THE IDENTIFICATION OF WHEAT VARIETIES IN THE SEEDLING STAGE

by

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INTRODUCTION

A problem of technical importance to the wheat industry is the reliable identification of varieties and the detection of impurities within a variety. At the present time there are two methods in common use for identifying varieties but neither method can be regarded as completely satisfactory to the investigator who desires reliable identification in a short space of time.

The system used by the grain trade is based on an examination of kernel characteristics. This means of identification is rapid and reliable for distinguishing between varieties for which the kernel characteristics are fairly definite. However, there are limitations to this method because of the similarity in kernel characteristics of many varieties and the variation in samples due to environmental conditions. Reasonably accurate identification can be made by examining mature plants; but this requires approximately four months from the time the seed sample is received until identification is made. A method combining the reliability of the second and, to a considerable extent, the rapidity of the first would be advantageous to the workers engaged in the production and processing of seed stocks. With a view to developing such a method studies were undertaken on the possiblility of distinguishing varieties in the seedlings stage.

The object of this paper is to report experiments the purpose of

which was to develop methods of identifying varieties of wheat in the seedling and young plant stage and of identifying off-types in varieties. Use was made not only of morphological characteristics but also reactions to diseases, and to two differential sprays.

REVIEW OF LITERATURE

Numerous studies have been made on the identification and systematic and botanical calssification of wheat. Clark and Bayles (2) give an excellent review of this literature and describe 239 varieties. In their study mature plant and kernel characteristica were used. Newman et al. (13) reported a study of the varieties grown in Western Canada based on similar characteristics. Peterson et al. (17) outlined a method of identification based on kernel characteristics alone.

In a study of seedling hairiness, Harrington (7) found that Marquis and Reward could be differentiated. Percival (16) in his wheat monograph, made use of the hairs on the leaf surface and coleoptile coloration in differentiating the wheat species. Miezynski (11) observed similar hairiness with respect to the genus Aegilops. In a classification of Australian wheat varieties Archer (1) used seedling characters in his key to the species but did not mention them in the variety descriptions. Vavilov (21) listed many seedling characters and gave their relative frequency distribution for the chromosome groups.

Repnikov (18) and Timofeeva and Zavylenkova (20) have reported varietal differences in phenol reactions of seeds. However, Freidberg (5) found that phenol reactions were satisfactory for the species but could be utilized only as an indication in testing of varieties of T. vulgare. He states, "Only could only say that if the reactions were different to a check variety that it was not that variety." Fraser and Gfeller (4) reported phenol reactions as useful in the separation of Marquis from Garnet and Reward. Some work has also been done with serological reactions in plants. However, Cooper (3) states, "A phylogenetic system

based on the reaction to serum of members of the various families has also been developed. It seems difficult however to give protein characters any higher taxonomic value than other characters, since it has been shown that the same reactive substance may occur in very distantly related families."

MATERIAL AND METHODS

Varieties

The varieties of Triticum vulgare Vill. selected for this study are listed in Table 1. Regent 975,6 Renown, Apex, Reliance, Marquis, Red Bobs, Canus and Thatcher are varieties approved by the official provincial committees of cerealists. Regent 975.26 is a selection from Regent 975.6 which is being processed as a foundation stock of Regent. Reward and Garnet were at one time recommended varieties and are still grown to some extent. Redman was included in this study as a new promising rust resistant wheat adapted for growing in the rust area and Rescue as the most promising of the saw-fly resistant wheats. Since the commencement of the study these two varieties have been named and recommended for license.

The varieties of Triticum durum Desf. are listed in Table 2. Carleton, Mindum and Pelissier are approved varieties, and Stewart has been recommended for license.

Golden Ball has been condemned on account of poor quality but is still in commercial production because of ist saw-fly resistance.

For convenience of designation in this thesis the varieties of Triticum vulgare will hereafter be referred to as bread wheats and those of Triticum durum as durum wheats.

Soil

The soil used in most experiments was a 3:1 mixture of a local black loam and sand which gave the following results on analysis: pH, 8.0; Nitrogen, fair to good; Phosphorous, fair to good; Potassium, excellent; and Carbonates in slight excess. Peat mixed with sand pH 5.5

Table 1. Varieties of Triticum vulgare Vill.

Variety	R.L.No.*	C.A.No.**	Cross from which derived
Regent	975.6	1938	H-44 x Reward
Regent	975.26	3616	H-44 x Reward
Renown	716.6	1915	H-44 x Reward
Redman	1834.1	3633	Regent x Canus
Apex	1342	1857	(H-44 x Double Cross) x Marquis
Reliance	1942	1498	Marquis x Kanred
Marquis	84	1396	Hard Red Calcutta x Red Fife
Canus	1321	1260	Marquis x Kanred
Rescue	2256	3567	Apex x S-615-9
Reward	79	1509	Marquis x Prelude
Garnet	15	1316	Preston A x Riga M.
Thatcher	1945	1820	(Marquis x Iumillo) x (Marquis x Kanred)
Red Bobs	1827	1637	Selected from Early Triumph

* Dominion Laboratory of Cereal Breeding numbers.

** Canadian Accession numbers.

H-44 was derived from the cross Yaroslav Emmer x Marquis.

Double Cross was derived from the cross (Marquis x Iumillo) x (Marquis x Kanred).

Table 2. Varieties of Triticum durum Desf.

Variety	R.L.No.*	C.A.No.**	Origin
Mindum	1344	1418	Selection from Hedgerow
Carleton	1663	3588	Vernal Emmer x Mindum^3
Stewart	1683	3599	Mindum x Vernal Emmer x Mindum ^{2}
Golden Ball	1250	1325	Introduced from South Africa
Pelissier	1743	1860	Introduced from Algeria

* Dominion Laboratory of Cereal Breeding numbers.

** Canadian Accession numbers.

was used in one experiment and ordinary unwashed sand (pH 8.3) was employed in another. Ammonium phosphate 16-20 was used in later experiments to assist in the control of root-rot organisms. This was applied at the rate of approximately 8 grams per 6-inch pot. Other nutrients used were ammonium sulphate and nitrate of soda applied at the above rate.

Seeding

The following three methods of seeding were employed:

1. Normal, where the seed was sown in rows in a bed or broadcast in 6-inch pots and covered approximately one inch deep.

2. Surface, where the seed was simply dropped on the surface of the soil and pressed firmly into it by means of a flat object.

3. When specific numbers of viable seeds of the varieties were required in mixtures the kernels were sprouted on blotters, in plates or petri dishes and then sown as in method 1.

Plant Material

Studies were made of seedlings in the one- or two-leaf stage and rarely in the three-leaf stage. All determinations were made from the primary shoot or from the first leaf, but in some experiments plants had necessarily reached the two- or three-leaf stage before reactions could be determined.

Details of Methods

The methods used for specific tests or experiments are included in sections covering individual experiments.

EXPERIMENTAL

In a preliminary study the varieties were examined for morphological characters of sufficient uniformity to be utilized for identification purposes. Some of the characters studied were pubescence or hairiness of the young plants, type of auricle, stem and leaf color, collar, size and shape of ligule, leaf venation, nerves of coleoptile, coleoptile coloration, shape of leaf blade, fold of leaf sheath, hairiness of the leaf margins and attitude of first leaf.

1. Pubescence

The hairiness of the young seedlings became evident very early, and the young plants could be classified two days after emergence. Although the character varied somewhat under different conditions, the varietal differenced remained relatively the same and no difficulty was experienced in classification.

Varietal differences were observed in length, number and distribution of the hairs on the plants. Actual counts of the number of hairs per given area of plant were not made, but the plants were classified on the basis of an arbitrary scale of 0-10, 0 being glabrous and 10 heavily pubescent. The leaf sheath was chosen for examination, although the upper surface of the blade of the first leaf might have been used with similar results.

A Spencer low power binocular microscope with a 1.0x objective and 12.5x oculars was used in determining pubescence. Natural sunlight is perhaps the best source of light in making such a classification. However, since a large part of the work was done at the time of the year

when natural sunlight was at its minimum, a system of artificial lighting had to be employed.

A microscope lamp was used in conjuntion with the binocular and found to be quite adequate, but since it was necessary to pull up the plants, this method could not be used in checking pubescence in purity tests in which it was necessary to grow off-type plants for further study. For this purpose a focusing flashlight case was fitted with a 6 ampere bulb and power was supplied, by means of a reducer and a small toy transformer, from a 110 volt greenhouse socket. Since it was necessary to check each plant for pubescence only to determine whether or not it was within the limits of the range of the parent variety, the light was passed behind the plants and the plants were examined through a large 5-inch reading glass. Off-types could be detected very easily, and approximately one thousand plants could be examined in one hour.

In bright sunlight, and accurate separation of the glabrous and nearly glabrous from the pubescent plants could be made without a lens.

In the work on identification tests, the separation for pubescence was made by means of a small hand lens or the naked eye. All determinations were checked with the binocular and relatively few corrections had to be made.

Table 3 shows the frequency distribution for each variety and the varieties are arranged in order of increasing pubescence.

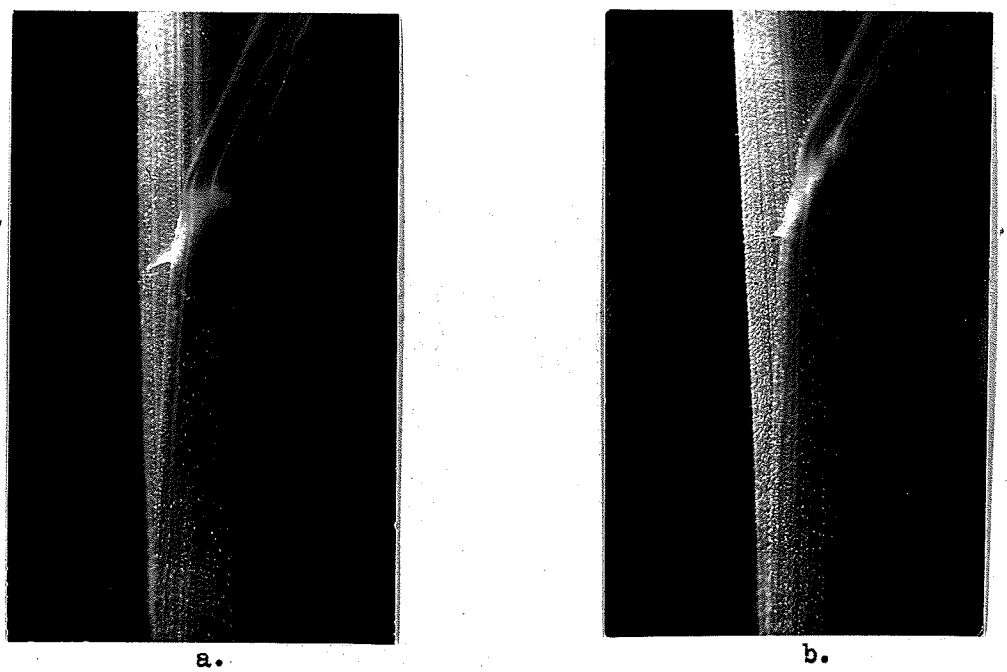
Table 3. Frequency distribution of seedlings of 18 varieties in pubescence classes.

Class	0	1	2	3	4	5	6	7	8	9	10	Mean
Rescue	9	167	23	1								1.08
Apex	4	162	25	8							1	1.23
Reliance	2	54	84	39	18	1				2		2.17
Marquis	1	25	74	68	23	3	5	1				2.46
Canus	1	29	52	79	31	8						2.67
Thatcher	1	13	39	45	67	30	5					3.37
Red Bobs		5	16	25	7	30	40	62	15			5.42
Reward		1	3	14	14	23	22	32	88		3	6.55
Garnet		1	2	7	18	21	8	37	105	1		6.80
Renown				1	1			14	19	26	139	9.40
Redman		1			1	1	1	2	13	39	142	9.53
Regent 975.6							1	2	20	39	138	9.56
Regent 975.26								3	16	41	140	9.59
Pelissier	126	1										0
Mindum	106	4										0.04
Golden Ball	84	25										0.23
Stewart	45	63										0.58
Carleton	23	62										0.68

The bread wheats were readily divided into four groups by this character. These may be defined as nearly glabrous, slightly pubescent, moderately pubescent and heavily pubescent. The variety Red Bobs is shown in the moderately pubescent group but under different environmental conditions would probably fall in the slightly pubescent group.

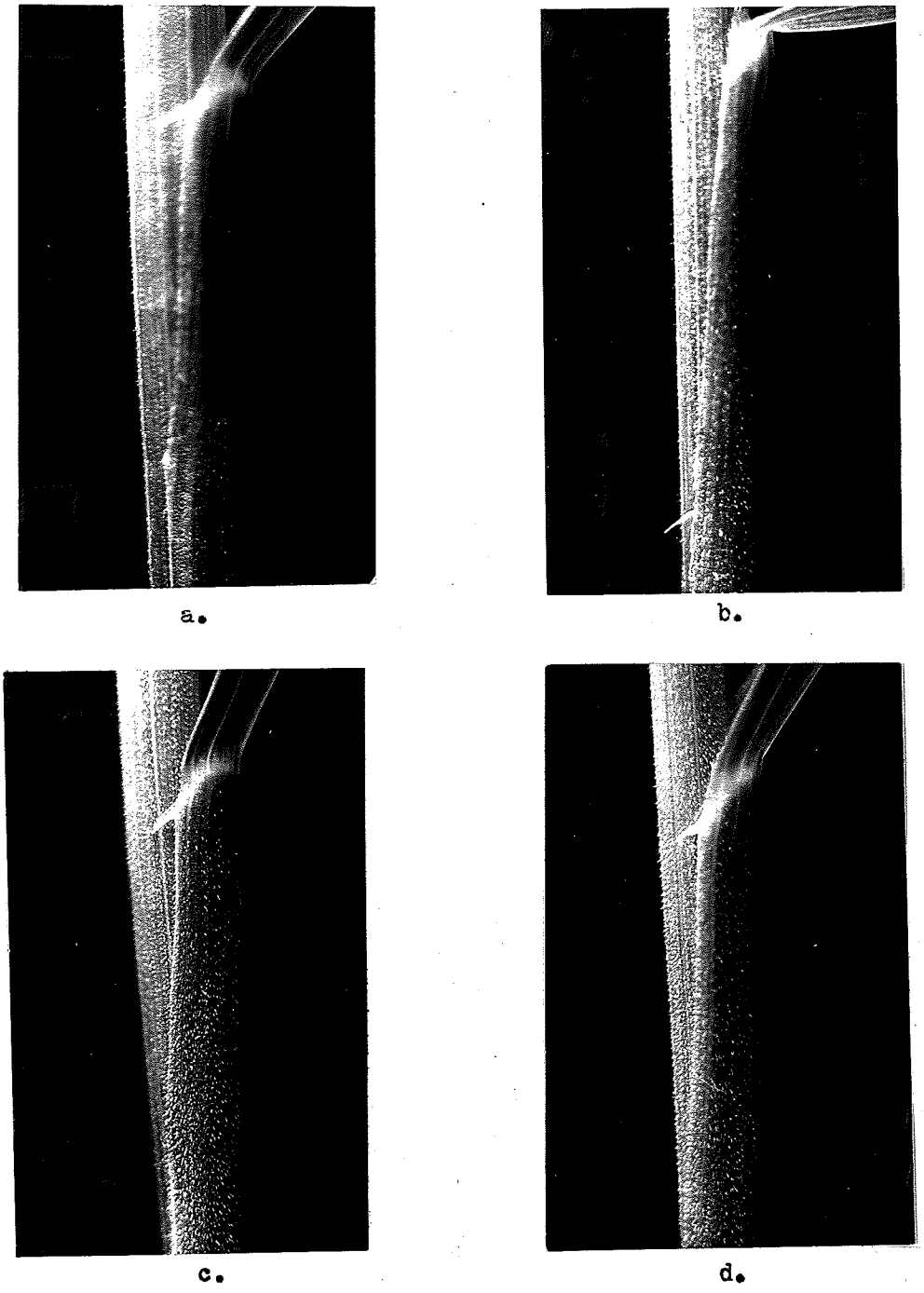
Figures 1 to 4 show the leaf sheaths and stems of the varieties arranged in the following order:

Nearly Glabrous	Slightly Pubescent	Moderately Pubescent	Heavily Pubescent
Rescue	Reliance	Red Bobs	Renown
Apex	Marquis	Reward	Redman
	Canus	Garnet	Regent 975.6
	Thatcher		Regent 975.26



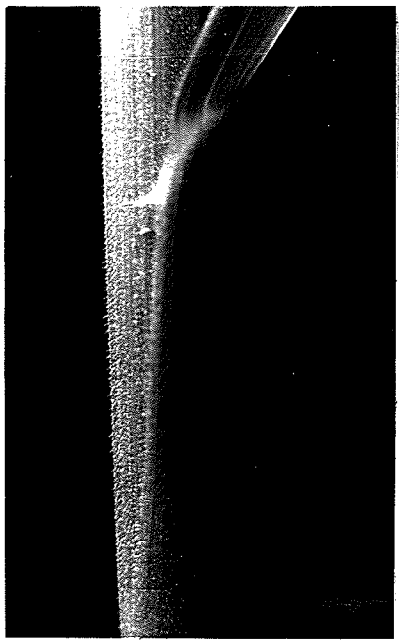
a. b.

Figure 1. Pubescence on leaf sheath and stem. Nearly glabrous: a, Rescue; b, Apex.

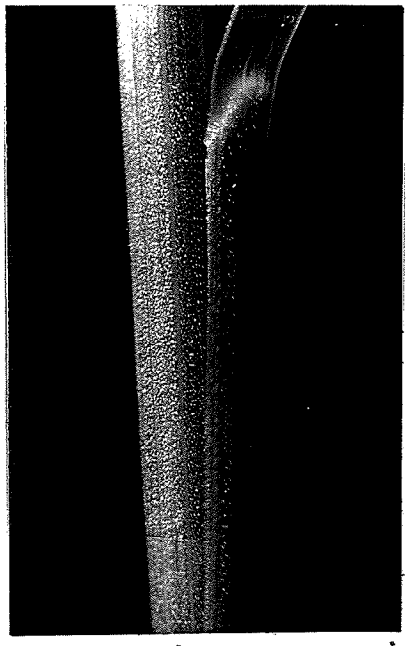


a. b. c. d.

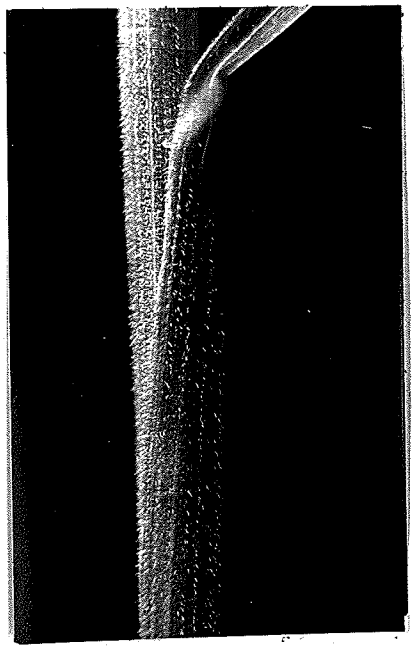
Figure 2. Pubescence on leaf sheath and stem. Slight:a,Reliance; b, Marquis; c, Canus; d, Thatcher.



a.

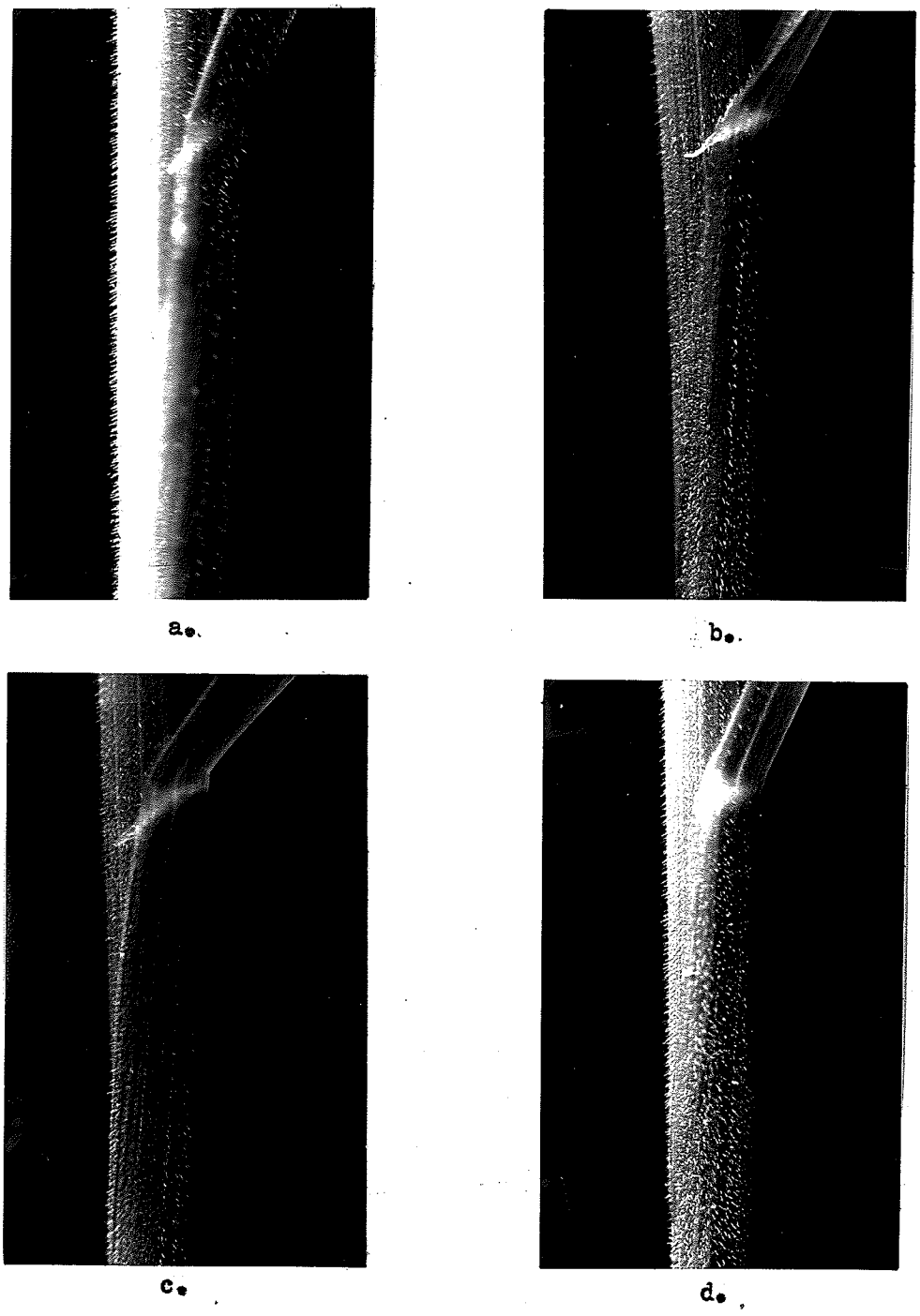


b.



c.

Figure 3. Pubescence on leaf sheath and stem. Moderate: a, Red Bobs; b, Reward; c, Garnet.



a. b. c. d.

Figure 4. Pubescence on leaf sheath and stem. Heavy: a, Renown; b, Redman; c, Regent 975.6; d, Regent 975.26.

The pubescence groups may be further subdivided on the basis of the length and distribution of the hairs, as shown below.

Nearly Glabrous

Rescue	extremely short and sparse.
Apex	short and sparse.

Slightly Pubescent

Reliance	short and moderately sparse.
Marquis	mixed (short and extremely short), moderately sparse.
Canus	mixed (short and extremely short), moderately sparse.
Thatcher	short, few.

Moderately Pubescent

Red Bobs	short and fine, few.
Reward	mixed (long and short), many.
Garnet	mixed (medium and short), many.

Heavily Pubescent

Renown	long, very many.
Redman	long, very many.
Regent 975.6	mixed (long and medium), very many.
Regent 975.26	mixed (long and medium), very many.

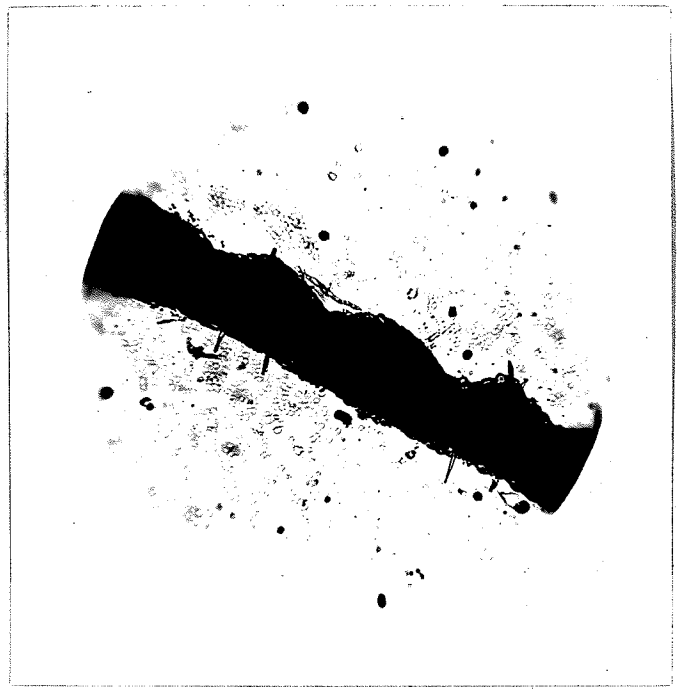
The hairs of the upper leaf surface were used by Harrington (7) in differentiating Reward and Marquis. He found that on Marquis the hairs were usually in single rows along the ridges, while on Reward the hairs were usually in three rows, with the hairs of the centre row longer than those of the other two rows.

Since this characteristic could only be observed in bright sunlight and the pubescence of the leaf sheath was considered to be easier

to determine, the number of rows of hairs on the upper leaf surface has not been used in this study. Photomicrographs of cross-sections of the leaves of each variety are shown in Figures 5 to 13. These have been included to indicate the length and distribution of the hairs on the upper and lower leaf surfaces, which are believed to be comparable to the hairs of the leaf sheath.

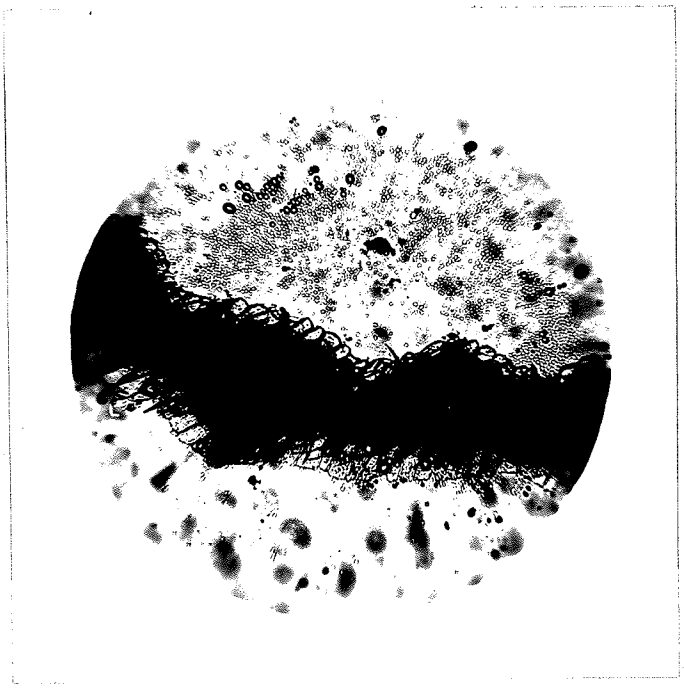
The durum wheats in general may be considered to be glabrous although one occasionally finds plants which show a few hairs.

a.

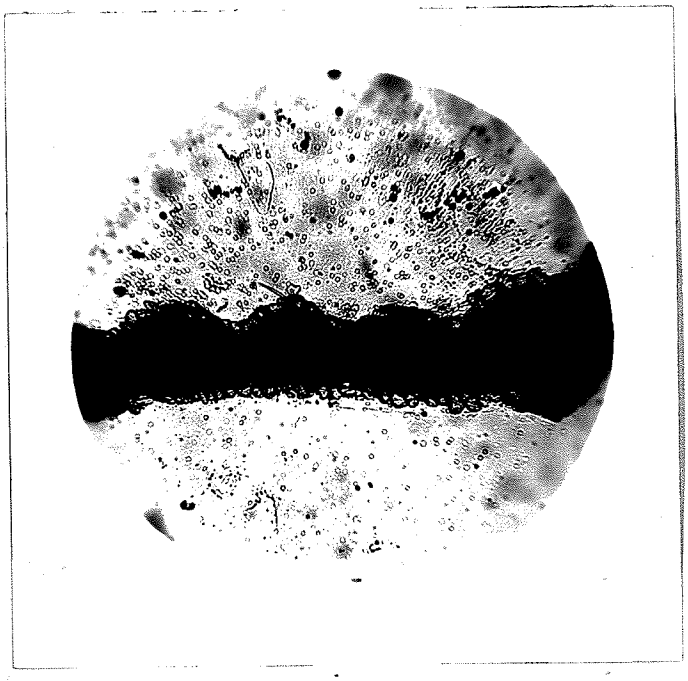


b.

Figure 5. Cross-sections of leaves showing hairs on upper and lower leaf surface. a, Rescue; b, Apex.



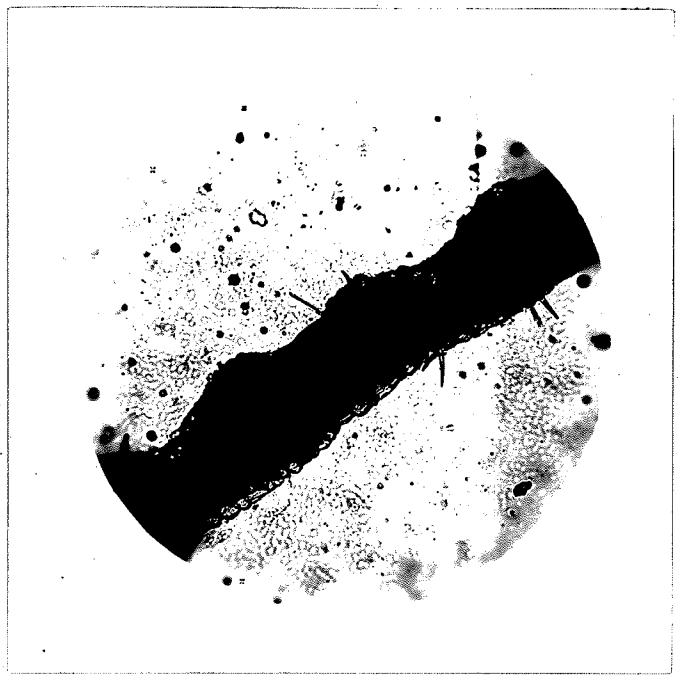
a.



b.

Figure 6. Cross-sections of leaves showing hairs on upper and lower leaf surface. a, Reliance; b, Marquis.

a.



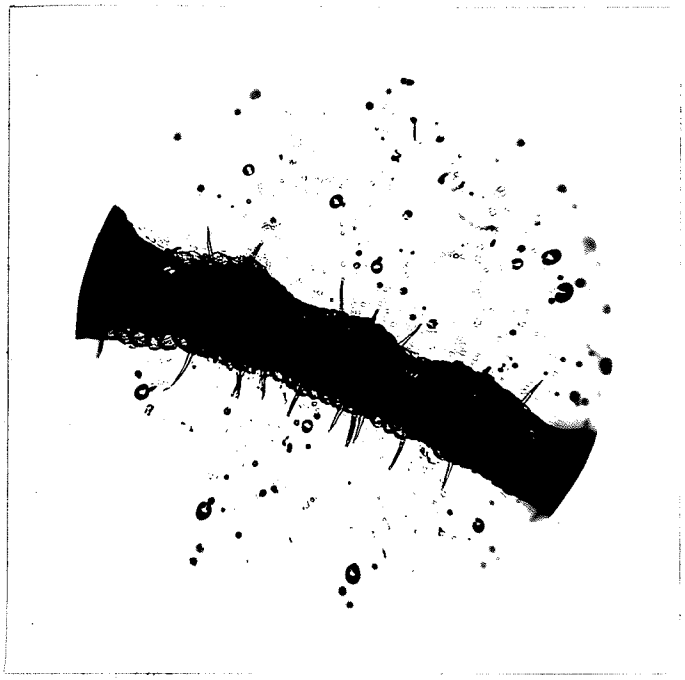
b.

Figure 7. Cross-sections of leaves showing hairs on upper and lower leaf surface. a, Canus; b, Thatcher.

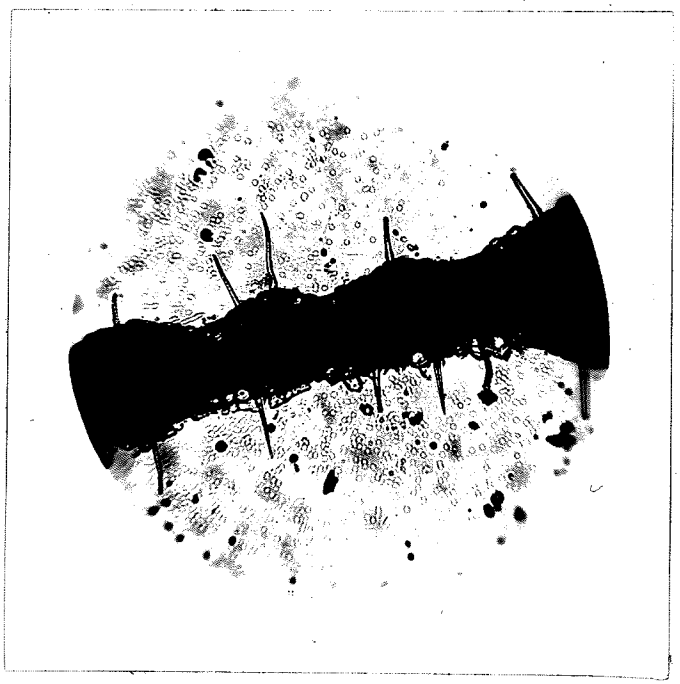
a.

b.

Figure 8. Cross-sections of leaves showing hairs on upper and lower leaf surface. a, Red Bobs; b, Reward.

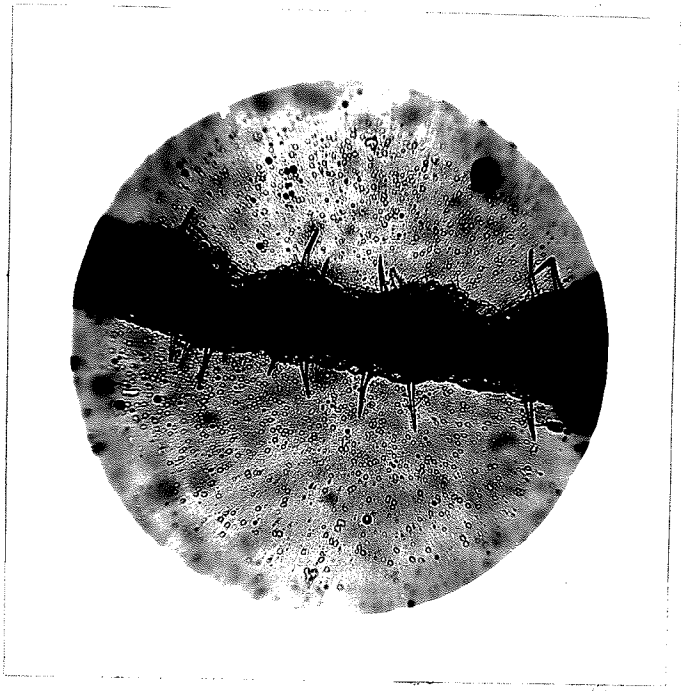


a.

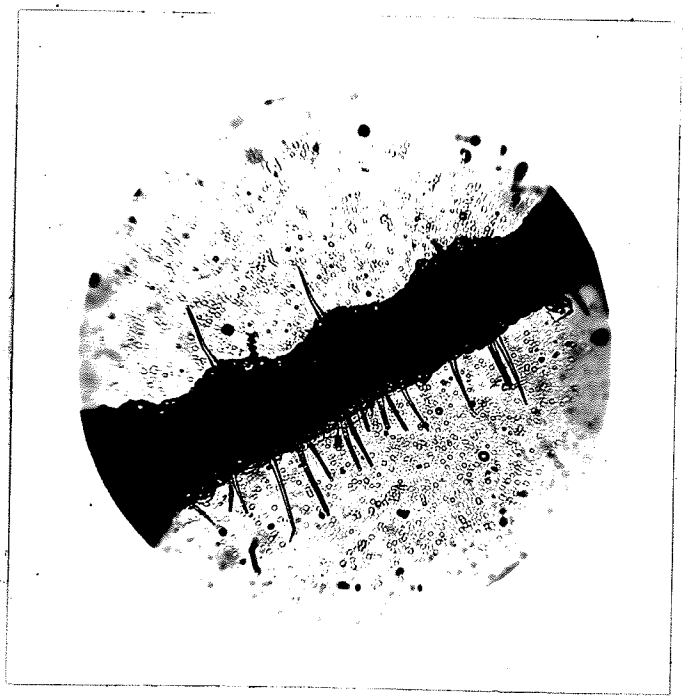


b.

Figure 9. Cross-sections of leaves showing hairs on upper and lower leaf surface. a, Garnet; b, Renown.



a.



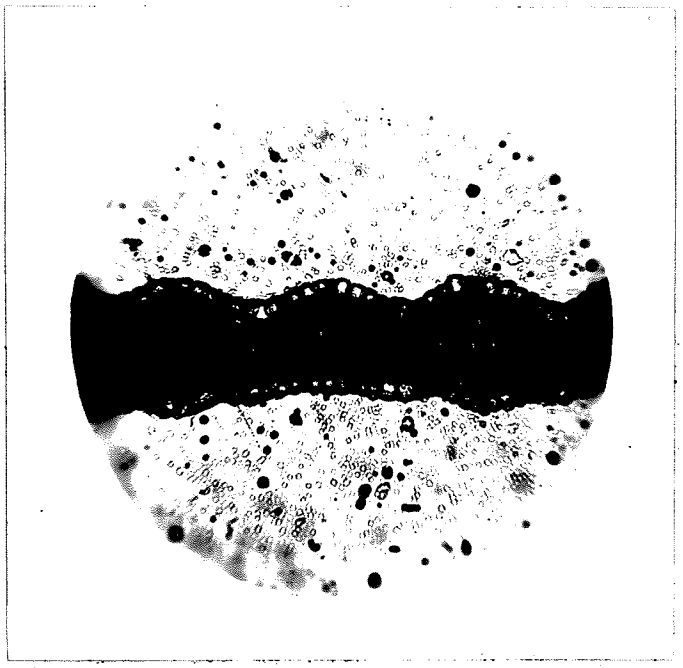
b.

Figure 10. Cross-sections of leaves showing hair on upper and lower leaf surface. a, Redman; b, Regent.975.6.

a.

b.

Figure 11. Cross-sections of leaves showing hair on upper and lower leaf surface. a, Regent 975.26; b, Pelissier.

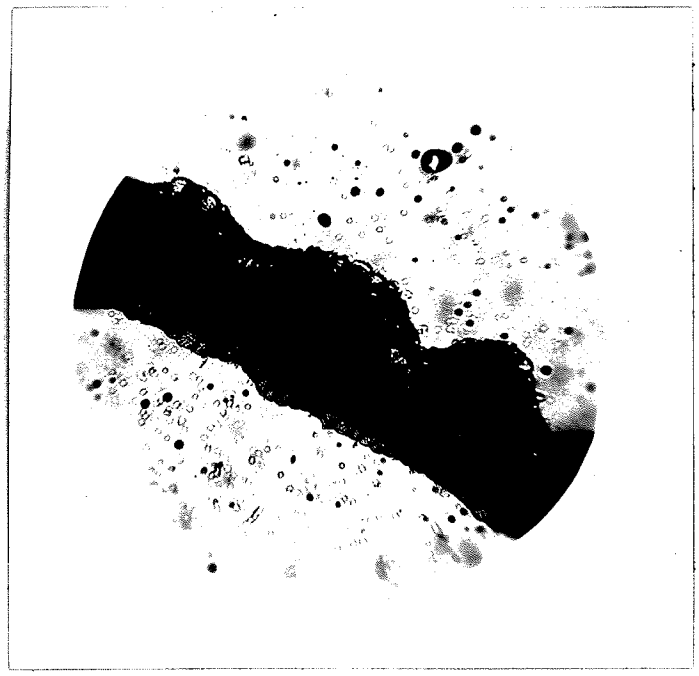


a.

b.

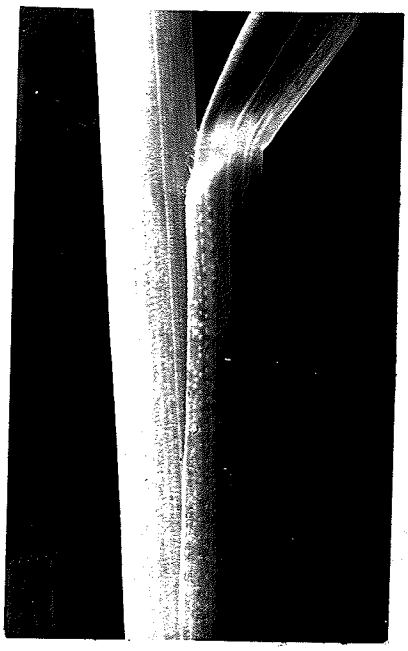
Figure 12. Cross-sections of leaves showing hairs on upper and lower leaf surface. a, Golden Ball; b, Mindum.

a.



b.

Figure 13. Cross-section of leaves showing hairs on upper and lower leaf surface. a, Stewart; b, Carleton.



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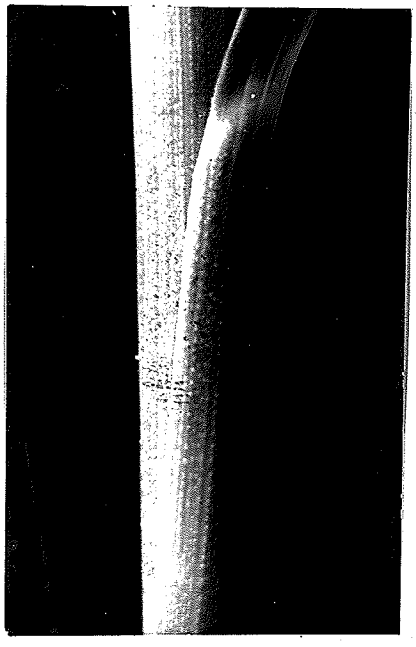
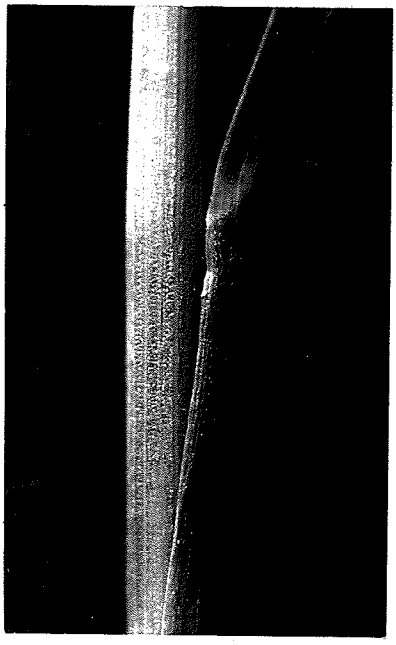


b.

Figure 14. Glabrous leaf sheath and stem. a, Pelissier; b, Golden Ball.



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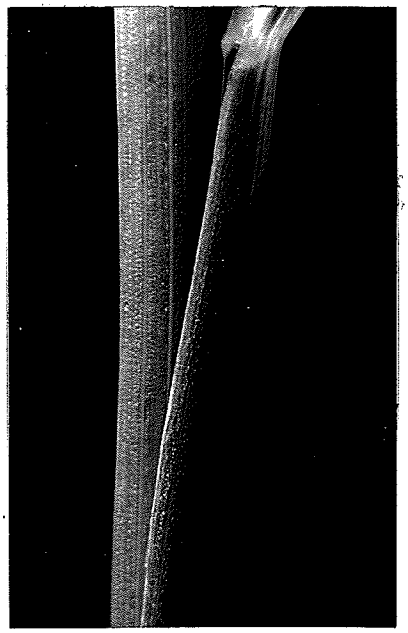
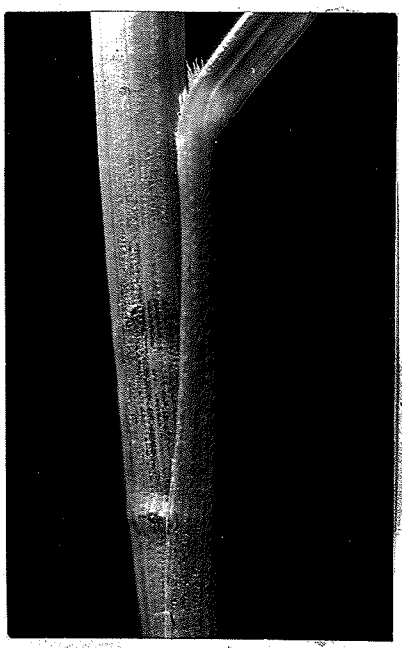


b.



c.

Figure 15. Glabrous leaf sheath and stem. a, Mindum; b, Carleton; c, Stewart.

2. Coleoptile Coloration

It is well known to cerealists that the varieties, Renown and Apex, produce reddish colored coleoptiles under some field and greenhouse conditions. However, in the preliminary study only an occasional plant of these varieties showed a definite reddish tinge. The color was on the nerves of the coleoptile. This character could not be considered sufficiently uniform to be characteristic of the variety under all conditions. The other varieties of bread wheats produced coleoptiles of varying shades of green. The variety Golden Ball produced a dark greenish-brown shoot which showed clearly through a colorless coleoptile, this character was reasonably uniform. The other durum varieties produced coleoptiles of a more yellowish-green. The variation in color was as great within a variety as between varieties.

The characteristic coloration of Golden Ball has been described above and it should be pointed out that the coleoptile is colorless, the shoot within the coleoptile sheath being colored. This condition should perhaps be referred to as early seedling color rather than coleoptile color and has been included in this section for the purpose of comparison with Renown and Apex. On the other hand, the color of Apex and Renown is in the coleoptile itself, the characteristic color being a reddish tinge with some brown for Renown and a much deeper reddish color for Apex.

Since the coloration of Renown and Apex could not be considered sufficiently uniform to be characteristic under normal greenhouse

temperatures it was decided to conduct a series of experiments to determine under what environmental conditions the character would be constant.

The first experiment consisted of growing the 18 varieties in soil and sand under continuous artificial light and natural daylight. The greenhouse temperatures were normal, 65° to 70° F.

In sand, with and without artificial light, no variety produced coleoptile pigmentation. Golden Ball gave its characteristic color. In soil Renown and Apex gave very slight coloration which was not constant. The effect of artificial light appeared to be negligible.

The second experiment was designed to compare the four varieties, Renown, Apex, Golden Ball and Regent 975.6, grown in peat and in soil with the following fertilizers: ammonium phosphate (16-20), ammonium sulphate and nitrate of soda. Normal and surface sowings were also compared. Two sets of each were prepared and placed in separate greenhouses. One greenhouse had a southern exposure and the natural light conditions were superior; the roof of the other was covered with snow. The average temperatures were 59° F. in the former and 58° F. in the latter.

In general the coleoptile color was green for all varieties with Golden Ball showing a very slight brownish tinge when fertilizers were used. There appeared to be varietal differences but these were very slight. However, a few plants of Apex showed some reddish-brown pigment and one plant was intensely red in the ammonium phosphate (16-20) treatment.

The nerves of the coleoptile were a darker shade of green than the other parts of the shoots. When grown in peat the coleoptiles were colorless with Golden Ball showing yellowish shoots which turned green about five days after emergence.

In a third experiment four series of the complete set of varieties were employed. One series was grown at a mean temperature of approximately 65° F. A second series was grown at a mean temperature of approximately 54° F. The third series was started at a low temperature (54?) and kept there for 24 hours, then transferred to a high temperature (65°F.) for 24 hours. This procedure was followed until five days after emergence. A fourth series was conducted in a similar manner except that it was started at a high temperature (65°F.). Notes were taken daily and the percentage of plants showing characteristic color was calculated from the total number of plants that emerged. Germination was very irregular with alternating temperatures.

In the series grown at 65° F. only 9% of the Renown plants showed reddish pigmentation and the color was weakly developed being only a slight streak along the nerve of the coleoptile. The color of Apex was quite similar but 13.95% of the plants showed coloration. Golden Ball showed its characteristic color in only 28.88% of the plants.

In the series grown at 54° F., 35.14%, 50.79% and 85% of the plants of Renown, Apex and Golden Ball respectively showed their characteristic color. The color in each variety was well developed. One to three plants of each of the following varieties, Marquis, Red Bobs, Rescue, Redman, Reward and Garnet showed a weakly developed reddish streak along the nerve of the coleoptile.

In the series started at a low temperature (54° F.), Golden Ball was the only variety which developed characteristic color and this was weakly expressed in 41% of the plants.

In the series started at a high temperature (65° F.) the characteristic color developed in Renown, Apex and Golden Ball. These varieties produced the following percentage of colored plants, 35, 57 and 71 respectively. A few plants of Marquis, Red Bobs, Rescue, Redman and Garnet gave a similar result to that in the series maintained at 54° F.

Under conditions of low temperature this characteristic coloration appears to reach its maximum development three days after emergence, remaining constant for about one day and then starting to disappear. At higher temperatures it reaches its maximum development two days after emergence and starts to disappear the following day.

It had been observed that a single kernel of Apex which was washed to the surface by watering produced an intensely colored shoot. For this reason it was decided to use surface sowings.

A fourth experiment designed to show the effect of light on the expression of coleoptile color with surface seeding was conducted. One hundred seeds of each variety were sown on the surface of the soil in 6-inch pots. The pots were placed in pans of water on the greenhouse bench and moisture was supplied to the kernels by the capillary action of the soil. Four conditions of light were employed, namely, natural daylight, continuous artificial light, daylight supplemented with ultra violet exposure and complete darkness. The mean temperature during the experiment was 66.0° F.

Artificial light was supplied from 500-watt Mazda lamps lowered to within 30-inches of the top of the greenhouse benches.

Ultra violet light was supplied from an "Alpine sun lamp" of the quartz mercury vapor type. The lamp was set on a stand in such a manner that the centre bracket of the reflector was 25-inches from the top of the greenhouse bench. Ten minute exposures were given in the morning and afternoon each day. Six pots were irradiated at once so as to insure complete coverage.

The kernels commenced to germinate two days after sowing and notes were taken daily. When plants showed characteristic color they were pulled and the number recorded.

Table 4 shows the percentage of plants showing characteristic coleoptile color for the experiment and also presents data for a normal seeding grown at a mean temperature of 56.0° F. and a surface seeding grown at a mean temperature of 60.0° F. In general the mean temperature of the test under continuous artificial light would be one to two degrees F. higher than the mean temperature of the remainder of the greenhouse for the period of the experiment. The various phases of this experiment will be discussed under separate headings.

Ultra violet light

The treatment with ultra violet light produced greater intensity of color in all plants, but the characteristic color of Renown, Apex and Golden Ball appeared to be suppressed in so far as the number of plants developing the characteristic was concerned. The variety Pelissier failed to develop reddish pigment with this treatment. Since only one test was conducted at only one period of exposure no definite con-

Table 4. Percentage of plants showing characteristic coleoptile coloration under different conditions of temperature, light and two methods of seeding.

Method of Seeding	Normal	Surface			
Mean Temperature	56° F.	60° F.	66° F.		
Light	Natural	Natural	Natural	Natural plus continuous artificial	Natural plus ultra violet	Dark chamber
Variety						
Regent 975.6	0	0	0	0	0	0
Thatcher	0	0	0	0	0	0
Canus	0	0	0	0	0	0
Reward	0	0	1	0	0	0
Marquis	1	0	0	0	0	0
Reliance	2	0	0	0	0	0
Regent 975.26	3	0	0	0	1	0
Redman	1	0	0	1	1	0
Red Bobs	6	0	0	0	0	0
Rescue	0	9	0	0	0	0
Garnet	0	12	3	0	0	0
Renown	58	79	71	78	64	0
Apex	72	97	77	95	87	0

Table 4. - Concluded.

Method of Seeding	Normal	Surface				
Mean Temperature	56° F.	60° F.	66° F.			
Light	Natural	Natural	Natural	Natural plus continuous artificial	Natural plus ultra violet	Dark Chamber
Variety						
Pelissier	0	41	23	11	0	0
Mindum	0	76	73	67	44	0
Carleton	0	87	64	67	63	0
Stewart	0	97	74	80	75	0
Golden Ball	85	71	58	57	48	0

clusion as to the effect of ultra violet light can be drawn but under the conditions of the test the expression of the character was not sufficient to warrant the employment of this method for identification purposes without further study.

Temperature

All varieties showed a greater percentage of colored plants at 60° F. than at 66° F.

Artificial light

The addition of artificial light to surface seeding showed an increase of 7% in the number of plants producing characteristic coloration for Renown and 18% for Apex, while Pelissier showed a marked decrease.

Method of seeding

Surface seeding at 60° F. increased color over normal seeding at 56° F. for the varieties, Rescue, Garnet, Renown, Apex and all the durums except Golden Ball which showed an increase of 14% with normal seeding. The varieties, Reward, Marquis, Reliance, Redman and Regent 975.26 developed some color under certain conditions but they must be considered as segregates, the result of natural crossing in the field.

The durum varieties other than Golden Ball developed a red area at the base of the stem at ground level with surface seeding. This condition is similar for all varieties and therefore could not be used as an identification character.

Dark Chamber

This test gave a negative result with the exception of Golden Ball which developed a very faint pink coloration in the stems. All other varieties were distinctly yellow with colorless coleoptiles.

The characteristic early seedling color of the variety Golden Ball is useful as an identification character, as is the characteristic coleoptile pigmentation of the varieties Renown and Apex. However, different conditions are required for the maximum expression of the two characteristic colors.

By means of this character Renown and Apex can be separated from the other bread wheats and Golden Ball from the other durum wheats.

3. The Use of Selective Sprays as a Means of Identification

Johnson (10) found that wheat species and varieties show a differential tolerance towards DDT (dichlorodiphenoltrichloroethane) applied as a spray. Leaves of seedlings of Arnautka, Spelmars and Khapli developed a pronounced chlorosis about a week after they were sprayed, whereas, Kota, Mindum and Einkorn showed no indication of chlorosis. Faint chlorosis was noted on Marquis, Kanred, Kubanka, Acme and Vernal. It was thought therefore that this method might be of use in the present study.

An experiment was designed to determine the varietal reactions to DDT and 2,4-D (dichlorophenoxyacetic acid) when used as sprays. Solutions were made up as follows: one ounce of pure DDT powder was dissolved in 1,000 c.c. of 95% alcohol. Ten c.c. of this stock solution were diluted to 200 c.c. with water after adding 5 c.c. of aerosol. Five grams of 2,4-D were dissolved in one gallon of water.

Four plantings of the eighteen varieties were made in 6-inch pots and the plants were sprayed slightly before the appearance of the second leaf, or five to seven days after emergence. Two series were sprayed with an alcoholic solution of DDT and the other two series were used as a control and sprayed with the same solution except that no DDT was present.

Chlorosis commenced to appear about five days after spraying and was quite pronounced on Renown and Apex. Five days later the plants were classified, varietal differences were distinct. The control plants did not develop chlorosis. The following scale was used in classification:

0. No chlorosis evident.

1. Tip of first leaf showing chlorosis.

2. Less than one half the area of the first leaf showing chlorosis.

3. One half the area of the first leaf showing chlorosis.

4. More than one half the area of the first leaf showing chlorosis.

5. The entire area of first leaf showing chlorosis.

6. The first leaf drying up and dying.

7. The first leaf drying up and dying with the stem showing some effect.

8. Stems more severely damaged than 7.

9. Plant severely damaged and dying.

10. Plants dead.

The average results of the two replicates are given in table 5 in which the mean rating is based on the above scale of 0 to 10.

Figure 16 shows a comparison of affected leaves and normal leaves of Apex, Renown and Pelissier.

The extent to which the varieties can be differentiated by DDT reaction alone is indicated below.

Bread Wheats

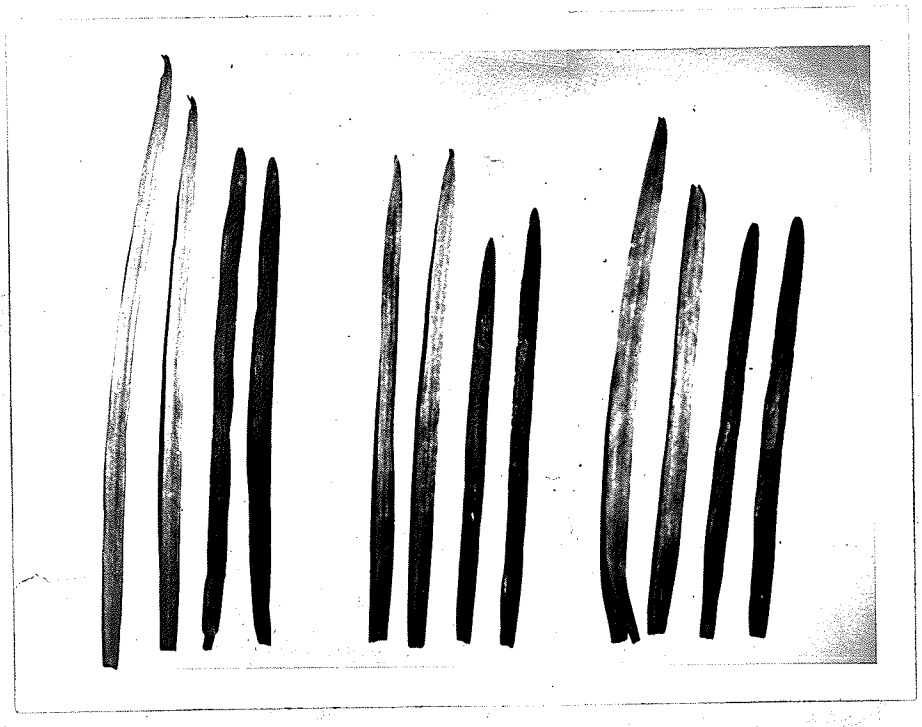
All or most plants chlorotic.

Heavy chlorosis.	Garnet.
Moderate chlorosis.	Apex, Renown.
About half of the plants chlorotic.	Reward, Reliance.
Few or no plants chlorotic.	Rescue, Regent 975.6, Regent 975.26, Thatcher, Red Bobs, Canus

Durum Wheats

All or most plants chlorotic.	Pelissier.
About half of the plants chlorotic.	Carleton, Golden Ball.
Few plants chlorotic.	Stewart, Mindum.

A similar experiment was conducted using 2,4-D as a spray but there were no varietal differences and the general effect of the spray was negligible.



a. b. c.

Figure 16. Chlorotic leaves (left) and normal leaves (right).
a, Apex; b, Renown; c, Pelissier.

Table 5. Reaction of varieties to DDT.

Variety	Mean percentage of plants showing chlorosis	Mean Rating
Thatcher	0.0	0.0
Regent 975.6	0.0	0.0
Regent 975.26	0.0	0.0
Canus	0.0	0.0
Marquis	0.0	0.0
Red Bobs	0.0	0.0
Redman	0.6	0.01
Rescue	8.6	0.1
Reward	49.2	0.4
Reliance	42.2	0.5
Renown	90.4	2.7
Apex	99.2	3.9
Garnet	100.0	5.2
Mindum	9.1	0.1
Stewart	20.3	0.2
Golden Ball	32.4	0.4
Carleton	46.0	0.5
Pelissier	100.0	2.5

4. Auricles

The auricles of 200 plants of each bread wheat variety were classified into types on the basis of size. Since many plants of all varieties produced a different type of auricle on each side of the plant, 30 classes were used. These have been grouped into five classes in Table 6, the longer auricle was considered as typical for a plant.

The plants were grown under various conditions of temperature and natural light but each variety was represented under each set of conditions. In general it was found that the type varied considerably with conditions and with the vigor of individual plants. Table 6 gives the results of the classification and also presents a numerical mean for each variety.

In the variety Garnet only 11% of the plants produced auricles. However, a fringe of small cilia was generally present on the edges of the collar. In all other varieties 70% or more of the plants produced auricles and the character was therefore considered to be reliable for the identification of Garnet. Although the variety Reward showed considerable variation in the type of auricle, 77% of the plants produced auricles. These were generally folded between the sheath and stem. This condition appeared to be quite characteristic.

In addition several varieties produced one or more spike-like hairs on the collar or auricles. Figure 17 shows this characteristic.

When used in conjunction with one or more of the major characters, the divisions outlined below gave a reliable indication as to variety.

Table 6. Classification of auricles for 200 plants of each bread wheat variety.

Type	Absent	Rudimentary	Short	Intermediate	Long		Percentage plants with auricles.
Numerical Value	1	2	3	4	5	Mean	
Variety							
Garnet	145	33	22			1.4	11
Apex	60	41	82	14	3	2.3	70
Red Bobs	60	35	92	11	2	2.3	70
Renown	46	21	54	35	44	3.1	77
Redman	48	12	100	33	7	2.7	76
Marquis	47	44	90	14	5	2.4	77
Reliance	44	24	92	29	12	2.7	78
Canus	46	19	105	23	7	2.6	77
Regent 975.6	21	22	89	39	29	2.7	90
Regent 975.26	21	8	125	24	22	3.1	90
Reward	33	16	99	32	20	2.9	84
Rescue	7	14	100	43	36	1.9	97
Thatcher	27	31	122	19	1	2.7	87

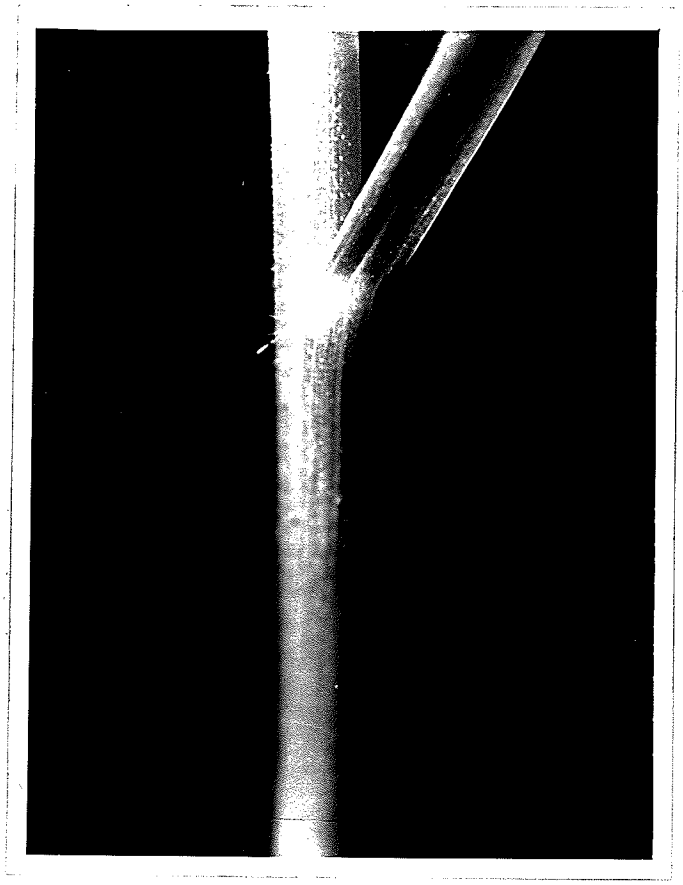


Figure 17. Spike-like hairs on auricle or collar of Thatcher.

Auricle usually absent, cilia present ..... Garnet

Auricle present on approximately 70% of plants, 2-5 spike-like hairs on auricle or collar..... Red Bobs, Apex

Auricle present on approximately 78% of plants, spike-like hairs inconspicuous or wanting..... Renown, Redman

1-3 spike-like hairs on auricle or collar ..... Marquis

1-2 spike-like hairs on auricle or collar, sometimes wanting... ..... Reliance, Canus

Auricle present on 85 to 90 percent of plants, spike-like hairs inconspicuous or wanting..... Reward, Regent 975.26, Regent 975.6.

2-5 spike-like hairs on auricle or collar.....Thatcher, Rescue

It was found that the durum wheats do not produce auricles but Mindum, Carleton, Stewart and, to a lesser degree Pelissier and Golden Ball, have cilia similar to those of Garnet.

5. Attitude of First Seedling Leaf.

The position of the first seedling leaf should be considered of minor importance in the identification of varieties. Although in a few varieties this leaf tends to fall forming an angle of 90° or more with the stem, as it is easily forced to this position in the watering of the plants, considerable care should be exercised in making an estimate of the character. It is not considered useful for single plant identifications but gives an indication whether Regent, Garnet or Reward is the prevailing variety. It is perhaps significant that the leaves of Regent 975.26 appear to fall 1 to 2 days earlier than those of Regent 975.6 and the character may be of greater value than the present study indicates.

The character appeared to be reasonably constant when the varieties were grown under different conditions and estimates were made on the basis of a scale of 1 to 10, erect leaves being scored as 1, and fully drooped leaves as 10. Table 7 gives the results of six readings taken 12 to 14 days after emergence. By this character the varieties may be divided into the following groups.

Bread Wheat

Erect	Intermediate	Drooped
Thatcher	Redman	Garnet
Apex	Canus	Regent 975.6
Rescue	Reliance	Reward
Renown	Marquis	Regent 975.26
Red Bobs		

Durum Wheat

Erect	Intermediate
Pelissier	Mindum
Golden Ball	Stewart
	Carleton

Table 7. Degree of drooping of first seedling leaf.

Variety	Readings						Mean
Thatcher	1	1	1	1	1	1	1.0
Apex	1	1	1	1	1	1	1.0
Rescue	1	1	4	1	1	1	1.7
Renown	3	2	2	2	2	2	2.2
Red Bobs	1	1	4	2	1	5	2.3
Redman	3	3	4	4	1	4	3.2
Canus	2	1	3	4	7	3	3.3
Reliance	2	1	5	4	5	4	3.5
Marquis	2	1	6	5	6	5	4.2
Garnet	8	6	8	9	2	7	6.7
Regent 975.6	7	8	7	8	8	9	7.8
Reward	8	8	7	8	9	9	8.2
Regent 975.26	8	9	8	9	9	9	8.7
Pelissier	1	1	1	1	1	1	1.0
Golden Ball	1	1	1	1	2	1	1.2
Mindum	3	1	5	4	1	5	3.2
Stewart	3	1	5	4	1	6	3.3
Carleton	3	1	5	4	5	5	3.8

6. Other Characters

The number of veins (vascular bundles) in the seedling leaves varies somewhat at different stages of growth, but the varietal differences were not constant owing to the variability within varieties.

The number of veins (vascular bundles) in the coleoptile was constant but there were no varietal differences.

The hairs of the leaf margins were found to vary in number, size and length on different varieties, but the differences were very minute and were not recorded. There were no distinct varietal differences in the shape of the leaf blades.

The fold of the leaf sheath was found to be constant and similar for all varieties.

The size and shape of ligule and collar were found to vary slightly but the variability within varieties was as great as between varieties.

The color of the stems and leaves was found to vary considerably and the relative varietal differences were reasonably constant, but the color varied under different light intensities and was difficult to define. Moreover, the differences that would be useful were found to follow closely the pubescence groups. Since pubescence was thought to be an easier character to work with, the differences in color were not recorded.

For the reasons outlined above these characters were not utilized in the practical identification tests conducted.

7. Varietal Descriptions and Keys for the Bread and Durum Wheats

Table 8 presents a summary of descriptions of varieties in the seedling stage. In this table pubescence and the length and distribution of the hairs are listed separately for convenience but they should be used together. Following Table 8 are keys, based on morphological characters and DDT reactions, for identifying varieties in the seedling stage. In the preparation of the table and keys the use of measurements has been purposely avoided with a view to providing a rapid means of identification. In the use of quantitive terms such as "short" and "long" (without defining them by actual units of measurement) it is assumed that the operator will set up approximate mental standards by comparison with seedlings of known identity.

In the identification of unknown samples it is recommended that a preliminary examination of kernel characteristics be made, as outlined by Peterson *et al.* (17). This will generally give an indication of the variety or the predominant variety in a mixed sample. This procedure followed by a study of the seedling characteristics should result in accurate identification.

Table 8. Seedling Characteristics of bread and durum wheat varieties.

Characteristic No.	1.	2.	3.	4.	5.	6.	7.	
Variety	Pubescence	Length and distribution of hairs	Coleoptile coloration	Reaction to DDT	Auricle	Appendages on collar or auricle	Position of first leaf.	Most Useful Characteristic
Rescue	Nearly glabrous	Extremely short and sparse	Green	Very slight chlorosis	Present 97%	Spike-like (2-5)	Erect	1, 2, 5, 6.
Apex	Nearly glabrous	Short, sparse	Deep Reddish	Moderate chlorosis	Present 70%	Spike-like (1-4)	Erect	1, 3, 4.
Reliance	Slight	Short, moderately sparse	Green	Slight chlorosis	Present 78%	Spike-like (1-2) sometimes wanting	Intermediate	1, 2, 5, 6.
Marquis	Slight	Mixed (short and extremely short) moderately sparse	Green	Nil	Present 77%	Spike-like (1-3)	Intermediate	1, 2, 5, 6.
Canus	Slight	Mixed (short and extremely short), moderately sparse	Green	Nil	Present 77%	Spike-like (1-2) sometimes wanting	Intermediate	1, 2, 5, 6.
Thatcher	Slight	Short, few	Green	Nil	Present 87%	Spike-like (2-5)	Erect	1, 2, 5, 6.
Red Bobs	Moderate	Short (fine), few	Green	Nil	Present 70%	Spike-like (2-5)	Erect	1, 2, 5, 6.
Reward	Moderate	Mixed (long and short), many	Green	Slight chlorosis	Present 84% Generally folded	Inconspicuous or wanting	Drooping	1, 5, 4, 7.
Garnet	Moderate	Mixed (medium and short)(medium predominant), many	Green	Heavy chlorosis	Absent 89%	Ciliate	Drooping	5, 1, 4, 7.
Renown	Heavy	Long, very many	Reddish-brown	Moderate chlorosis	Present 77%	Inconspicuous or wanting	Erect	1, 3, 4.
Redman	Heavy	Long, very many	Green	Very slight chlorosis	Present 76%	Inconspicuous or wanting	Intermediate	1, 5, 7, 4.
Regent 975.6	Heavy	Mixed (long and medium), very many	Green	Nil	Present 90%	Inconspicuous or wanting	Drooping, later	1, 2, 7, 5.
Regent 975.26	Heavy	Mixed (long and medium), very many	Green	Nil	Present 90%	Inconspicuous or wanting	Drooping, early	1, 2, 7, 5.
Mindum	Glabrous	None	Yellowish green	Slight chlorosis	Absent	Ciliate	Intermediate	
Carleton	Glabrous	None	Yellowish green	Slight chlorosis	Absent	Ciliate	Intermediate	
Stewart	Glabrous	None	Yellowish green	Slight chlorosis	Absent	Ciliate	Intermediate	
Pelissier	Glabrous	None	Yellowish green	Moderate chlorosis	Absent	Usually wanting	Erect	4.
Golden Ball	Glabrous	None	Colorless, stem dark greenish-brown	Slight chlorosis	Absent	Usually wanting	Erect	3.

Key for Seedling Identification of Bread Wheat Varieties.

A. Leaf sheath nearly glabrous.

B. Coleoptile with deep reddish color ..... Apex

BB. Coleoptile without deep reddish color..... Rescue

AA. Leaf sheath slightly pubescent.

B. Auricles or collar with 2-5 spike-like appendages; hairs (pubescence) short, few ..... Thatcher

BB. Auricle or collar with 1-3 spike-like appendages; hairs (pubescence) mixed (short and extremely short), moderately sparse..... Marquis

BBB. Auricle or collar with 1-2 spike-like appendages, sometimes wanting.

C. Hairs (pubescence) short, moderately sparse..Reliance

CC. Hairs (pubescence) mixed (short and extremely short), moderately sparse..... Canus

AAA. Leaf sheath moderately pubescent.

B. Auricles usually present.

C. Auricle usually folded between leaf sheath and stem.. ..... Reward

CC. Auricle or collar with 2-5 spike-like appendages .... Red Bobs

BB. Auricle absent (rarely present) ..... Garnet

AAAA. Leaf sheath heavily pubescent.

B. Coleoptile with reddish-brown tinge ..... Renown

BB. Coleoptile without reddish-brown tinge.

C. Hairs (pubescence) long ..... Redman

CC. Hairs (pubescence) mixed (long and short).

D. First leaf droops (early) ..... Regent 975.26

DD. First leaf droops (later) ..... Regent 975.6

Key for Seedling Identification of Durum Wheat Varieties

A. Early seedling color dark greenish-brown..... Golden Ball

AA. Early seedling color yellowish-green.

B. Chlorosis from DDT moderate ..... Pelissier

BB. Chlorosis from DDT slight .....Mindum, Carleton, Stewart

8. Reactions to Disease

In a review of the literature on the seedling reactions to stem rust of wheat Puccinia graminis Tritici. Erkss. and Henn. it was found that the seedling reactions of a few of the varieties included in this study were not reported and that for some of those reported, strains different from those now under consideration, had been used. Tests were made to determine the typical reaction of each variety to several physiologic races of stem rust.

The seedlings were grown in 4-inch pots and two determinations were made for each variety to each race of rust employed. The seedlings were inoculated when the first seedling leaf was well developed, about seven days after emergence. The "finger method" of inoculation was used. Following inoculation, the plants were placed in moist chambers for 24 hours, after which they were placed on the benches in the greenhouse where they remained until notes were taken on their rust reactions.

The system used in recording the types of stem rust infection was that originally devised by Stakman and Levine (19) as described by Johnson (9), and is as follows:

Type 0. Host immune. No uredinia are formed; hypersensitive flecks are frequently present. The reaction is then indicated by "0;".

Type 1. Host very resistant. Uredinia are minute, each being surrounded by a well defined necrotic area.

Type 2. Host moderately resistant. Uredinia are small to medium in size, and are commonly found in islands of green tissue surrounded by necrotic halo.

Type 3. Host moderately susceptible. Uredinia are medium in size, and

do not coalesce very frequently. Hypersensitiveness is absent, but the pustules may be surrounded by chlorotic areas.

Type 4. Host very susceptible. Uredinia are large and generally confluent. Hypersensitiveness is absent, but slight chlorosis may accompany pustules.

Type X. Host reaction heterogeneous. Uredinia on the same leaf vary in size; frequently all the types of infection are found occurring together on the same leaf.

The signs (+) (-) were used to indicate quantitative variations in the above types. Owing to the fact that this system of recording is not familiar to all plant breeders, the symbols were translated into terms of resistance and susceptibility as shown below.

Infection Type		Abbreviation
0 and 0;	Immune	I
1, 2-, 2	Resistant	R
2+, X	Moderately Resistant	MR
3-, 3	Moderately Susceptible	MS
3+, 4	Susceptible	S

The work was started on the 20th of October and completed on the 23rd of January. During this period ofthe winter, environmental conditions for the development of stem rust are known to be poor. Neatby (12) found that under greenhouse conditions, even with artificial illumination, reactions in the middle of winter were not entirely satisfactory, infections sometimes failing to take place on all the seedlings. Hart and Forbes (8) obtained a higher degree of infection in light than in darkness but in no case did they obtain 100% infection. They used

seven varieties of wheat and two races of stem rust, obtaining a range in percentage of infection from 54.8% to 90.1% under light.

In this study when the susceptible host used as a check failed to produce pustules, the entire test was repeated. In general the infections were reasonably good.

Table 9 shows the seedling reactions for the twelve physiologic races studied. The varieties are grouped according to the species to which they belong. The results are in reasonable agreement with those reported by Newton et al. (14, 15). Both sources of data were used in the preparation of keys which follow Table 9. Physiologic Race 34 was not available for testing and Race 50 was not tested.

Attempts to identify varieties by means of their rust reactions failed, owing to the low percentage of infections. It is believed that the method might be reasonably efficient if used in the fall or spring months.

Table 9. Seedling reactions of 18 wheat varieties to 12 physiologic races of Puccinia graminis Tritici.

Variety	Physiologic race											
	2	11	17	19	29	30	36	39	56	63	80	139
Triticum vulgare												
Thatcher	I	I	I	I	I	I	R	MR	R	R	I	I
Regent 975.6	R	S	S	R	S	S	MR	R	S	R	S	MS
Regent 975.26	R	S	S	R	S	S	S	R	S	R	S	MS
Renown	I	S	S	R	S	S	R	R	R	R	R	R
Redman	I	S	S	R	S	S	R	R	R	R	R	R
Apex	I	R	I	I	I	I	MS	R	MS	S	I	I
Reliance	MS	S	I	I	I	I	S	MS	S	S	I	I
Canus	MR	S	I	I	I	I	S	R	S	R	I	I
Rescue	MR	S	MS	R	MS	I	S	MS	S	S	MS	R
Marquis	R	S	S	R	S	S	S	R	S	R	S	MS
Red Bobs	R	S	S	R	S	S	S	R	S	R	S	S
Reward	R	S	S	R	S	S	S	MR	S	MS	S	S
Garnet	S	S	S	S	S	S	S	S	S	S	S	S
Triticum durum												
Mindum	I	S	S	S	MR	S	R	S	I	S	R	I
Carleton	I	I	I	I	I	S	I	R	I	I	S	I
Stewart	I	I	I	I	I	S	I	R	R	I	S	I
Pelissier	S	S	S	S	S	S	S	S	S	S	S	S
Golden Ball	MR	S	MR	MS	MS	MS	R	S	S	R	S	S

Key for Identification of Bread Wheat Varieties based on Rust Reactions

A. Immune to race 17 or 20.

B. Moderately resistant to race 34 ..... Thatcher

BB. Susceptible to race 34.

C. Resistant to race 11 ..... Apex

CC. Susceptible to race 11.

D. Resistant to race 39 ..... Canus

DD. Moderately susceptible to race 39..... Reliance

AA. Susceptible to race 17 or 29.

B. Resistant or moderately resistant to race 36.

C. Resistant to race 80 ..... Renown, Redman

CC. Susceptible to race 80 ..... Regent 975.6

BB. Susceptible to race 36.

C. Resistant to race 19.

D. Resistant to race 39.

E. Resistant to race 63.

F. Resistant to race 50 ..... Marquis

FF. Susceptible to race 50..... Red Bobs

EE. Moderately susceptible to race 63.. Reward

DD. Susceptible to race 19 ..... Rescue

CC. Susceptible to race 19 ..... Garnet

Key for Identification of Durum Wheat Varieties based on Rust Reactions

A. Immune to race 19 ..... Carleton, Stewart

AA. Susceptible to race 19.

B. Moderately resistant to race 29 ..... Mindum

BB. Susceptible to race 29.

C. Resistant to race 36 .....Golden Ball

CC. Susceptible to race 36 ..... Pelissier

9. Practical Identification Tests.

The remainder of the present study is concerned with practical applications of the methods of identification that have been described. Since the methods were developed to meet two types of problems, first, the identification of pure or relatively pure varieties and secondly, the detection and identification of off-type plants within varieties, tests involving these problems were devised.

The tests were conducted at all stages of the study to determine what progress was being made, and all results are shown.

Identification of Varieties.

The samples were grown in 6-inch pots under number. A complete set of named varieties were grown for comparison. Final identification was made when the third leaf was well developed.

Test 1: This test was made early in the study when the only character extensively studied was pubescence and it was believed that Garnet lacked auricles. The results are given in Table 10 which shows that eleven were identified incorrectly but that all were placed in their proper pubescence group.

Test 2: The results in Table 10 show that errors in bread wheats involved Apex, Marquis and Reliance which are very closely related wheats and quite similar. However, Apex was placed in the wrong pubescence group. The durum varieties, other than Golden Ball which has a characteristic early seedling color, could not be distinguished, but at the stage of growth at which they were examined this color had disappeared.

Table 10. Preliminary results in the identification of varieties using two seedling characters, pubescence and presence or absence of auricles.

Varieties in pubescence groups	Identified as:		
	Test 1.	Test 2.	Test 3.
Nearly Glabrous			
Rescue	Rescue	Rescue	Rescue
Apex	Apex	Reliance	Apex
Slightly Pubescent			
Reliance	Marquis	Marquis	Reliance
Marquis	Thatcher	Apex	Marquis
Canus	Red Bobs	Canus	Canus
Thatcher	Reliance	Thatcher	Thatcher
Moderately Pubescent			
Red Bobs	Canus	Red Bobs	Red Bobs
Reward	Reward	Reward	Reward
Garnet	Garnet	Garnet	Garnet
Heavily Pubescent			
Renown	Regent 975.6	Renown	Renown
Redman	Regent 975.26	Redman	Redman
Regent 975.6	Redman	Regent 975.6	Regent 975.6
Regent 975.26	Renown	Regent 975.26	Regent 975.26
Glabrous			
Pelissier	Pelissier	Stewart	Carleton
Mindum	Golden Ball	Pelissier	Pelissier
Golden Ball	Mindum	Mindum	Golden Ball
Stewart	Stewart	Golden Ball	Mindum
Carleton	Carleton	Carleton	Stewart

Test 3: In this test the distinguishing characteristics used were coleoptile color, pubescence, auricle and degree of drooping of the first leaf. As shown in Table 10 all the bread wheats were correctly identified indicating that identification on the basis of these four seedling characters is highly efficient. Results with the durum wheats are, however, unsatisfactory.

Detection and Identification of Off-types

The samples of 100 seeds each of varieties containing various proportions of different off-types were prepared by an assistant, who kept an exact record of the composition of the sample. A complete set of named varieties were grown for comparison. Final identification was made in the third leaf stage.

In tests 4, 5, 6 and 7 germinated kernels were planted in flats, by an assistant who kept a record of the identity and location of each off-type plant.

In tests 8, 9 and 10 the number of plants of each variety expected on the basis of total germination was calculated. The number of abnormal plants were not included in this calculation as only an occasional abnormal plant could be positively identified. In general these plants expressed only one of the major characters, pubescence, characteristic color or reaction to DDT. The exclusion of abnormal plants from the calculation appears to be reasonable since it is believed relatively few of these plants would normally reach maturity.

Tests 4, 5, 6 and 7: These tests were designed to test the accuracy of the identification of off-type plants within varieties when the pre-

dominant variety was known. Tests 4 and 5 were predominantly Thatcher and 6 and 7 were predominantly Regent 975.6. Plantings were made on the 10th of November. The mean daily temperature for the first 13 days of growth was 63° F. The characteristic coleoptile color failed to develop so that the majority of the Renown and Apex plants were misplaced in identification. The only characters that could be used were pubescence and auricles as the droopiness of leaves was found to be of little value. The complete result is given in Table 11 and definite improvement in the number correctly classified is indicated from test to test through test 7. However, it must be pointed out that the separation required for sample 7 should be comparatively simple. On the other hand all of the off-types in the samples were found and only two Marquis plants in test 5 were identified erroneously as the predominant variety. By the use of two characters 84% of the plants were classified correctly.

Test 8: This test involved the identification of 20 samples. The information available was that they were samples of bread wheat and that only one strain of Regent was used. The samples were sown in 6-inch pots and covered very lightly. The plants were examined and marked for coleoptile color by means of tooth picks. To indicate plants identified as nearly glabrous or pubescent, plants of the type having the lowest frequency were marked with small marking tags. For example, three nearly glabrous plants were tagged in sample 7 and in sample 3 five pubescent plants were tagged. Characteristic coleoptile color was reasonably well expressed. Five days after emergence the plants were sprayed with DDT and identification was completed twelve days later.

The results are given in Table 12 and in general the agreement of

Table 11. Results of the detection and identification of individual off-type plants in varietal mixtures, the predominant variety being known.

Test No.	Varieties Used	No. Plants	Identified as: Thatcher	Garnet	Regent	Reward	Apex	Rescue	Marquis	Renown	Reliance	doubtful	Marked as off-type not named	Correct	Wrong
4.	Thatcher	91	74	2	2			1	1	2	1	4	4	74	17
	Regent	5				2				3				0	5
	Apex	4					1	1	1				1	1	1
	TOTALS	100												75	25
5.	Thatcher	93	79	4			1			1	1	5	2	79	14
	Marquis	3	2									1		0	3
	Renown	2			2									0	2
	Redman	2			1					1				0	2
	TOTALS	100												79	21

Table 11 - concluded.

Test No.	Varieties Used	No. Plants	Thatcher	Garnet	Regent	Reward	Apex	Rescue	Marquis	Renown	Reliance	doubtful	Marked as off-type not named	Correct	Wrong
6.	Regent	90			87					2		1		87	3
	Apex	2	1				1							1	1
	Marquis	3	1				1		1					1	2
	Renown	5			4							1		0	5
	TOTALS	100												89	11
7.	Thatcher	9	7				2							7	2
	Regent	91			87		3			1				87	4
	TOTALS	100												94	6
GRAND TOTAL		400												337	63

Table 12. Results of the determination of the percentages of varieties in mixed samples, using four seedling characters, coleoptile color, pubescence, presence or absence of auricles and chlorosis from DDT.
Test 8.

Sample No.			Varieties				Total Germination	No. of Abnormal Plants
			Apex	Renown	Regent	Thatcher		
1.	Composition		100					
	Identification	No. Expected	95					
		No. Found	95				95	3
2.	Composition		97	3				
	Identification	No. Expected	91.18	2.82				
		No. Found	90	4			94	
3.	Composition		95		5			
	Identification	No. Expected	95		5			
		No. Found	95		5		100	
4.	Composition		93			7		
	Identification	No. Expected	88.35			6.65		
		No. Found	91			4	95	2
5.	Composition		79	7	7	7		
	Identification	No. Expected	73.47	6.51	6.51	6.51		
		No. Found	74	4	8	7	93	

No. Expected calculated from total germination, abnormal plants were not included in total germination.

Table 12 - continued

Test 8 - continued

Sample No.			Varieties				Total Germination	No. of Abnormal Plants
			Apex	Renown	Regent	Thatcher		
6.	Composition			100				
	Identification	No. Expected		83				
		No. Found		74	9		83	
7.	Composition		3	97				
	Identification	No. Expected	2.67	86.33				
		No. Found		86	3		89	1
8.	Composition			95		5		
	Identification	No. Expected		78.85		4.15		
		No. Found		71	7	5	83	3
9.	Composition			93	7			
	Identification	No. Expected		88.35	6.65			
		No. Found		74	21		95	
10.	Composition		7	79	7	7		
	Identification	No. Expected	6.79	76.63	6.79	6.79		
		No. Found	5	70	17	5	97	3

No. Expected calculated from total germination, abnormal plants were not included in total germination.

Table 12 - continued

Test 8 - continued

Sample No.			Varieties				Total Germination	No. of Abnormal Plants
			Apex	Renown	Regent	Thatcher		
11.	Composition					100		
	Identification	No. Expected				99		
		No. Found				99	99	
12.	Composition		3			97		
	Identification	No. Expected	2.82			91.18		
		No. Found	1			92	94	1
13.	Composition			5		95		
	Identification	No. Expected		4.95		94.05		
		No. Found		3		95	99	
14.	Composition				7	93		
	Identification	No. Expected			6.93	92.07		
		No. Found			8	91	99	
15.	Composition		7	7	7	79		
	Identification	No. Expected	6.79	6.79	6.79	76.63		
		No. Found	6	7	5	79	97	

**No. Expected calculated from total germination, abnormal plants were not included in total germination.

Table 12 - concluded

Test 8 - concluded

Sample No.			Varieties				Total Germination	No. of Abnormal Plants
			Apex	Renown	Regent	Thatcher		
16.	Composition				100			
	Identification	No. Expected			89			
		No. Found			89		89	
17.	Composition			3	97			
	Identification	No. Expected		2.49	80.51			
		No. Found		3	80		83	
18.	Composition				95	5		
	Identification	No. Expected			85.50	4.50		
		No. Found			85	5	90	
19.	Composition		7		93			
	Identification	No. Expected	6.16		81.84			
		No. Found	6		83		88	1
20.	Composition		7	7	79	7		
	Identification	No. Expected	5.95	5.95	67.15	5.95		
		No. Found	6	8	67	4	85	

No. Expected calculated from total germination, abnormal plants were not included in total germination.

the number expected and the number found are reasonably satisfactory. Samples 1, 6, 11 and 16 were pure varieties. In sample 6, nine plants were called Regent instead of Renown. This situation can be explained by the fact that Renown did not always give 100% expression of the two characters, coleoptile color and reaction to DDT. A similar discrepancy was shown for samples 5, 7, 8, 9, 10, 13 and 20. Characteristic color and reaction to DDT are the only characters by which these two varieties can be differentiated in the seedling stage at the present time.

In sample 2 an extra plant of Renown was found and cannot be explained unless it is assumed to be a volunteer plant.

Sample 3 represents a perfect separation and in samples 4, 15, 17, 18 and 19 the number of types found and number expected on the basis of total germination are in very good agreement. Sample 12 shows a plant identified as Renown and this can only be explained as a plant of Thatcher at the higher limit of pubescence for Thatcher. A similar condition explains the situation of sample 14.

Although the general result is good it must be pointed out that the accuracy of identification is confounded with imperfect germination and varieties. It cannot be stated definitely that a particular plant was identified correctly or incorrectly, because differential germination may have altered the proportions of the ingredients of the mixture. However, the result is quite satisfactory for all practical purposes and appears to compare favorably with results of identification by mature plant characteristics.

Test 9: In this test ten samples were involved and two of these were durum. The samples were sown in 6-inch pots by the surface method

and artificial light was used until germination was considered to be complete. The plants were marked for coleoptile color by means of tooth picks. Two days after emergence the light was discontinued and approximately 125 grams of very fine soil was sprinkled amongst the shoots. The mean daily temperature for this period of the test was 62° F. Due to the possibility of some kernels germinating after being covered with soil the plants were not sprayed until 8 days after the first kernels had germinated. The plants were not tagged for pubescence but this character was used in the final identification which was completed on the twelfth day after spraying.

As shown in Table 13 germination was slightly lower than that of test 8 but it was within the limits required for No. 1 seed. The discrepancy between the varieties Renown and Regent is somewhat reduced compared to test 8 and is perhaps accounted for by the improved conditions for the development of coleoptile color. The discrepancies here represent more nearly those which would be expected from the reaction to DDT alone. The high value for Thatcher in samples 1 and 3 can only be attributed to errors in identification.

In the two durum samples the determination of the percentage of Pelissier by means of DDT reaction appears to be fairly accurate. The remainder of the sample could not be identified as to variety but it was known that it was not Golden Ball and therefore could have been either Carleton, Stewart or Mindum.

Test 10: In this test the information available was that not more than nine varieties were involved. These were Regent 975.6, Renown, Thatcher, Apex, Marquis, Redman, Rescue, Reward and Garnet. Artificial

Table 13. Results of the determination of the percentages of varieties in mixed samples, using four seedling characters, coleoptile color, pubescence, presence or absence of auricles and chlorosis from DDT.
Test 9.

Sample No.		Varieties							Total Germination	No. of Abnormal Plants
		Apex	Renown	Regent	Thatcher	Pelissier	Carleton	Durum		
1.	Composition	7	8	75	10					
	No. Expected Identification	6.30	7.20	67.50	9					
	No. Found	6	6	67	11				90	
2.	Composition	7	68	10	15					
	No. Expected Identification	5.74	55.76	8.20	12.30					
	No. Found	6	49	12	15				82	1
3.	Composition	50	20	17	13					
	No. Expected Identification	43	17.20	14.62	11.18					
	No. Found	36	18	15	17				86	9
4.	Composition	10	15	15	60					
	No. Expected Identification	9	13.50	13.50	54					
	No. Found	6	13	14	57				92	4
5.	Composition	25	15	20	40					
	No. Expected Identification	23	13.80	18.40	36.80					
	No. Found	18	16	20	38				92	2

Table 13 - concluded

Test 9 - concluded

Sample No.		Varieties							Total Germination	No. of Abnormal Plants
		Apex	Renown	Regent	Thatcher	Pelissier	Carleton	Durum		
6.	Composition	27	35	13	25					
	No. Expected	22.68	29.40	10.92	21					
	Identification No. Found	26	24	14	20				84	5
7.	Composition	15	37	23	25					
	No. Expected	12.75	31.45	19.55	21.25					
	Identification No. Found	12	29	19	25				85	2
8.	Composition	25	30	25	20					
	No. Expected	21.50	25.80	21.50	17.20					
	Identification No. Found	19	20	28	19				86	1
9.	Composition					40	60			
	No. Expected					31.60	47.4			
	Identification No. Found					32		47	79	
10.	Composition					20	80			
	No. Expected					16.80	67.20			
	Identification No. Found					18		66	84	

light was used until the plants were marked for coleoptile color. The mean temperature for this early period of the test was 60° F. The plants were sprayed with DDT four days after planting of the germinated seed. Final identification was made fifteen days after spraying.

It was noticed that a few check plants of Redman and Rescue produced reddish coleoptiles. Germination was considerably improved but not perfect, the lowest being 92% and the highest 99%. Due to the high percentage of abnormal plants in sample 7 an attempt was made to identify them. Seven were believed to be Renown and one Apex. The other four could not be identified. These are included in Table 14 as abnormal plants.

In sample 1, of the 22 plants identified as Regent, 10 obviously must have been Redman. In sample 2 eight plants showed reddish coleoptiles but no effect from DDT. Since they were heavily pubescent they were called Renown. If these had been called Redman there would still be a discrepancy of one for Renown. The eleven plants called Regent again must have been Redman. In sample 3 none of the plants showed chlorosis but eight plants produced reddish coleoptiles. Three of these were Rescue as they were nearly glabrous. The other five were called Redman. Sample 4 gave reasonable agreement with expected results except for Thatcher. In samples 5 and 8 all of the Redman seedlings were called Regent. There appeared to be two extra plants of Renown found in each. This could be due to the fact that the plants were left a few days too long before final classification was made and an occasional plant of Redman showed some reaction to DDT. Sample 6

Table 14. Results of the determination of the percentage of varieties in mixed samples, using four seedling characters, coleoptile color, pubescence, presence or absence of auricles and chlorosis from DDT.
Test 10.

Sample No.		Varieties						Total Germination	No. of Abnormal Plants
		Apex	Renown	Regent	Thatcher	Redman	Rescue		
1.	Composition		60	12		10	18		
	No. Expected		58.80	11.76		9.80	17.64		
	Identification No. Found		58	22			18	98	
2.	Composition	12	18		50	20			
	No. Expected	11.16	16.74		46.50	18.60			
	Identification No. Found	12	27	11	43			93	2
3.	Composition			75		12	13		
	No. Expected			69		11.04	11.96		
	Identification No. Found			74		5	13	92	
4.	Composition	65	15		12		8		
	No. Expected	55.90	12.90		10.32		6.88		
	Identification No. Found	60	13		5		8	86	6
5.	Composition		11	9		80			
	No. Expected		10.56	8.64		76.80			
	Identification No. Expected		13	83				96	2

Table 14 - concluded

Test 10 - concluded

Sample No.			Varieties						Total Germination	No. of Abnormal Plants
			Apex	Renown	Regent	Thatcher	Redman	Rescue		
6.	Composition			10	5	5		80		
	Identification	No. Expected		9.80	4.90	4.90		78.40		
		No. Found		6	7	5		80	98	
7.	Composition		60	25	15					
	Identification	No.Expected	50.40	21.00	12.60					
		No.Found	52	17	15				84	12
8.	Composition			10	9		75	6		
	Identification	No.Expected		9.70	8.73		72.75	5.82		
		No.Found		12	79			6	97	1
9.	Composition		7			60	18	15		
	Identification	No.Expected	6.30			54	16.20	13.50		
		No.Found	7	3		54	15	11	90	4
10.	Composition		13		75			12		
	Identification	No.Expected	12.87		74.25			11.88		
		No.Found	12		75			12	99	

shows an excellent separation of Rescue with the usual discrepancy for Renown and Regent. In sample 7 the separation was good. Sample 10 shows a practically perfect separation.

In sample 9 fifteen plants were classified as Redman but it was believed that this was mainly a fortunate chance agreement and that at the present stage of the work the Redman plants in question might easily have been taken for Regent.

These tests show the possibilities of the use of seedlings in the analysis of seed samples. Apex, Rescue and Thatcher were separated accurately from mixtures. The separation of Renown from Regent and Redman was not as efficient and Redman and Regent could not be differentiated in mixtures. Pure or relatively pure varieties were identified accurately.

Purity Test

Impurities in seed stocks may arise from several sources, the principal ones being mechanical mixture and natural crossing. Goulden and Neatby (6) found great differences in the extent of natural crossing with pure lines of Marquillo. The purification of a variety is accomplished by pure line selection and the work is generally done in the field. This process is slow, several years being required for the production of a uniform foundation stock.

A study was begun involving 20 pure lines of Renown, previously selected in the field. One hundred plants of each line were grown in a bed in the greenhouse and the plants were examined for pubescence, coleoptile coloration and reaction to stem rust. The

test was made in duplicate and a separate series of 50 plants of each line was grown to determine the reaction to DDT. For the stem rust test races 2, 19, 36, 38, 48, 49, 80, 139, 152 and 155 were used in a mixture. Renown was reported to be resistant to all of the above races.

Table 15 shows the average result of the two tests compared with that of the parent variety Renown.

No single line or plant was found to be off-type for the character pubescence. The majority of the lines showed a greater percentage of colored plants than Renown, but lines 14 and 16 were slightly lower. All lines produced a greater percentage of chlorotic plants when sprayed with DDT with the exception of line 12 which produced a slightly lower percentage than Renown.

The stem rust infections were considered to be reasonably good in spite of a relatively high percentage of "escapes" with the susceptible host in the second test. Renown produced 2.32% susceptible plants and line 6 produced 19.8% susceptible plants. Lines 9, 12, 14, 16 and 24 also produced a greater percentage of susceptible plants than Renown. All other lines produced a lower percentage of susceptible plants than Renown.

If the percentage susceptibility is accepted as a measure of impurity then the elimination of lines showing greater susceptibility than Renown would improve the pure line stocks and the ultimate foundation stock.

Table 15. Percentage of plants showing colored coleoptile, chlorosis with DDT and susceptibility to stem rust in 20 pure lines of Renown.

Line No.	Percentage of plants with colored coleoptile	Percentage of plants showing chlorosis	Percentage of susceptible plants
Renown	77.4	68.0	2.32
1	91.8	100.0	1.0
2	88.8	91.7	0.0
3	88.6	97.7	0.0
4	92.0	100.0	0.0
5	82.9	82.9	1.0
6	87.5	78.1	19.8
9	82.2	100.0	4.0
12	92.8	60.7	5.0
14	76.7	93.0	3.0
15	92.5	87.5	1.0
16	72.1	81.4	5.0
18	82.2	91.1	2.0
19	80.8	97.9	2.0
20	88.4	93.0	0.0
22	87.8	90.2	2.0
23	84.2	100.0	0.0
24	81.8	100.0	8.0
25	85.7	78.6	1.0
26	92.7	85.3	1.0
28	88.6	91.4	1.0

CONCLUSIONS

It is evident from the results presented that no one characteristic when used alone is sufficient for the identification of wheat varieties in the seedling stage. For certain varieties a combination of all the characters used in this study is fairly satisfactory and appears to be as efficient as identification based on an examination of mature plants. The number of varieties which can be identified in the seedling stage might be increased by further investigation.

The degree of success attained by the use of DDT indicates that a study of other chemicals might yield highly effieient methods of identification.

Stem rust reactions appear to be promising as a method of identification provided that the tests are made under the most suitable conditions. It is, of course, possible that the inclusion of plant diseases other than stem rust might provide a more satisfactory means of identification.

The techniques outlines in this paper are quite useful in the detection of off-types that are likely to occur in Western Canadian wheats and hence in the processing of Foundation Stocks.

It is concluded that further study and development of the principles and methods outlined in this study will greatly improve the efficiency and precision of varietal identification.

SUMMARY

1. A study was made of the use of seedling characters for the identification of 13 varieties of bread wheat and five varieties of durum wheat. Morphological characteristics, coleoptile color, early seedling color and reactions to DDT and stem rust were employed.

2. The bread wheats can be divided into four groups by the amount of pubescence on the leaf sheaths and stems: the durum wheats are glabrous.

3. Coleoptile color was used in the identification of Renown (reddish-brown) and Apex (deep reddish).

4. Golden Ball produced a dark greenish-brown shoot which was found to be useful in separating it from the other durum wheats.

5. Reactions to DDT were found to be suitable for distinguishing Renown, Apex and Pelissier from other varieties. These three varieties produced moderate chlorosis when sprayed with DDT.

6. The presence or absence of auricles and the spike-like hairs on the auricle or collar was found to be useful as a supplementary character in the identification of the bread wheats.

7. The attitude of the first seedling leaf was valuable in separating the two strains of Regent in relatively pure samples.

8. Stem rust reactions may be useful in identification work but optimum conditions for the development of the fungus appear to be essential.

9. Keys are presented for the identification of the varieties studied.

10. Reasonably pure samples of the bread wheats were identified accurately.

11. By a combination of characters it was found that Rescue, Apex and

Thatcher could be separated accurately when in mixtures, while Renown could be separated from all varieties except Regent and Redman.

12. It was found that Golden Ball and Pelissier could be separated accurately from the other durums, while Mindum, Carleton and Stewart could not be distinguished one from the other.

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