1.37	0.67
2	Understand Culture Influence	2.39	1.10	Understand Culture Influence	2.55	1.04	Leisure/pleasure	2.00	0.96
3	Work or associate With USA Spanish Speakers	2.50	0.95	Work or associate With USA Spanish Speakers	2.69	0.98	Understand Culture Influence	2.07	1.06
4	Leisure/pleasure	2.67	1.16	Leisure/pleasure	3.01	1.05	Work or associate With USA Spanish Speakers	2.12	0.85
5	Correspond	2.81	1.15	Work here with Spanish speakers From abroad	3.06	0.91	Correspond	2.15	1.06
6	Work here with Spanish speakers From abroad	2.83	0.91	Correspond	3.14	1.03	Read for Research/job	2.36	1.05
7	Read for Research/job	2.93	1.12	Read for Research/job	3.22	1.02	Work here with Spanish speakers From abroad	2.37	0.93
8	Work abroad	3.28	1.01	Work abroad	3.54	0.98	Work abroad	2.76	0.92
9	Live abroad	3.38	1.10	Live abroad	3.58	0.98	Study abroad	2.88	1.14
10	Study abroad	3.39	1.05	Study abroad	3.64	0.95	Live abroad	2.98	0.97

interest plainly is that of travel and not that of living and working in a foreign country.

The second and third selections after travel (Table 3: items 3 and 4) reflect some recognition of the impact on the United States, both historical and current, of the peoples and cultures from the Hispanic world.

The miscellaneous topics holding the middle four priority slots (Table 3: items 4-7) were approximately equivalent and revealed neither enthusiasm nor outright rejection.

In Table 3 the responses of the first year students and those of second year/advanced courses are given in italics when they differ in rank from those of the total population. Also, these different rankings are bracketed in groups of two or three items to point out that the choices in each block are merely a reversal or slight reordering of the responses that fall in the same rank slots in the total population.

The discrepancies in the ranking of items by the sub-groups as compared with that of the survey population as a whole are minimal. Nevertheless, in considering the responses of the two sub-groups, it should be noted that in every item given the second year and advanced students show stronger inclination to use their Spanish professionally in various ways than do the first year students. For example, the second year and advanced student group comparatively gives a lower ranking to its first choice (travel) than do the first year students. Thus, while travel is the unanimous number one selection across the board, its relative weight differs considerably among groups.

Obviously more research involving other institutions and other foreign languages is needed before generalizations can be made. The findings of this survey, however, suggest the possible importance of such studies as a basis for structuring foreign language curricula and course content.