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THE RANGE IN COLOUR OF THE FLOWERING GLUME OF CYNOSURUS CRISTATUS L. AND ITS RELATION TO THE GERMINATION CAPACITY OF THE "SEED"*.

by L. Corkhill

Introduction.

It is well known that commercial lines of seed of Crested Dogstail (Cynosurus crestatus L.) often exhibit marked differences in colour, some samples in bulk being canary yellow while others are almost black. There is often great variation within a line in the colour of the individual seeds which may vary from greenish yellow through various shades of yellow, orange, and brown to almost a black colour. In some samples, however, the range in colour is more restricted, such samples naturally exhibiting a more uniform appearance.

It is important to understand at the outset the commercial attitude towards the colour of a sample. Until recently the great demand by farmers was for seed of a bright yellow colour, which, although of a lower bushel weight than darker seed, was nevertheless more attractive in appearance. As a general rule the germination was good so that as far as utilisation in New Zealand was concerned this type was satisfactory.

With an extension of exports it was found that the New Zealand samples, although regarded in England with favour because oftheir bright clean appearance, were generally of indifferent germination. It was found, moreover, that samples of darker colour could stand transshipment much better than those of lighter colour.

It is known in the trade that a very dark colour may be imparted to seed by heating in the sack, the stripped seed being very liable to this unless care is taken to

* The term "seed" is in this work used in the wide sense meaning "caryopsis".

prevent it. Farmers generally look upon a dark sample with suspicion and prefer the lighter coloured yellow samples.

General observations, however, have shown that there are distinct differences between plants in regard to the colour of the seeds at comparable stages in growth, It was considered that any data which could throw light on colour development and give further facts on its probable utility would be useful.

The investigations recorded in Part 1. were carried out with the object of attempting to ascertain whether the darkness in colour of Crested Dogstail seed is due to maturity alone, or whether there are other factors concerned. The question to which answers have been sought are:-

1. Do fully mature seeds of different plants differ in intensity of colour?

2. Does earliness or lateness of flowering exert any effect on the depth of colour attained by the seeds?

3. Do short period changes in the weather during ripening exert any effect on the ultimate colour of the seeds?

4. Is there any correlation between darkness in colour of fully mature seeds and the presence or absence of pigmentation in such parts of the plant as the flowering stem or sterile spikelets?

In Part 2. of the work (page 49) an attempt has been made to ascertain:-

1. Whether there are differences in the germination capacity of seeds of different colour groups from any single plant.

2. Whether seeds of the same colour group but from different plants exhibit variation in germination capacity.

PART 1.

Materials and Methods.

Selection was made from spaced plants nine inches apart grown in rows eighteen inches wide. There was thus ample room for the full development of each plant, competition and the shade factor having been eliminated.

Twenty-eight plants from both commercial and local strains were chosen. Plants were selected over a wide range of date of flowering in order to ascertain whether earliness or lateness of flowering produced any effect on the seed colour. It was noticed that different plants showed wide variation in the amount of purple colouration developed on the seed-stalk, rachis, sterile spikelet, flowering glume, and palea. The selection included plants as diverse as possible in this respect.

The plants were identified by means of numbered pegs.

At flowering time each plant was examined, and those heads which bloomed at approximately the same time were retained while the remainder were clipped off. On a small number of the plants only seven heads remained, but usually it was possible to retain from eight to twelve. By naked eye and with a X12 hand lens a close examination was then made of the stalk, rachis, sterile spikelets, and, where visible, the flowering glume and palea, with special reference to the amount of purple colouration developed. As the amount of purple in the seed-stalks increased with maturity, they were examined at fortnightly intervals, and the amount and position of the colour recorded.

A few days after the completion of blooming of each plant one of the seed-heads was clipped off, placed in a labelled seed envelope, and taken to the laboratory for further examination. At three-day intervals, one seed-head from each plant was removed and examined. The length of time between collecting the first and last head of a plant ranged from three to five weeks depending on the number of seed-heads. If the selected heads of the same plant bloomed simultaneously, it would naturally be supposed that examination of seeds from heads harvested at three day intervals would serve to show differences due to maturity. The possibility that pronounced changes of weather during the ripening period might exert an effect on the colour of the seed and modify the results of maturity was also kept in mind.

To obviate the effects of any after-ripening, the seed-heads were examined in the laboratory as soon as possible after being removed from the plant. A dissecting microscope with a magnification of twenty diameters was used for these observations which were made in reflected daylight against a white background. As depth of colour depends so much on intensity of light, examinations were made only during uniform and favourable periods of the day. Artificial light was found to be unsuitable for complete differentiation.

Before removing the seeds, the head was examined under the microscope to determine the amount and position of the purple and green pigments in the rachis and sterile spikelets. The seeds were then removed from the head and about two hundred (i.e. usually about one-third to one-half) were examined under the microscope. To expedite examination the seeds were placed in rows

so that there was little likelihood of any escaping observation or being examined more than once.
They were placed with the flowering glume* uppermost, and twenty diagrams were painted to depict the range in colour. (See Plates i.ii.and iii, pages 9-11)
The number of seeds corresponding to each colour group was noted, enabling the percentage of the differently coloured seeds in the head to be obtained.
Each colour diagram was identified by a letter :- a.b.c.etc. These groups are arbitrary but serve the purpose of classifying the seeds. With such a large number of colour groups the majority of the seeds approximated closely to the diagrams.

* When speaking of the colour of the seed reference is strictly being made only to the colour of the flowering glume.

Results:

Of the twenty-eight plants under examination four were omitted from the results because of the very high percentage of undeveloped group y seeds. The figures relating to the remaining twenty-four are given in Tables 1 - 9 (pages 12-21)

The colour groups range in order from the lightest at the top to the darkest at the base of the column. Groups x and y have been separated and placed at the bottom of each table as these seeds must be considered apart from seeds of the other groups. The straw coloured seeds of group y are usually poorly developed, consisting only of "husk", while those of group x, though often well developed, have lost any bright colouration they may have possessed.

Seeds which resembled a colour diagram except that they had two-thirds or more of the area of the flowering glume straw coloured have been identified in the tables by means of an asterisk.

In order to stress any difference in the final colour of the seeds of different plants, graphs have been prepared by plotting the darkest colour group in each head against the maturity of that head (pages 28-36)* The graphs shown in Figs.1 - 7 (pages 28-34) are plotted with mantessae of the same colour groups. Plants A 13, A 16, and A 18(Fig.8, page 35) and A 4. (Fig. 9, page 36) contain some different colour groups and have been plotted separately.

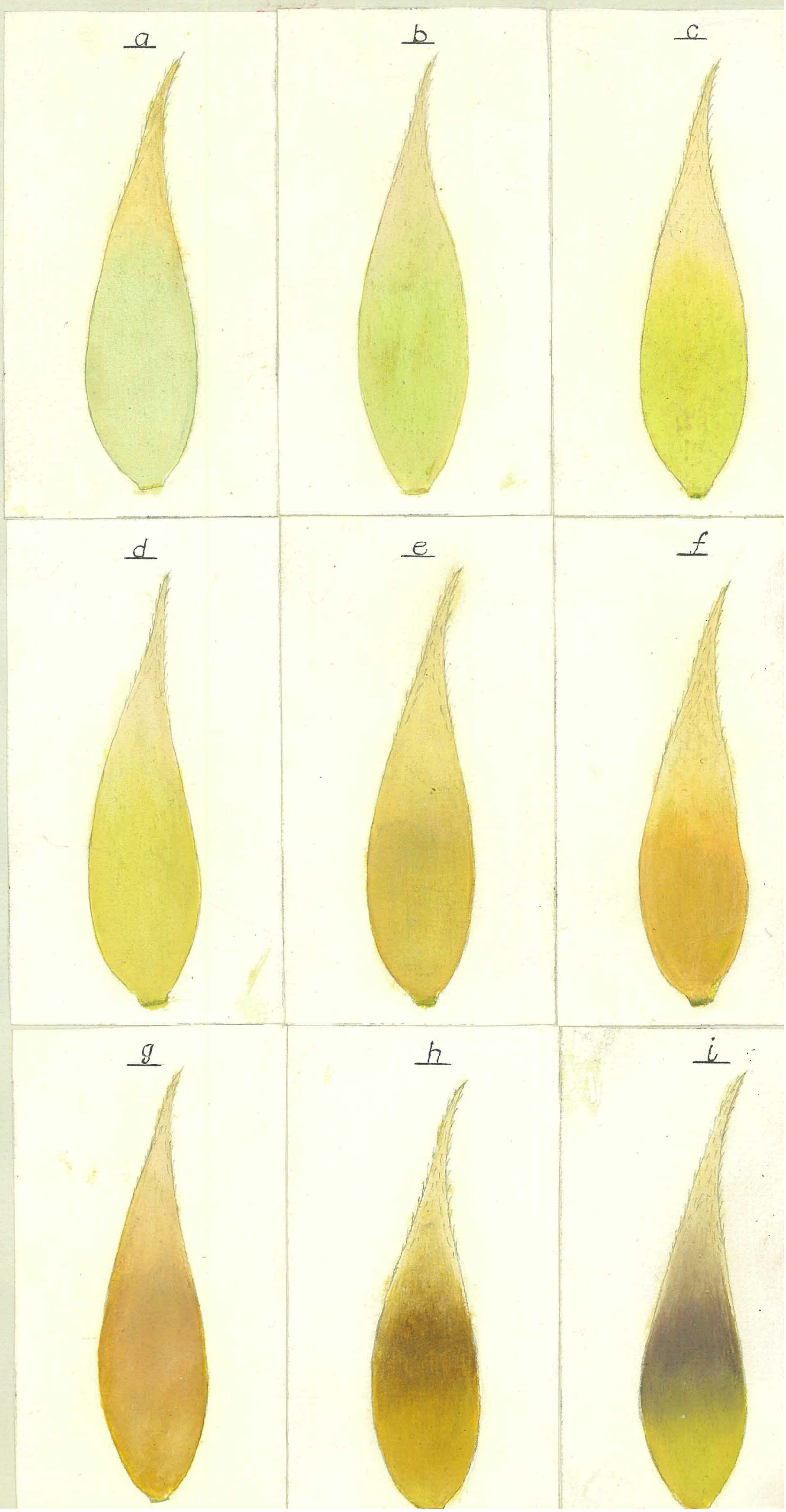
* The darkest colour group comprising at least 5% of the seeds in the head (excluding group y) was used for the construction of the graphs, as figures lower than this were not regarded as significant.

Groups y and x have been omitted from the graphs.

With the exception of Plants A 13, A 16, A 18 and A 4, graphs of plants which flowered at approximately the same time are grouped together, but allowance must be made for the fact that the first heads were not necessarily collected on the same date. At the base of each graph the date when the first head was collected is shown. This grouping does not apply to graphs of Plants A 13, A 16, and A 18 (Fig.8 page 35) which are grouped together as they resemble one another in having certain colour groups not occuring in the other graphs. Furthermore, Plant A 4 has some different graphs from all the foregoing plants and has therefore been plotted separately.

For ease of reference the grouping of the plants in the tables has been made comparable with that of the graphs.

PLATE 1.




j
k
l
m
n
o
p
q
r

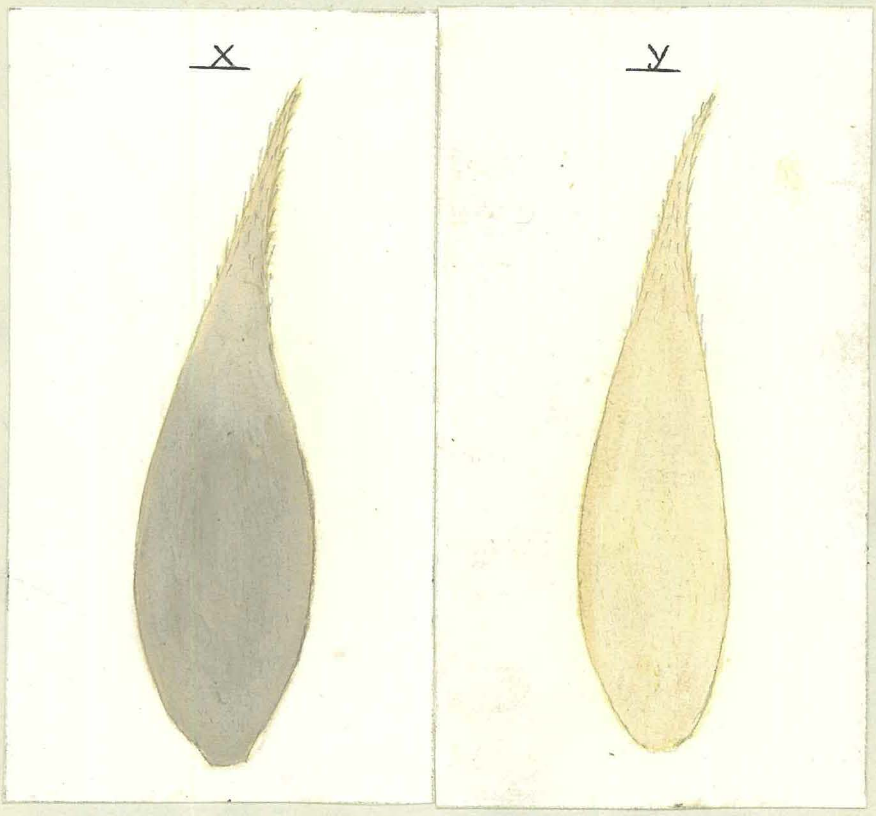

X
Y

TABLE 1.

COLOUR GROUPS OF SEEDS FROM HEADS COLLECTED AT 3 DAY INTERVALS.

Plant A 1.

Heads:-	1	2	3	4	5	6	7	8	9.
Groups.	%	%	%	%	%	%	%	%	%
a	17								
b	50	45	49						
c		25	26		42*				
d				49	7*				
e						19	23	11	3
f				14					
g									
h						49	16	11	
i									
j									
k						5	16	14	
l									
m									10
n						5	9	10	11
o									
p								6	3
q									
r									
x								21	14
y	33	30	25	37	51	22	36	27	59

Plant A 8.

Heads:-	1	2	3	4	5	6	7	8	9	10.
Groups.	%	%	%	%	%	%	%	%	%	%
a	51	12								
b	33	38	21	13						
c	8	12	20	45						
d		12	33	15						
e			19		43*	55				
f					38*					
g						22				
h						12	41	18	13	
i										
j										
k							31	32	18	
l										
m									12	49
n								16		
o										
p							9	18	25	9
q										2
r										
x							3	7	13	21
y	8	26	7	27	19	11	16	9	19	19

Plant A 9.

Heads:-	1	2	3	4	5	6	7	8	9	10.
Groups.	%	%	%	%	%	%	%	%	%	%
a	22									
b	58	21	31							
c	10	52	39							
d		19	7							
e				43*	19*		6	24*		
f				36*						
g										
h					11	46	46	19		21
i										
j					39					
k					14	30	21	9	11	22
l										
m										24
n							5		21*	
o										
p						12	6		13	
q						3				6
r										
x								14	19	9
y	10	8	23	21	17	9	16	34	36	18

TABLE 2.

COLOUR GROUPS OF SEEDS FROM HEADS COLLECTED AT 3 DAY INTERVALS.

Plant A 7.

Heads:-	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Groups.	%	%	%	%	%	%	%	%	%	%	%	%	%	%
a	77	64												
b	11	21	51	21										
c			41	62	45	28*								
d						31	7							
e					23							4	18	6
f					23	15					11			
g														
h							37						11	
i														
j														
k							40	12	23		9	7	21	
l										5			7	
m												18		5* 19
n									4					
o											11			
p								46	40	25	29	8	12	5
q								14	4	50	7	7	1*	26
r														
x								7	6	1	4			4
y	12	15	8	17	9	26	16	21	23	19	29	56	30	35

Plant A 6.

Heads:-	1	2	3	4	5	6	7	8	9	1o	11	12
Groups.	%	%	%	%	%	%	%	%	%	%	%	%
a												
b												
c		7*										
d	8* 23		38*									
e	37*	56*	16*		52*	3*						
f						3*						
g												
h				16	10		3	11	13			
i												
j												
k				11			21	21	7		22	
l												
m						25	27	31	35	24* 11	3* 8	2
n				18	4	4*						
o												
p				8				10			20	
q							22		11	2* 16	27	10* 58
r												
x				11	7	26	4	3	29		2	
y	32	37	46	36	27	39	23	24	5	47	18	30

Plant A 12

Heads:-	1	2	3	4	5	6	7	8
Groups.	%	%	%	%	%	%	%	%
a								
b								
c	19	22						
d	75		40					
e		54			41	8	27	
f		6						
g								
h			18	21	17	33	17	20
i								
j		8	36					
k				30	18	25		
l								
m						1	23	53
n								
o								
p				19	16	17		11
q				10		5	22	10
r								
x								
y	6	10	6	20	8	11	11	6

TABLE 3.

COLOUR GROUPS OF SEEDS FROM HEADS COLLECTED AT 3 DAY INTERVALS.

Plant A 10.

Heads:-	1	2	3	4	5	6	7	8	9	10
Groups:	%	%	%	%	%	%	%	%	%	%
a	89	71								
b		16	63	57*	50* 10	11*				
c			24	26*	33*	12*	20*			
d						24* 35	3*			
e										
f										
g										
h								8		
i										
j										
k										
l										
m								11*	8*	62*
n								14		
o										
p										
q										
r										
x							64	42	26	14
y	11	13	13	17	7	18	13	25	66	24

Plant A 22.

Heads	1	2	3	4	5	6	7	8	9	10	11	12	13
Groups	%	%	%	%	%	%	%	%	%	%	%	%	%
a	93	15	13										
b		45	36	75									
c		17	26	17		8*							
d					51	35*				8			
e							6* 40	17	4*	15	16	7	9
f													
g													
h						9	15	29		9	20	13	
i													
j													
k								17	3	5	11	6	
l													
m									7	10		25	13* 29
n										5			
o													
p									10	4	3		
q													
r													
x									7		5		
y	7	23	25	8	49	48	39	37	69	44	45	49	49

Table 3 (Continued.)

Plant A 21.

Heads:- Groups.	1 %	2 %	3 %	4 %	5 %	6 %	7 %	8 %	9 %	10. %
a	68		11							
b	13		44							
c		10* 23								
d		31	26	11						
e										
f		21		1						
g										
h						7				
i										
j										
k						17	9			
l										
m										5* 6
n					13*	4*				
o								4	18* 26	16* 6
p						13	21		9	
q							15	10* 64	13	25* 5
r										
x						9	34	10	8	
y	19	15	19	88	87	50	21	12	26	37

Plant A 11.

Groups	1 %	2 %	3 %	4 %	5 %	6 %	7 %	8 %	9. %
a									
b									
c	46	8*							
d	23	6*	7*	16* 22	25*				
e						2			
f									
g									
h				6	8*				
i									
j									
k									
l									
m						6	3* 9	11	3*
n					9				
o									
p									
q									
r									
x				8	5	7		6	
y	31	86	93	48	53	85	88	83	97

TABLE 4.

COLOUR GROUPS OF SEEDS FROM HEADS COLLECTED AT 3 DAY INTERVALS.

Plant A 15

Heads:-	1	2	3	4	5	6	7	8	9	10
Groups.	%	%	%	%	%	%	%	%	%	%
a	65									
		17*	10*							
b	18	50	9							
c			15	3*		6*				
d				16*	15*	6*				
						6*				13*
e					15*	14		5	4	8
f										
g										
h						10	2			5
i										
j										
k							6			
l										
								12*	22*	
m							5	24	16	12
n					15*	10	28*	7	8	
o										
p										
q										
r										
x						12	16	12	14	4
y	17	33	66	81	55	36	43	40	36	58

Plant A 3.

	1	2	3	4	5	6	7	8.
	%	%	%	%	%	%	%	%
a								
	32*							
b	15							
	9*	9*						
c	3	26		29*				
				36*				
d			40*	7	4			
e					64*	57*	50*	48*
f								
g								
h								
i								
j								
k								
l								
m							12*	17
n								
o								
p								
q								
r								
x				6		11	12	8
y	41	65	60	22	32	32	26	27

TABLE 5.

COLOUR GROUPS OF SEEDS FROM HEADS COLLECTED AT 3 DAY INTERVALS.

Plant A 24.

Heads:-	1	2	3	4	5	6	7	8	9
Groups.	%	%	%	%	%	%	%	%	%
a	95	82	76	16					
b			6	28	14				
						18*			
c			5	9	20	34			
							28*		
d					10	14	7		
							9*		15*
e							7		3
f									16*
g									
h									
i									
j									
k									
l									
								33*	
m								16	
n									
o									
p									
q									
r									
x						6	16	19	11
y	5	18	13	47	56	28	33	32	47

Plant A 19

Heads:-	1	2	3	4	5	6	7	8	9
Groups.	%	%	%	%	%	%	%	%	%
a	100	91	16						
b		3							
				10*					
c			23	4					
d				4					
					12*				
e					5		24		36
f									
g									
h						8			
i									
j									
k						7			
l									
m							8	1	5
n									
o									
p						2			
q						1	3	2	
r									
x					18	16	6	7	4
y		6	61	82	65	66	59	90	55

Plant A 26.

Heads:-	1	2	3	4	5	6	7	8	9	10	11
Groups.	%	%	%	%	%	%	%	%	%	%	%
a	100	89	20								
b		8	16								
c			44	22	49	22		13			
											3*
d				47	27	28		26	28	9	19
							4*				
e						8	29	13	4	39	
f				6		5					
g											
h							32	28		12	7
i											
j									37	6	
k											
l											
m											14
n											
o											
p											
q											
r											
x											2
y		3	20	25	24	37	35	20	31	34	55

TABLE 6.

COLOUR GROUPS OF SEEDS FROM HEADS COLLECTED AT 3 DAY INTERVALS.

	Plant A 14.												Plant A 25.								
Heads:-	1	2	3	4	5	6	7	8	9	10	11		1	2	3	4	5	6	7	8	9.
Groups.	%	%	%	%	%	%	%	%	%	%	%		%	%	%	%	%	%	%	%	%
a	98	91	53	62								a	100	99	68	44	13		6		
b			20	3	2*							b			4	17					
					8*																
c			14		10	10*						c				4			2*		
								4*											8*	3*	
d					9	6		9		10*		d						19	20	4	4
							13*	5*	18*	5*	3*						13*	8*		4*	
e						15	7	14	10	8	5	e					4	6	6	11	
f												f									
g												g									
h						20		17	12		5	h									
i												i									
j												j									
k								4	6		3	k								5	
l												l									
											6*										
m							10*		3	4	5	m									16
n												n									
o												o									
p												p									
q												q									
r												r									
x						9	4			3	3	x				11	30	16	12	16	
y	2	9	13	35	71	40	66	47	51	70	70	y		1	28	24	40	51	46	57	80

TABLE 7.

COLOUR GROUPS OF SEEDS FROM HEADS COLLECTED AT 3 DAY INTERVALS.

Plant A 23

Heads:-	1	2	3	4	5	6	7
Groups.	%	%	%	%	%	%	%
a	17						
b	15		19*				
c		8*	5*	25*	6*		
d		29*		6*	26*		
e					7*		
f							
g							
h							
i							
j							
k							
l							
m					9*		29* 6
n							
o							
p							
q							5
r							
x		15	9		5		4
y	68	48	67	69	47	100	56

Plant A 27

Heads:-	1	2	3	4	5	6	7
Groups.	%	%	%	%	%	%	%
a		18	64				
b	5	11	20				
c	35		2	3	3		
d	21	3		11* 7	33	17	
e				11* 21	20	14	
f					9		2
g							
h							
i							
j						1	
k							
l							5
m						2	12* 3
n						2	
o							10
p							11
q							12
r							
x		18		3		2	5
y	39	50	14	44	35	62	40

Plant A 28.

Heads:-	1	2	3	4	5	6	7	8
Groups.	%	%	%	%	%	%	%	
a	17		26					
b	26		23					
c	14	35	18			16* 3		
d		13				30		
e				8* 8	9*	6		
f								
g								
h						13		
i								
j						9		
k				15				
l								
m				3	10* 6		2* 7	
n								
o								
p								
q					1		11	
r								
x								
y	43	52	33	66	74	23	80	

TABLE 8.

COLOUR GROUPS OF SEEDS FROM HEADS COLLECTED AT 3 DAY INTERVALS.

Plant A 13.

Heads:-	1	2	3	4	5	6	7	8	9	10
Groups.	%	%	%	%	%	%	%	%	%	%
a	95	92	57							
b		1	13							
c			10	32	13		3*	7		
							9*			
d				24	16	32	14	15	5	
e					15	8		7	7	3
f				14	3	9				
g										
h							27	10		7
i										
j										
k							5	10		
l									3	19
										11*
m									5*	5
n										
o										9
p										
q										
r										
x						3	4	1		
y	5	7	20	30	53	48	38	50	80	46

Plant A 16.

Heads:-	1	2	3	4	5	6	7	8	9	10
Groups.	%	%	%	%	%	%	%	%	%	%
a	67									
b	20									
c										
d		4								
e	3	10								
f										
g		9								
h					4		8			
i										
j										
k					16	17	32			
l			58	6		11				
m							5			8
n										12
o			6			11		3	10	
p				22	40	23	17	2	23	25
q				5	1			7	27	23
r										
x		19	10	21	7	4	5	3	5	6
y	10	58	26	46	32	34	33	85	35	26

Plant A 18.

Heads:-	1	2	3	4	5	6.
Groups.	%	%	%	%	%	%
a	7					
b	10	14				
c	22	20		17		
				3*		
d		32	23*	36		
e	39	9		9	7*	
f						1
g		9				
h			12	4		
i						
j						
k			13		27	
l			5			5
					8*	
m					7	11*
n						
o						
p					4	
q					4	14*
r						
x			18	5	12	7
y	22	16	29	26	31	62

TABLE 9.

COLOUR GROUPS OF SEEDS FROM HEADS COLLECTED AT 3 DAY INTERVALS.

Plant A 4.

Heads:-	1	2	3	4	5	6	7	8.
Groups.	%	%	%	%	%	%	%	%
a	36							
b	20							
c	20	6	7					
					7*			
d		50	44		33	23	15	5
e								23
f								
g								
h				26				
i				18	25	30	20	
j								
k								
l								
m				6	3	4		1
n								
o								
p								
q								
r					2		10	24
x				9			5	
y	24	44	49	41	30	43	50	47

Discussion of Results:

In considering the colour of the caryopsis we have examined only the flowering glume, which should be considered as a part of the mother plant. The most widely accepted view on the phylogeny of the grasses is that they have originated by reduction and modification from lily-like plants. The palea is commonly assumed to represent the outer perianth whorl, and the flowering glume is considered as being a bract. In fertilization the characters of the embryo and endosperm are influenced by the characters of the pollen parent, but there is no evidence that this influence would extend to the flowering glume and palea. It is not necessary, therefore, to consider the pollen parent when studying characters of the flowering glume and palea.

The results shown in Tables 1 to 9 will be discussed under three headings, viz.

1. The range in colour of the seeds of a single head.
2. The occurence of different colour groups in different plants.
3. The anomalous groups x and y.

The graphs which have been constructed from data in the tables show some results more clearly. These will be considered later (page 37) under the following headings:-

1. The trend in seed colour with increase in age of the seed-heads, and the final colour attained by seeds of different plants.
2. The rate of increase in the colour intensity of the seeds.

1. The Range in Colour of the Seeds of a Single Head:

In any one head the different seeds cannot usually all be included in the same colour group. Just after blooming all the seeds of a head are green, but in a few days some begin to show a yellow tint. As the head becomes more mature some take on a deeper yellow colour while others may be still green, and others again will be intermediate. With further maturity, as the yellow in some of the seeds gives place to various shades of brown, the number of colour groups present usually increases. In the final heads collected the range may be maintained but in some cases it decreases and in others actually increases.

It may be thought that the range in colour of the seeds of a single head is due to the difference in the dates of blooming of the flowers. As there is an average of four to five days between the blooming of the terminal and basal flowers of the same spikelet and an average of about eight days between the opening of the first and last flower in the head, the above contention without further evidence, would tend to carry weight. On this hypothesis, the seeds from the flowers which bloomed first would be the most mature and would therefore be the darkest in colour, while the seeds from flowers which bloomed last would be lighter until the final stage of development when colour increase ceased. When all of the seeds had reached this stage they would be uniform in colour. This, however, is found to be the case only in two of the twenty-four plants studied.

Since fourteen heads of Plant A 7, (Table 2 page 13) have been collected and analysed, it will serve as a good example to illustrate the diversity of seed colour of the most mature heads. The darkest colour present, group q, appears first in head 8 and some seeds of this group are present in each of the heads collected later. As head 14 was collected eighteen days later that head 8 and thirty-nine days after the yellow colour began to develop in some of the seeds it seems reasonable to assume that all the seeds of this head should have reached their final colour. But in head 14, as in the other heads, there are some seeds which are much lighter in colour than group q. Looking at this from a slightly different standpoint, it can be assumed that as the final colour was first present in head 8 (twenty-one days after the first head was collected), then the addition of the average period of flowering of a head (eight days) to this should give the approximate time when all seeds were of the same colour. As has been shown previously, however, even after thirty-nine days, that is eighteen days after the final colour first made its appearance, the head still showed yellow seeds with only a tinge of brown. It is apparent, therefore, that age is not solely responsible in determining the degree of darkness of colour attained by the seeds.

The position in the spikelet my exert some influence in determining the degree of darkness of the seeds. In plants where the dark colour group q occurs, some evidence has been collected which indicates that the terminal seed of a spikelet is often eventually darker in colour than the other seeds of the same spikelet, even although the terminal flower is the last in the spikelet to bloom. This seed can be recognised by its withered rachilla or by a rudimentary sterile flower attached to the rachilla. Although it is usually quite well filled it is always smaller than the other seeds. In head 10 of Plant A 16 (Table 8 page 20) 75% of the terminal seeds were classified as group q, the rest being placed in groups p and n, but only 22% of the "non-terminal" seeds were included under group q. Although similar counts have not been made with seeds of other plants, in a number of cases it has been noted that the majority of the group q seeds were terminal.

Observations, as far as they go, appear therefore to indicate that the effect of age alone on the darkness of the seed colour may be modified by the position of the seed in the spikelet.

2. The Occurrence of Different Colour Groups in Different Plants:

Although the lighter coloured groups are very similar in different plants, this cannot be said of the darker groups. With increase in age of the seeds there is a uniform trend from group a through group b and c to group d, but after this stage is reached there is remarkable diversity in the colours attained by seeds of different plants. There is marked difference, for example, between plants in the degree of reddish colouration developed in some of the more mature seeds. Some plants contain seeds of such reddish coloured groups as q, l and o, while others contain none of these groups. Reference to the analysis of Plant A 16, given in Table 8 (page 20) shows that a large number of the seeds have a decided reddish tint. Plant A 4 (Table 9, page 21) on the other hand, has no trace of red in any of the seeds, the darker seeds in this case having a very slight purple tint. The seeds of the other plants examined are intermediate between ~~these two extremes~~, such differences of colour in the seeds of different plants lead to the conclusion that the colour of the darker seeds is associated with different strains.

In support of this conclusion reference will be made to seed size and shape. During examination it was noticed that at a comparable stage of maturity, seeds of an individual plant showed a fairly marked uniformity of shape and size. In some cases the shape or size was so characteristi that a mere glance at the seed was sufficient to indicate the plant from which they were derived. It seems, therefore, that within the species, there are strains which are recognisable by the size, shape, and colour of the more mature seeds.

3. The Seeds of Groups y and x.:

In these two groups the bright pigmentation so characteristic of the seeds of the other groups is absent.

Seeds of group y are usually very poorly developed, consisting almost entirely of "husk", but occasionally development may be normal. Immediately after flowering, all of the seeds in a head are green in colour, but as they become more mature some take on a yellow tint while others become totally straw coloured. Thereafter, each head contains some of these straw coloured seeds of group y.

Although the seeds of group x lack the bright colour development of most of the groups, they are darker than those of group y and ofter exhibit a greyish colour. Usually they are fairly well developed. They always appear at a later date than the first appearance of the group y seeds.

In the seeds of both of these groups there is a loss of pigmentation. In the case of the poorly developed group y seeds the explanation seems to be that the loss is due to infertility and the ultimate death of all parts of the caryopsis. In regard to the majority of the group x seeds and the well developed ones of group y, however, the explanation will not hold, as apart from the loss in colour, the seeds exhibit normal development. Only the fact that this loss in pigmentation does occur in some seeds has been ascertained, the cause not having been investigated.

There seems to be individuality in the plant with regard to the development of group x seeds. For example, Plants A 12 (Table 2 page 13) and A 28 (Table 7, page 19) contain no seeds of this group, while plant A 25 (Table 6, page 18) contains a relatively large number. It appears that this fact furnishes additional evidence to the idea of strains within the species.

Fig. 1

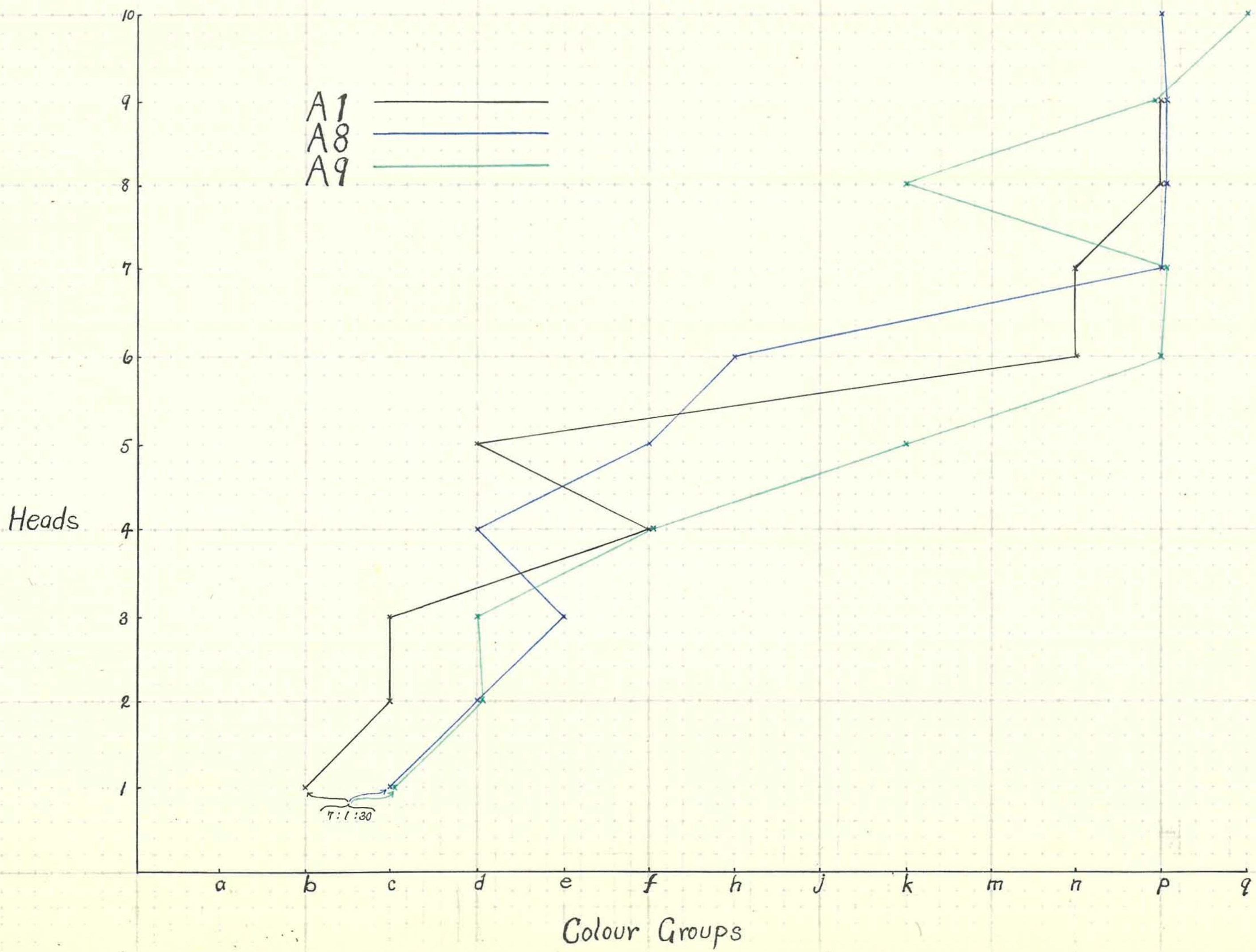

A1
A8
A9
Heads
10
9
8
7
6
5
4
3
2
1
a
b
c
d
e
f
h
j
k
m
n
p
q
Colour Groups
7: 1:30

Fig.2.

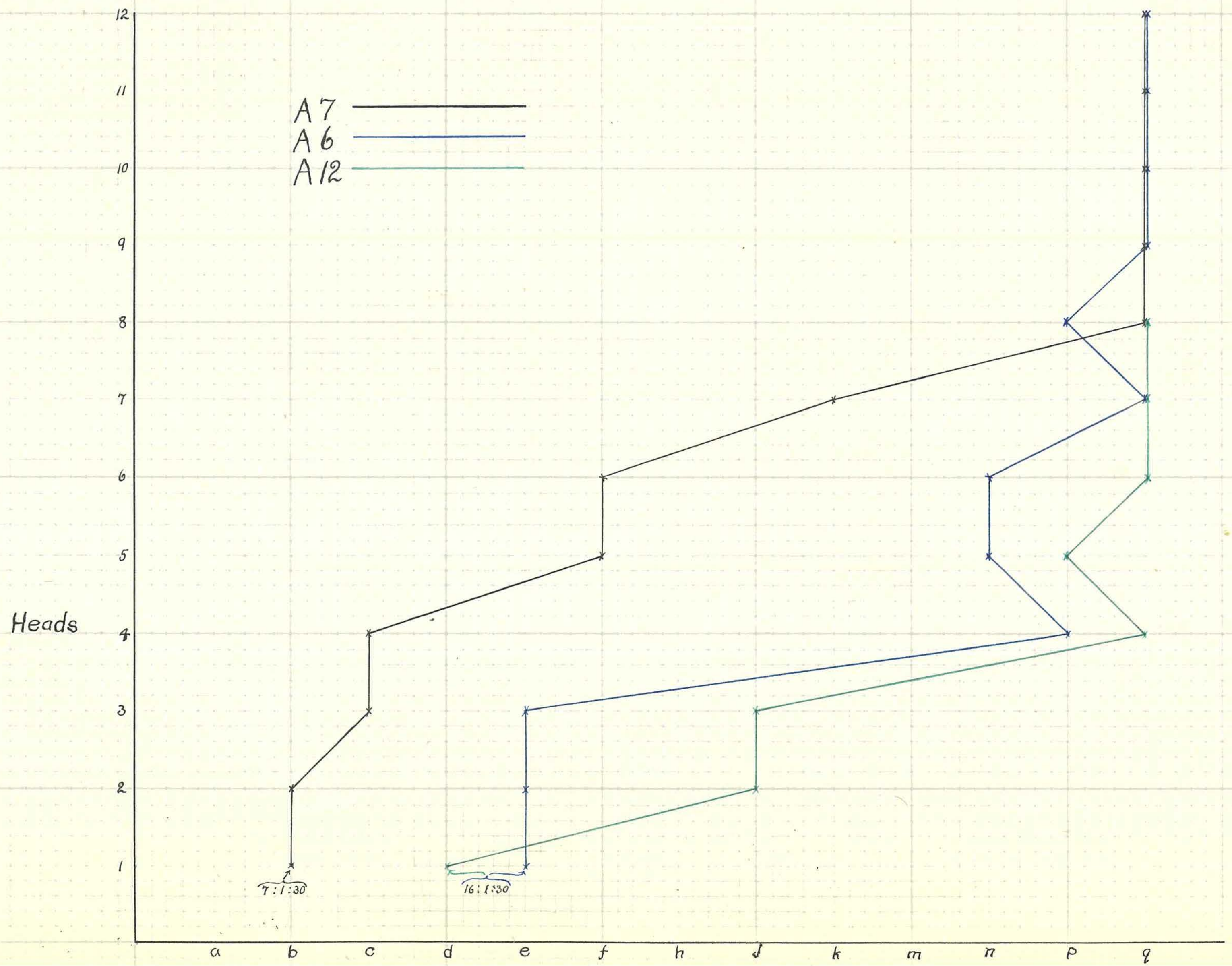


Fig. 3.

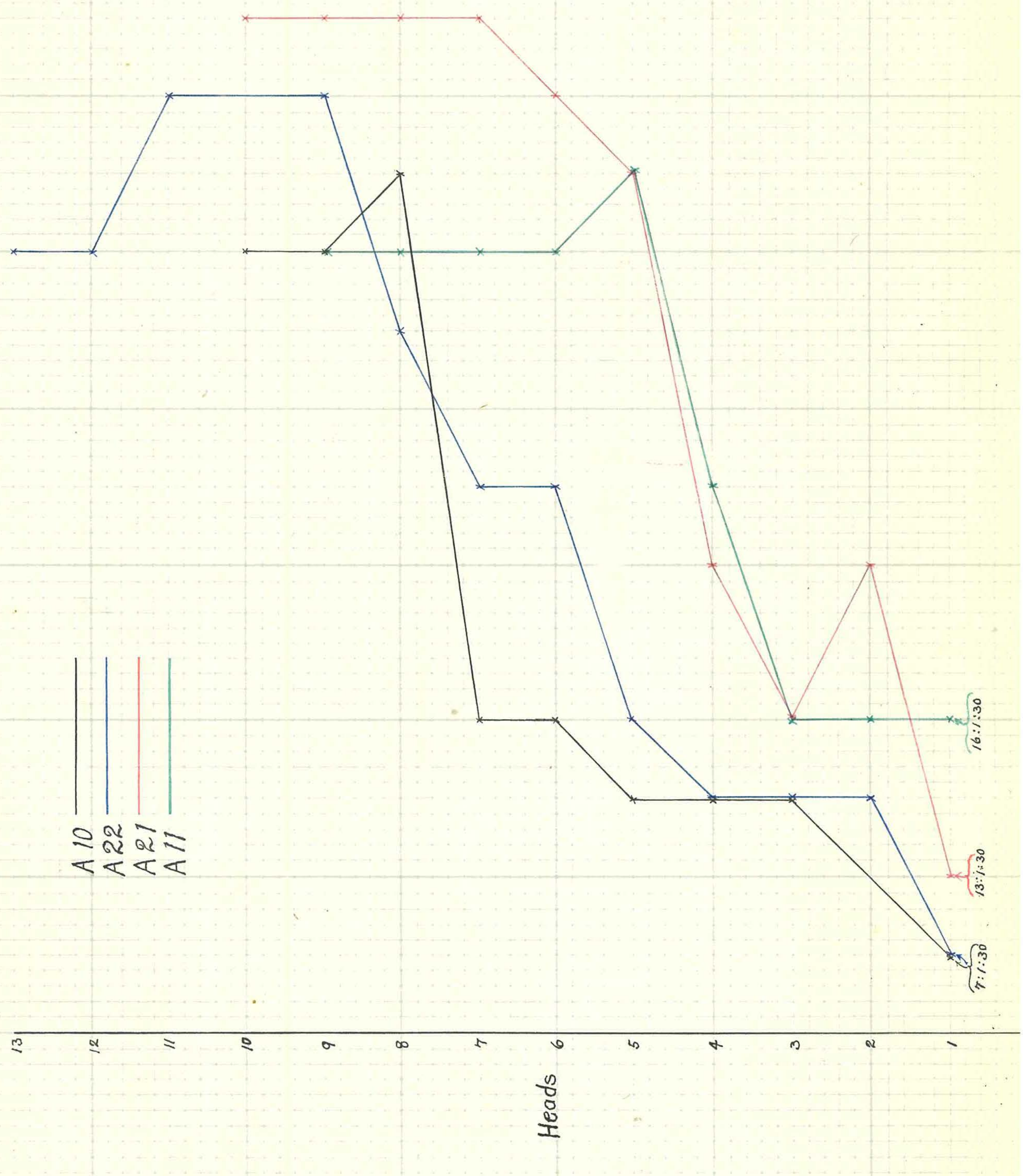


Fig. 4.

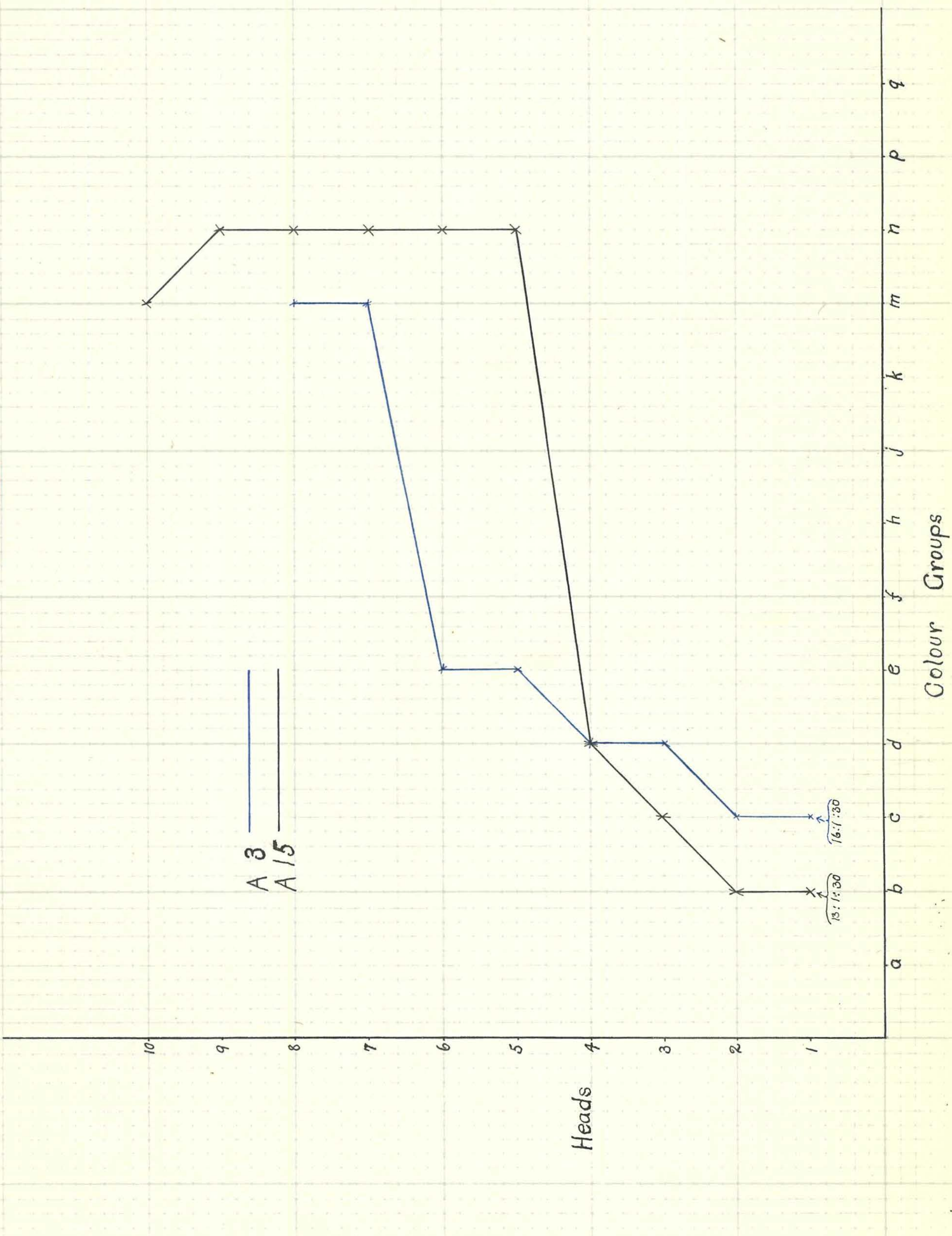

A 3
A 15
Heads
10
9
8
7
6
5
4
3
2
1
a
b
c
d
e
f
h
j
k
m
n
p
q
Colour Groups
13:1:30
16:1:30

Fig 4

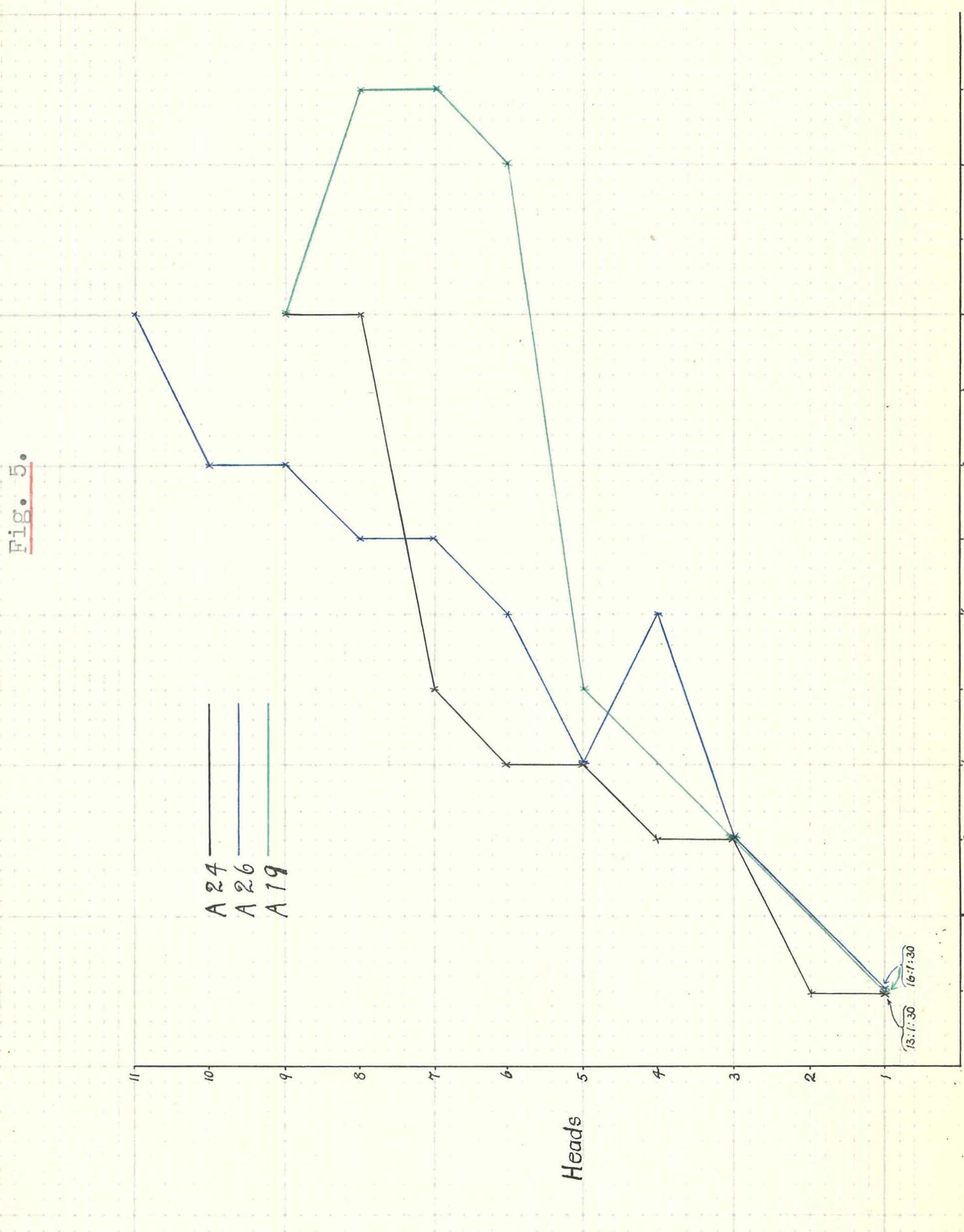

A 24
A 26
A 19
Heads
1
2
3
4
5
6
7
8
9
10
11
a
b
c
d
e
f
h
j
k
m
n
p
q
13:1:30
16:1:30

Fig. 5.

Fig. 6.

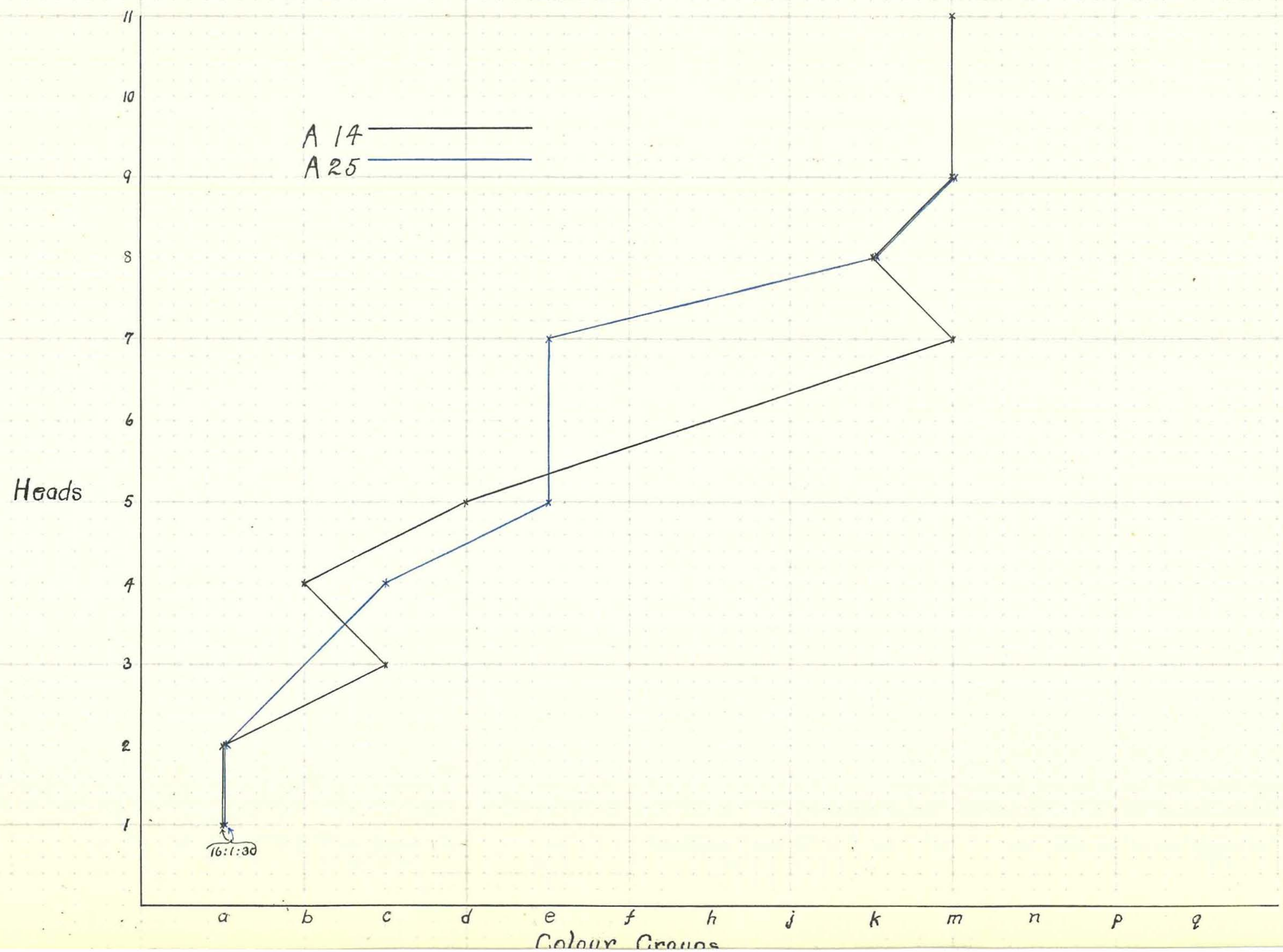

A 14
A 25
Heads
11
10
9
8
7
6
5
4
3
2
1
16:1:30
a
b
c
d
e
f
h
j
k
m
n
p
q
Colour Groups

Fig. 7.

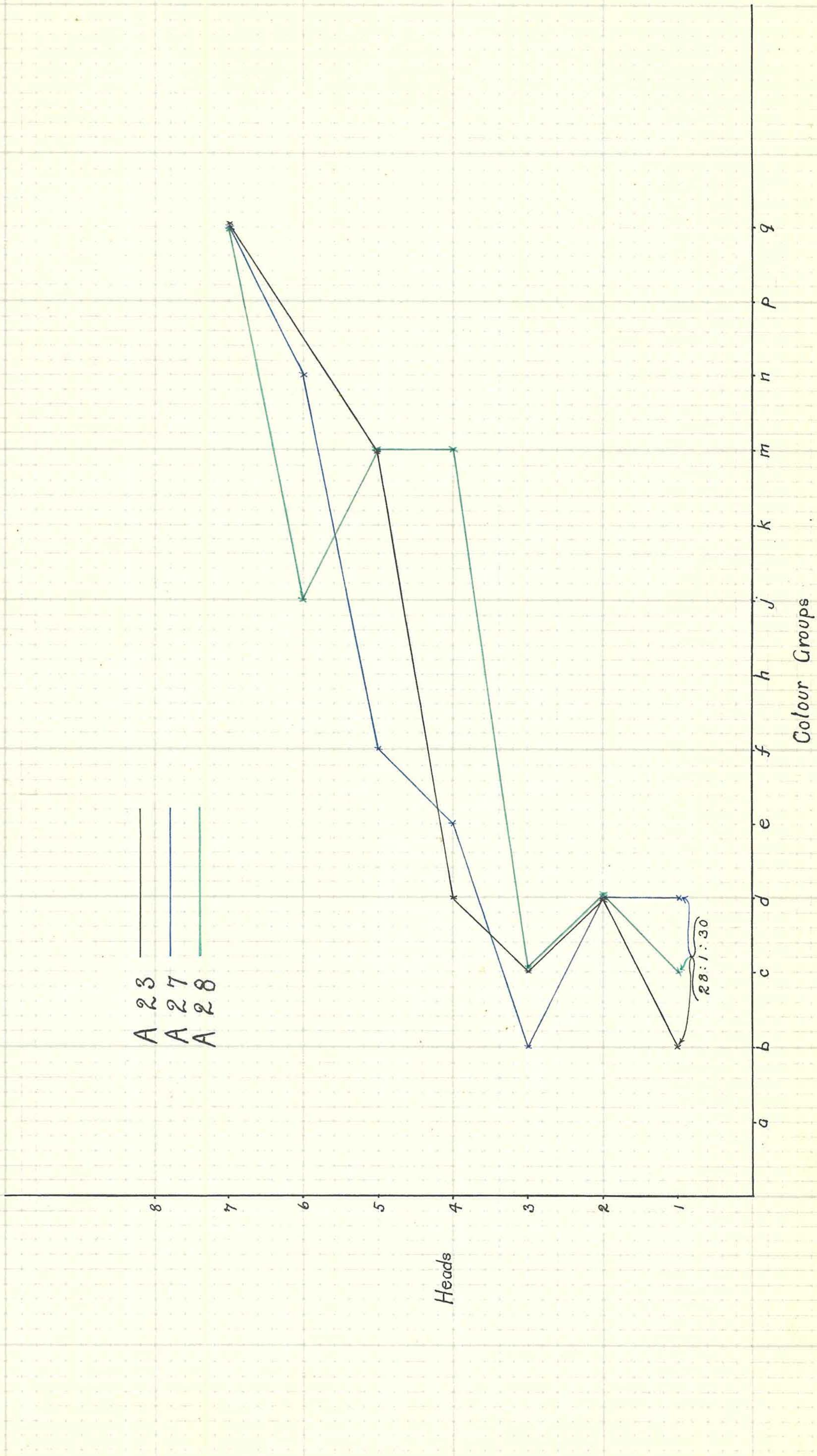

A 23
A 27
A 28
28:1:30
Heads
8
7
6
5
4
3
2
1
a
b
c
d
e
f
h
j
k
m
n
p
q
Colour Groups

Fig. 8.

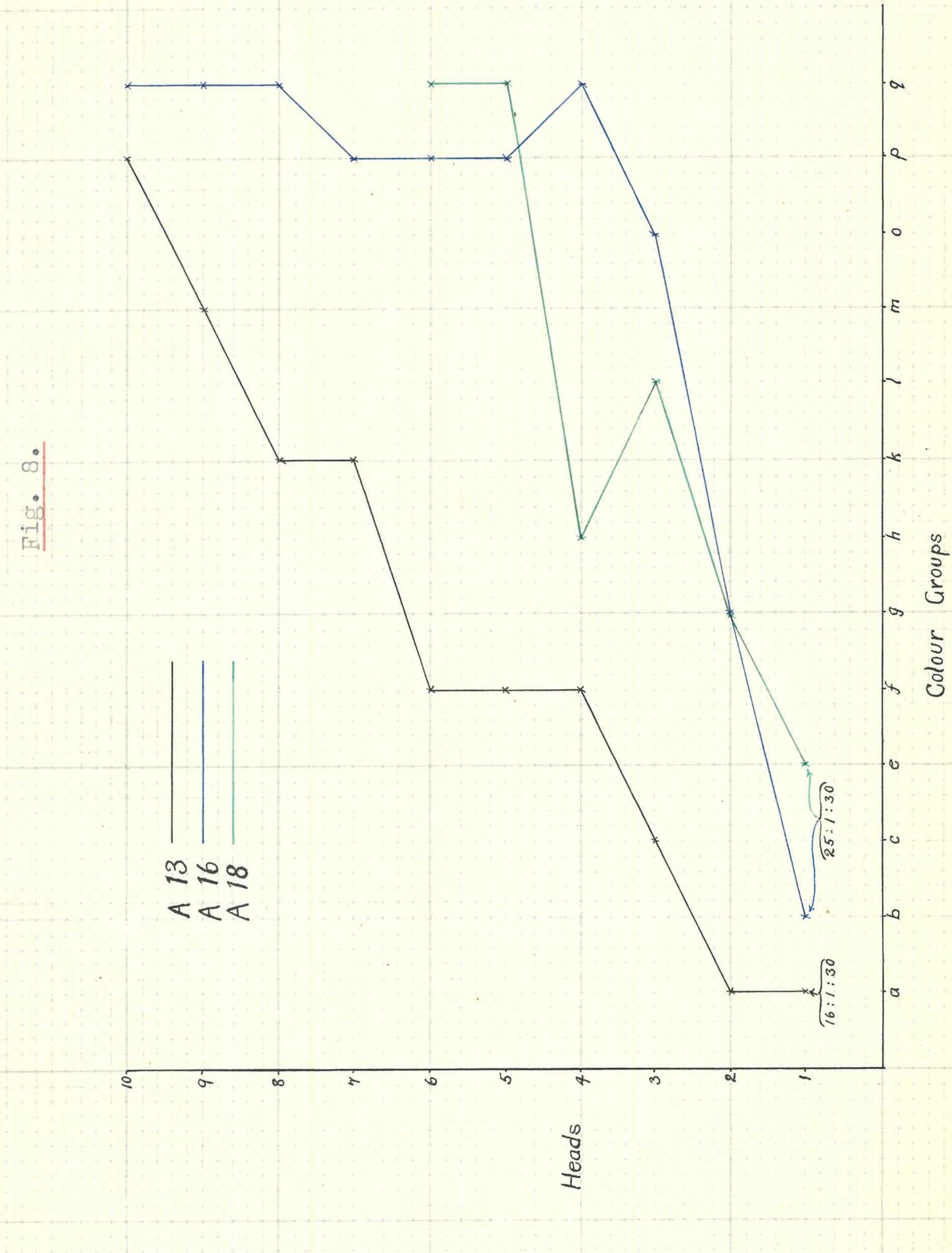
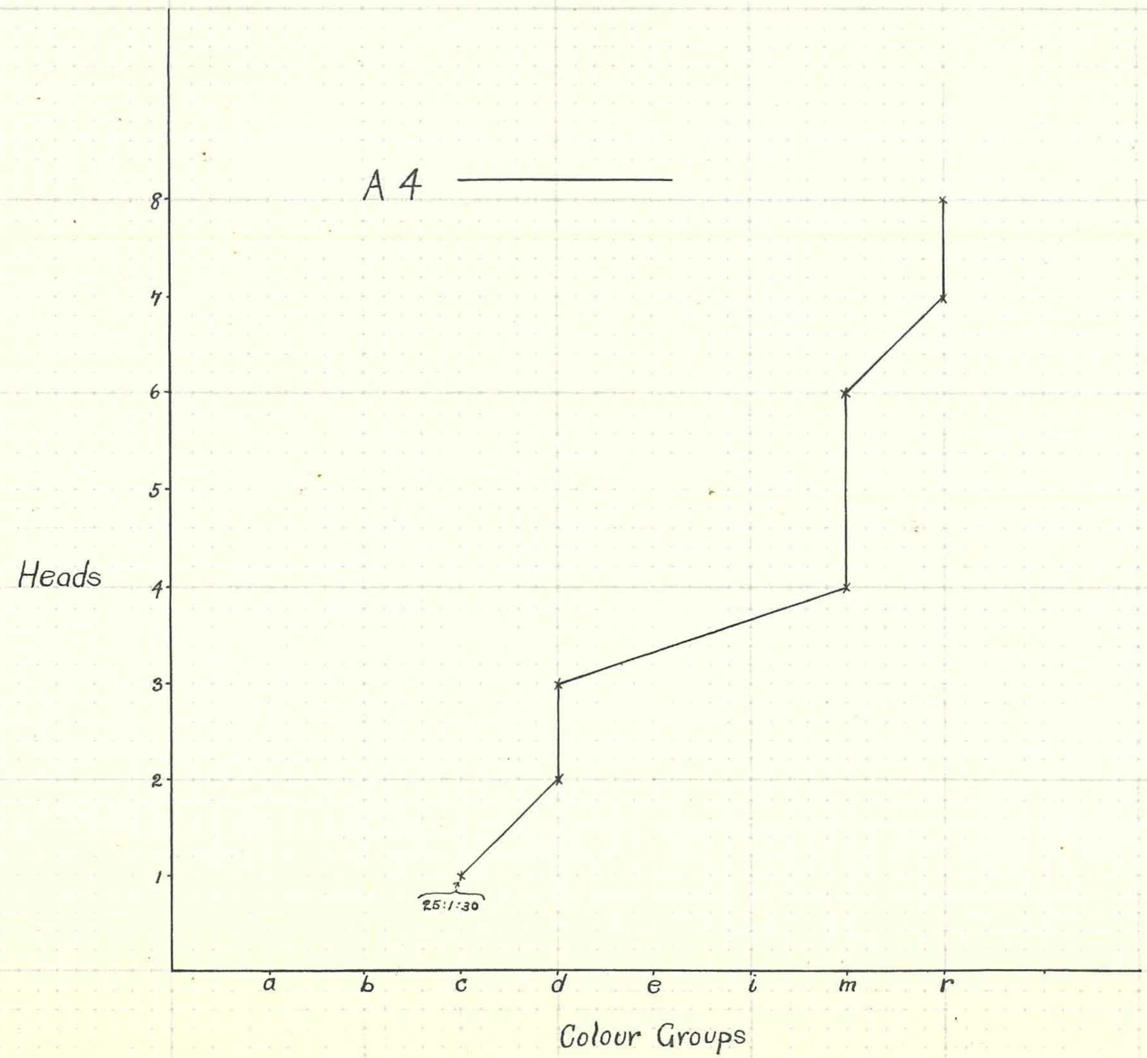

A 13
A 16
A 18
Heads
10
9
8
7
6
5
4
3
2
1
a
b
c
e
f
g
h
k
l
m
o
p
q
Colour Groups
16 : 1 : 30
25 : 1 : 30

Fig. 9.



Discussion of Results Shown in the Graphs:

As mentioned previously (page 7) these graphs were constructed with the object of stressing any differences in plants in regard to the darkness of colour of the seeds in the final stage of ripening. The darkest colour group in each head has been plotted against the maturity of that head. The graphs also show the rate of increase in the intensity of colour of the seeds.

In this discussion reference will occasionally have to be made to the tables from which the graphs were constructed.

1. The Trend in Seed Colour with Increase in Age, and the Final Colour Attained by Seeds of Different Plants:

For the purpose of discussion the plants of which graphs have been constructed can be grouped into the following classes:-

Class 1. Plants which show a more or less general trend in seed colour from green to the darkly coloured group q.

Class 2. Plants which show a more or less general trend of seed colour to a lighter coloured group than group q.

Class 3. Plants which, in the more mature heads, show a reversion to a lighter coloured group than that of the seeds of the heads collected at a slightly earlier date.

The graph of Plant A 4 is not included in the above classification and will be discussed separately.

In the majority of the plants, with increased maturity of the seed-heads there is a fairly regular trend in seed colour, which, except in plants of Class 3 is maintained. However, in a number of plants this trend is interrupted and there is reversion to a lighter coloured group. This aspect of the trend in seed colour will be discussed before considering the three separate classes.

For the purpose of these graphs it appears that the three-day interval between collecting the heads of any one plant, though suitable for the observations of change in seed colour, was in some cases too short to cover differences in flowering dates of the selected heads. Consequently, relatively slight reversions cannot be regarded as significant. There are, however, reversions which appear to be too great to be explained merely by differences in flowering dates. One of the most marked reversions in seed colour is that occurring in head 8 of Plant A 9 (Fig.1 page 28). The analysis of this head shown in Table 1 (page 12) reveals that the seeds are on the whole rather similar in darkness of colour to those of head 5, being lighter coloured than those of heads 6 and 7. The fact that head 8 was collected 9 days later than head 5 seems to rule out the possibility of any slight variation in their periods of maximum blooming causing this disparity. It seems impossible to account for this marked reversion unless it is concluded that for some reason the seads of head 8 increased in darkness of colour at a slower rate than those of the other heads of this plant.

It is quite possible that a number of the reversions in seed colour could be due to a difference in the rate of colour development of the seeds of different heads of the one plant, but in view of the experimental error introduced by the differences in flowering dates of the selected heads it cannot be stated definitely that this is the case.

In the latter part of the graphs there are sometimes reversions in colour from a dark group to one only slightly lighter in colour such as from group p to group n and from group q to group p as shown in Plant A 6 (Fig. 2 page 29). The difference in darkness of groups p and n. and groups q and p respectively is only comparatively slight so that no significance can be attached to such reversions.

These plants will now be considered on the basis of the colour of the darkest seeds in the final head collected.

Class 1.

The plants of this class comprise A 9 (Fig.1 page 28) A 7, A 6, A 12 (Fig.2 page 29); A 21 (Fig 3 page 30); A 23, A 27, A 28 (Fig. 7 page 34); A 16 and A 18 (Fig. 8 page 35).

The final heads of these plants contain some seeds of group q which is the darkest group of the series excepting perhaps group r present only in Plant A 4 which is considered later.

In Plants A 7, A 6, A 12, A 21, A 16, and A 18, the group q seeds continue to be present in two or more heads. In these plants there does not seem to be any tendency to reversion to a lighter colour group. Only seven heads of plants A 23, A 27 and A 28 were collected and the group q seeds were present only in the last head in each case. There is a possibility that if more heads had been collected reversion may have been found to have taken place. There is sufficient evidence, however, to justify the conclusion that very dark coloured seeds are produced in the field and continue to be present for a long period.

It is interesting to note here that the number of group q seeds may in some plants be very large. For example, in head 12 of Plant A 6 and head 8 of Plant A 22 the percentage of group q seeds was respectively 97% and 84% (excluding immature group y seeds from the calculation)

It is obvious that seeds almost black in colour may be developed under natural conditions, although it is realised that artificial causes such as heating of stripped seed in the sack may bring about this result.

Class 2.

The plants of this class comprise A 1, A 8 (Fig 1, page 28); A 3 (Fig 4, page 31); A 24, A 26 (Fig. 5, page 32); A 14, A 25, (Fig. 6, page 33); and A 13 (Fig. 8, page 35).

With increase in age, the seeds of these plants show a fairly regular trend in colour up to a group lighter in colour than that attained by the darkest seeds of Class 1.

In Plants A 3, A 24, A 26, A 14 and A 25, the darkest coloured seeds present are group m. As can be seen from the coloured diagrams the difference between the colour of this group and that of group q is very marked. The darkest coloured seeds of Plants A 1 and A 8 are group p. There is only a comparatively slight difference between groups p and q so that these two plants might have been included in Class 1. In fact there is a small percentage of group q seeds in head 10 of Plant A 8. In Plant A 13 the darkest coloured group present is group o.

In Plants A 26, A 25, and A 13 of this class the darkest group occurs only in the last head collected, while in the other plants the darkest group is present in the last two or more heads. It is possible that in these three plants the seeds may have become darker in colour if the final head had been collected at a later date.

The evidence from these graphs and those of Class 1. points to the fact that there is variation in plants in reference to the final darkness of colour attained by the seeds. Although the length of time after flowering is important up to a point in increasing the darkness of colour, the individuality of the plant seems to be an important factor in determining the ultimate colour of the darkest seeds produced.

Class 3.

The plants of this class comprise A 10, A 22, A 11, (Fig.3 page 30); A 15 (Fig.4, page 31); and A 19 (Fig. 5, page 32).

The graphs of these plants show that there is a fairly regular trend to the darkest group present in the plant and then reversion to a lighter coloured group in the final heads. The darkest group in the different plants is not always the same, but in all five cases the colour group to which reversion of the darkest seeds takes place is group m.

It is possible that the reversion could be due to a loss in intensity of the pigmentation of the darker seeds. It is improbable, however, that this loss in colour is due to the weather after collecting the head containing the darker colour group. In Plants A 22, A 15 and A 19 the heads in which the first reversion of seed colour occurred were collected on February 9th. while those of Plant A 10 and A 11 were collected on January 31st. The weather of the three days immediately preceding these dates was not at all comparable. The meteorological charts show that on February 6th., 7th., and 8th. there were 12.3, 13.3 and 13.0 hours of bright sunshine and no rain, while on January 28th., 29th. and 30th. there were only 8.8, 3.4 and 9.8 hours of bright sunshine and a total of 0.38 inches of rain. There was no marked difference in temperature during these two periods. The evidence shows that if there is a loss of intensity of colour of the seeds it cannot be attributed to the weather at this stage.

It is possible that in some plants a loss in colour of the darkest seeds is a natural process taking place after the darkest colour has been attained. In the other plants studied, however, there is no evidence of this being so.

Another explanation is that the darkest coloured seeds of the heads in question have been shed in the field. In all of the plants of this class there was only a relatively small proportion of dark coloured seeds in the heads collected immediately prior to those showing reversion. It is quite possible that a small percentage of the darker coloured seeds may have previously been present in the heads concerned but have been shed in the field. Against this explanation it might be pointed out that no reversion is shown in the later heads of those of Class 1 of which a number of heads were collected after the first appearance of the darkly coloured group q seeds. But examination of the analysis of the seeds of these plants shown in the tables reveals that, compared with the five plants showing reversion, there is a relatively high percentage of dark coloured seeds. Shedding of some of the seeds of the dark coloured groups would still leave a fairly large percentage of these seeds.

The evidence is not sufficiently exhaustive to enable it to be concluded as to whether the reversion can be definitely attributed to a natural loss in intensity of colour of the darkest seeds of some plants or to shedding of these seeds. If the former is the case, an analogy can be drawn between these plants and those in which a loss in pigmentation was assumed to produce the group x seeds (page 26). If the latter is true the five plants under consideration would then be placed in either Class 1 or Class 2 according to the colour group of the darkest seeds produced in each case.

Plant A 4 (Fig. 9 page 36).

The graph of Plant A 4 has still to be considered. In this case there is a fairly regular trend in seed colour up to group r which is equally as dark as group q but quite distinct in colour.

There are some groups in this plant which do not occur in any other of the plants considered. None of the seeds had the slightest red or copper coloured tint often discernible in a number of other plants. The darkest seeds were very characteristic of the plant, supporting the evidence of various strains within the species.

2. The Rate of Increase in the Colour Intensity of the Seeds:

The graphs clearly reveal that, in general, the rate of increase in intensity of colour from green to the darkest colour attained by the seeds is not uniform. The changes from group a up to about group e are relatively slow, but after this stage is reached the dark colour increases more rapidly. A few days at this stage may produce a marked difference in the intensity of colour of the seeds.

The length of time taken for the seeds to pass from group a to the darkest group attained, although sometimes similar in different plants, often shows wide variation. The graph of Plant A 16 (Fig. 8 page 35) shows the very rapid increase in colour of the seeds of this plant, which required only 9 days to pass from group b to group q. The seeds of Plant A 13 (Fig.8), on the other hand, required twenty-one days to pass from group c to group p. This is still another respect in which different plants are by no means uniform.

In addition to the investigations that have thus far been recorded, work was carried out on various other lines such as:-

1. The effect on the colour of the seeds of short period changes in the weather during ripening.
2. The relation between the amount of purple colouration developed in the seed-stalks and sterile spikelets and the darkness of the seeds.
3. Date of flowering in relation to the ultimate darkness of colour of the seeds.

As the number of plants examined was too small to enable accurate statistical results to be obtained this aspect of the work will be considered very briefly.

The Effect on the Colour of the Seeds of Short Period Changes in the Weather During Ripening:

By study of meteorological records and the trend of seed colour shown in the graphs, an attempt was made to ascertain whether marked changes in the amount of rain and sunshine over short periods during ripening exerted any effect on the seed colour.

The results were entirely negative, no relation being found between the amount of rain or sunshine over short periods and the trend of seed colour. If there were any effects caused by changes in the weather they were concealed by the number of other factors affecting seed colour.

The Relation between the Amount of Purple Colouration Development in the Seed-stalks and Sterile Spikelets to the Darkness of the Seeds:

For this purpose the plants were arranged in groups according to the amount of purple pigmentation in the seed-stalks and sterile spikelets, and they were also grouped according to the colour group of the darkest seeds present. From these date correlation tables were constructed. The numbers were too small to enable reliable results to be obtained so that the tables have not been included. As far as they go, however, the results show no correlation between darkness of seed colour and the amount of purple in either the sterile spikelets or the seed-stalks.

Date of Flowering in Relation to the Ultimate Darkness of Colour of the Seeds:

The plants were arranged into four groups according to the time of blooming. The interval between the groups was about six days so that the period between the dates of flowering of the plants of the first and last groups was about eighteen days. The plants were also grouped according to the colour group of the darkest seeds present, and a correlation table was constructed.

Here again there was found to be no correlation.

Conclusions:

1. With increase in age of the seed-heads the seeds become darker in colour, some almost black finally being produced. There is variation between plants, however, with regard to the final darkness of colour attained by the seeds. Although, up to a point, the length of time after flowering is important in increasing the darkness in colour, the individuality of the plant seems to be an important factor in determining the ultimate colour of the darkest seeds. There is evidence here that within the species there are definite strains, some of which produce seeds almost black in colour while in others the final colour is decidedly light.

2. Seeds of a single head cannot usually all be included in the same colour group. In the earlier stages of ripening this variation may be due to the difference in the dates of blooming of the flowers. In the later stages, however, this explanation does not hold. There is some evidence that the position of the seed in the spikelet is influential in determining the degree of darkness of the seeds, the terminal seed often being eventually darker than the others.

3. The lighter colour groups up to about group d are very similar in different plants. There may be marked difference between plants, however, in the amount of red pigmentation of

the more mature seeds and in the size and shape of the caryopsis. It is concluded that within the species there are strains which are recognisable by the size, shape and colour of the more mature seeds. This conclusion is strengthened by the fact that individuality exists in plants with regard to the production of group x seeds.

4. The rate of increase in the colour intensity of the seeds takes place relatively slowly from group a to about group e, but after this stage the speed ~~the speed~~ is more rapid. The length of time taken for the seeds to pass from group a to the darkest group attained, although sometimes similar in different plants, often shows wide variation.

PART 2.

The Relation of the Colour of the Flowering Glume and the Weight of the Caryopsis to the Germination Capacity of the "Seed".

Laboratory germination tests have been carried out by N.R.Foy of the Government Seed Testing Station with various lines of Crested Dogstail seed of different general colour. The lines were graded into eleven classes according to the general colour of the samples. On the whole, there was a higher germination capacity in the darker samples, the germination percentage ranging from 98% in the darkest to 65% in the lightest sample. Moreover, the vitality of the seeds of the darkest coloured sample was greatest as shown by the fact that after a period of four years the germination percentage of seeds from the darkest sample was 80% and from the lightest only 6%

It should be noted that in Foy's work the different samples were grouped according to their general colour. In any one class there would be a certain amount of variation in colour of the seeds comprising that class. In addition, the seeds of any one line would be derived from many different plants of probably a large number of strains.

Method:

For this work the seeds were selected by individual examination under the microscope so that they could be allotted to their exact colour groups. With the object of ascertaining whether the individuality of the plant exerts any effect on the germination capacity of the seeds, germination tests were made with seeds of the various colour groups from different plants.

The seeds of each head of a plant were roughly classified into colour-groups by spreading them out on a piece of mirror and examining with a pair of binocular lenses giving a magnification of three diameters. The mirror enabled the flowering glume to be examined without the necessity of having this surface uppermost.

After the seeds had been sorted into their approximate colour groups they were examined under the microscope, using the same method as in the former work. The seeds were placed with the flowering glume uppermost and by comparison with the colour charts each seed was allotted to its exact colour group. Any seed that did not coincide exactly with the colour of one of the charts used was discarded. As the number of seeds from each plant was limited due to the fact that seeds from only about ten heads were utilised, sufficient for a germination test could be obtained from only a few of the most commonly occuring colour groups. Plants were chosen which contained sufficient seeds giving a range of colours usually from group a up to groups h,k,p,or q. In most cases 200 seeds were used for germination tests of each colour group but sometimes only 150 or even 100 of a certain group were obtainable. The total number of seeds used was 9010.

Germination tests were carried out with seeds from only eight of the twenty-eight plants. The other plants were neglected either because sufficient seeds with the desired range of colour groups could not be obtained, or the proportion of straw coloured poorly developed seeds was so high that it was impossible to obtain sufficient seeds for tests of even one or two groups.

After the seeds had been finally sorted into the colour groups, each of the lots of 200 seeds was weighed carefully to one-tenth of a millegram.

The germination tests were carried out at the Government Seed Testing Laboratory under the direction of Mr. N.R.Foy. They were thus executed under standard seed testing conditions.

The germination percentages were calculated after periods of eight and eighteen days.

The results obtained from the germination tests are set out in Tables 10 - 17 (Pages 52-54)

To facilitate consideration of the results shown in these tables graphs have been constructed. Fig.10 (page 56) shows graphs plotted for each of the eight plants to illustrate the difference in the germination percentage of the respective colour groups. In Fig.11 (page 58), the relation between the colour of the flowering glume and the seed weight is shown for each of the eight plants, while in Fig.12 (page 60), the germination percentage has been plotted against the weight of the seeds.

TABLES SHOWING THE WEIGHT AND GERMINATION CAPACITY OF SEEDS OF THE DIFFERENT COLOUR GROUPS.

TABLE 10. PLANT A 7.

Colour Group.	Number of seeds Tested.	Weight in mgs. of 200 Seeds.	Percentage Germination After 8 Days.	Percentage Germination After 18 days.
a	200	54.4	6.0	9.5
b	200	75.4	100	11.5
c	200	91.1	22.5	68.5
e	200	109.0	79.0	98.5
h	200	120.8	94.0	99.5
k	200	136.1	98.0	100.0
p	200	132.1	98.5	100.0
q	200	116.6	97.0	99.5

TABLE 11. PLANT A 4.

Colour Group.	Number of Seeds Tested.	Weight in mgs. of 200 Seeds	Percentage Germination After 8 days	Percentage Germination After 18 days.
a	150	50.1	32.0	63.0
b	150	71.7	75.5	92.0
c	200	86.6	91.5	97.5
d	200	121.6	97.0	99.5
e	150	141.6	97.5	98.0
i	200	127.0	93.0	98.0

TABLE 12. PLANT A 26.

Colour Group.	Number of Seeds Tested.	Weight in mgs. of 200 Seeds.	Percentage Germination After 8 days.	Percentage Germination. After 18 days.
a	200	90.2	70.0	81.5
b	150	133.9	89.0	96.5
c	180	176.7	98.0	99.0
d	200	193.2	96.5	99.0
e	150	204.3	94.5	100.0
h	200	198.9	95.5	97.5

TABLE 13. PLANT A 8.

Colour Group.	Number of Seeds Tested.	Weight in mgs. of 200 Seeds	Percentage Germination After 8 Days	Percentage Germination After 18 Days
a	100	65.6	9.0	45.0
b	200	91.3	27.5	57.5
c	200	109.4	55.0	80.0
d	200	121.3	73.5	88.0
e	200	147.1	93.0	95.5
h	200	153.8	99.5	99.5
k	200	166.3	98.5	99.0
p	100	157.4	100.0	100.0

TABLE 14. PLANT A 21.

Colour Group	Number of Seeds Tested	Weight in mgs. of 200 Seeds.	Percentage Germination After 8 Days	Percentage Germination After 18 Days
a	130	67.7	34.0	47.0
c	150	94.0	81.0	85.5
d	150	99.6	96.5	97.0
e	150	108.5	95.5	96.0
k	150	121.3	100.0	100.0
q	150	135.5	100.0	100.0

TABLE 15. PLANT A 22.

Colour Group.	Number of Seeds Tested.	Weight in mgs. of 200 Seeds.	Percentage Germination After 8 days.	Percantage Germination After 18 Da
a	200	41.2	0	0
b	200	67.9	2.0	11.0
c	200	85.2	17.5	37.0
d	200	100.0	57.5	66.0
e	200	121.8	86.5	90.0
k	130	129.7	88.0	98.0

TABLE 16. PLANT A 13.

Colour Group	Number of Seeds Tested.	Weight in mgs. of 200 Seeds.	Percantage Germination After 8 Days	Percentage Germination After 18 Day
a	200	71.6	22.5	49.0
b	100	92.0	62.0	85.0
c	120	97.3	60.0	86.0
d	200	123.4	87.5	96.0
e	200	125.8	90.0	97.5
h	100	158.0	96.0	99.0
k	100	142.8	94.0	99.0

TABLE 17. PLANT A 9.

Colour Group.	Number of Seeds Tested.	Weight in mgs. of 200 Seeds.	Percentage Germination After 8 days.	Percentage Germination After 18 Da
c	200	104.5	55.5	70.0
d	150	120.4	75.5	88.5
e	200	134.9	85.5	97.5
h	150	152.4	97.0	100.0
k	150	144.0	97.0	100.0

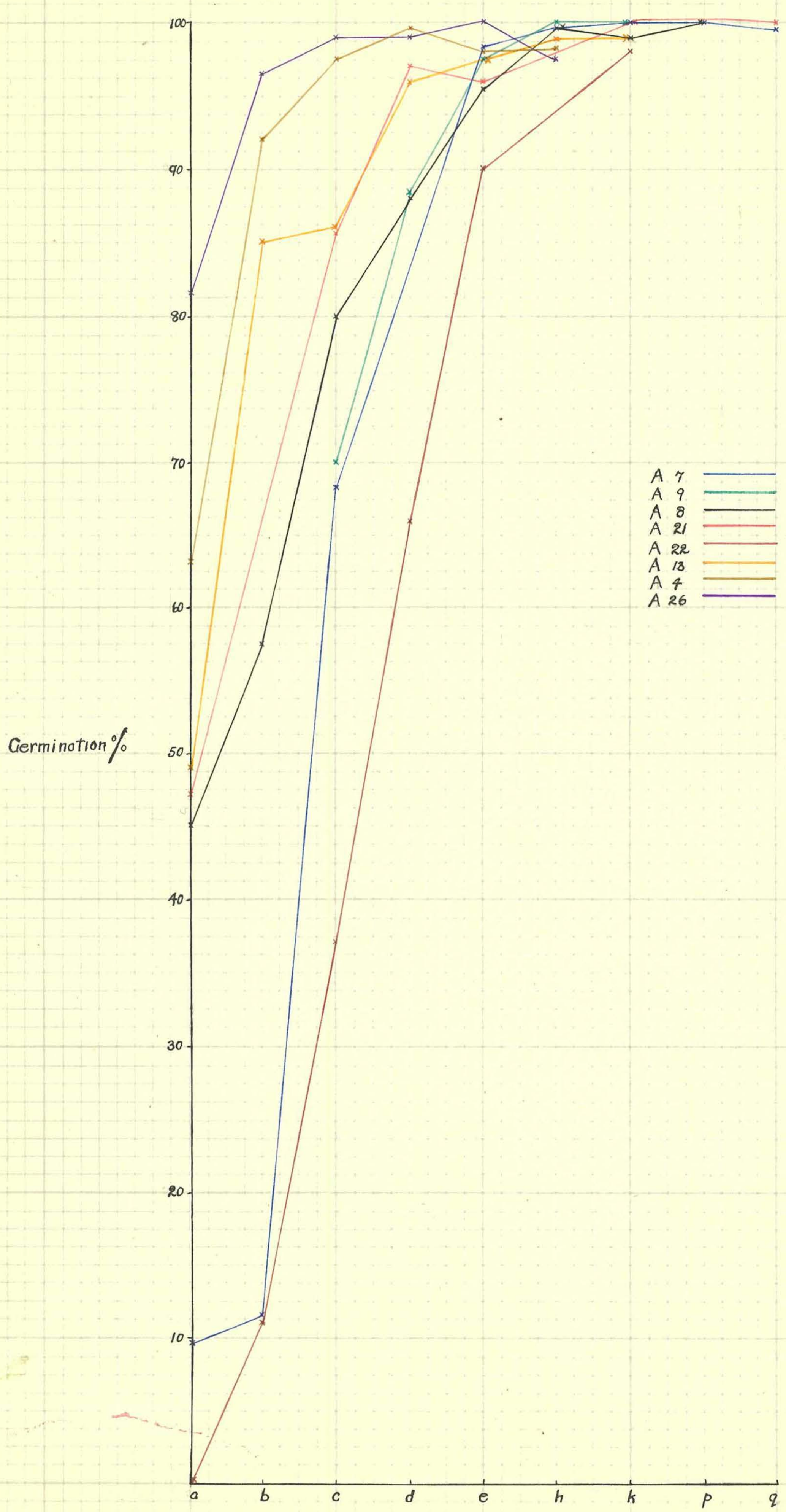
Results:

The Vitality of the Seeds of the Different Colour Groups:-

In assessing the vitality of the seeds reference is made to the speed of germination. On examination of the germination percentages after eight days shown in the tables, it will be noticed that in all of the plants seeds of the lighter colour groups such as a,b and c, germinate more slowly than those of the darker groups. In the lighter coloured seeds the ratio of germination % after eight days to germination % after eighteen days is lower than in the darker coloured seeds, showing that the germination vigour or vitality is greater in seeds of the darker colour groups.

Fig. 10.

GERMINATION CAPACITY OF SEEDS OF DIFFERENT COLOUR GROUPS.



The Relation of the Colour of the Flowering Glume to the Germination Capacity of the Seed:-

From an examination of the graphs shown in Fig. 10 (page 56), it is apparent that there are marked differences in germination capacity between seeds of the lighter and darker colour groups. The graph of each plant reveals that with increase in intensity of colour there is a corresponding increase in the germination capacity of the seeds up to a maximum which is maintained in the darker groups. In the darkest groups of Plants A 4 and A 26, however, there is a decrease in the % germination of 1.5% and 2.5% respectively but no significance can be attached to such a relatively small difference.

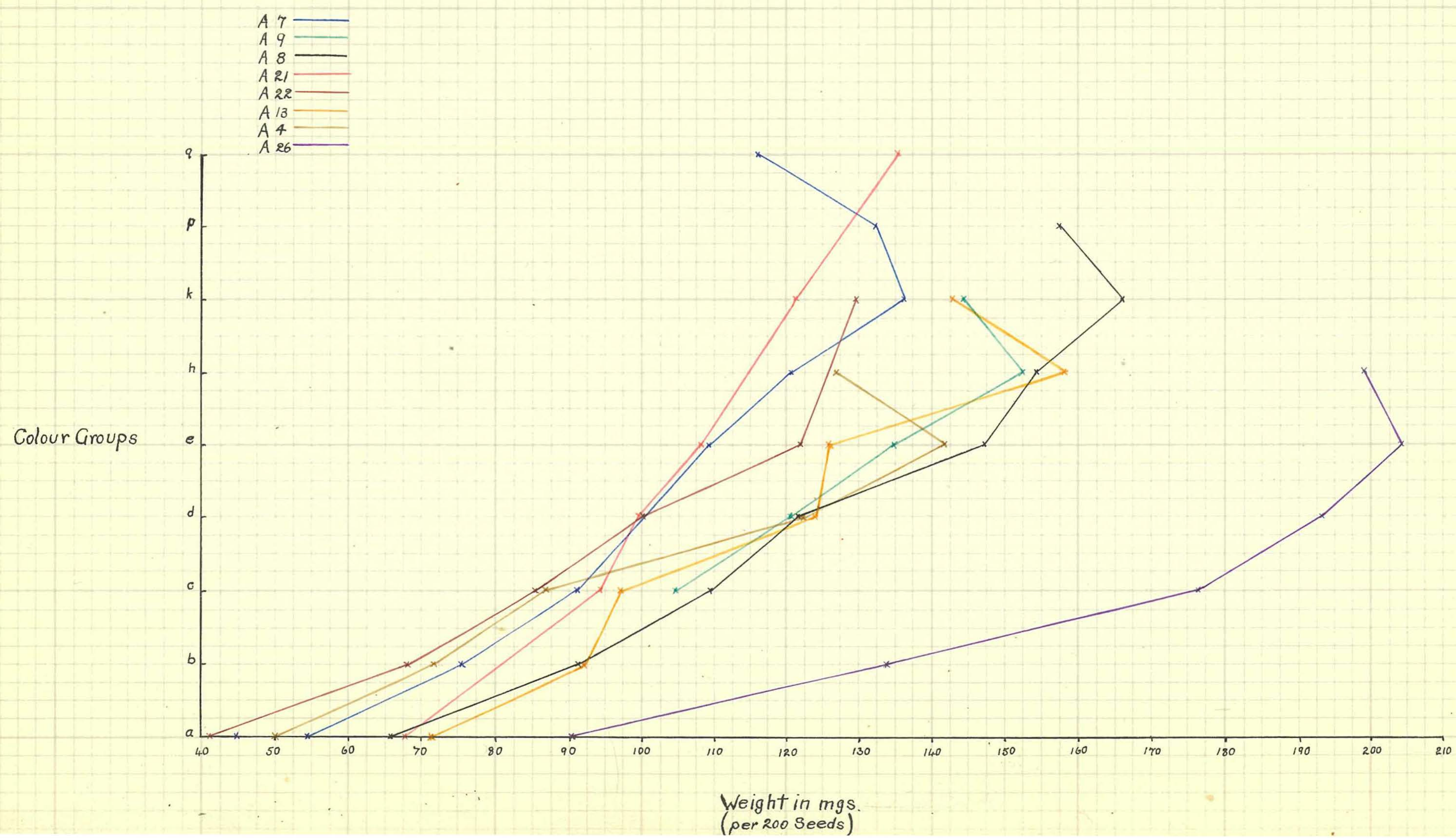
When the graphs of individual plants are compared it is seen that seeds of the same colour group but from different plants may exhibit markedly different germination. For example, the % germination of seeds of group a varies from 0% in Plant A 22 to 81.5% in Plant A 26, being intermediate between these two extremes in the other plants. This difference in germination capacity of seeds of similar colour groups is evident in all of the lighter coloured groups up to group e in some cases and h in others. In the darker groups there is no significant difference in this respect between seeds of different plants, the germination percentage in all casses being very high.

Those plants which exhibit a high germination % in the light coloured group a seeds reach their maximum germination of approximately 100% in a lighter coloured group than do those which show a low percentage germination in the group a seeds.

Fig 11, p 58

Fig. 11.

WEIGHTS OF SEEDS OF DIFFERENT COLOUR GROUPS.



Comparison of the Weights of Seed of the Various Colour Groups from Different Plants.

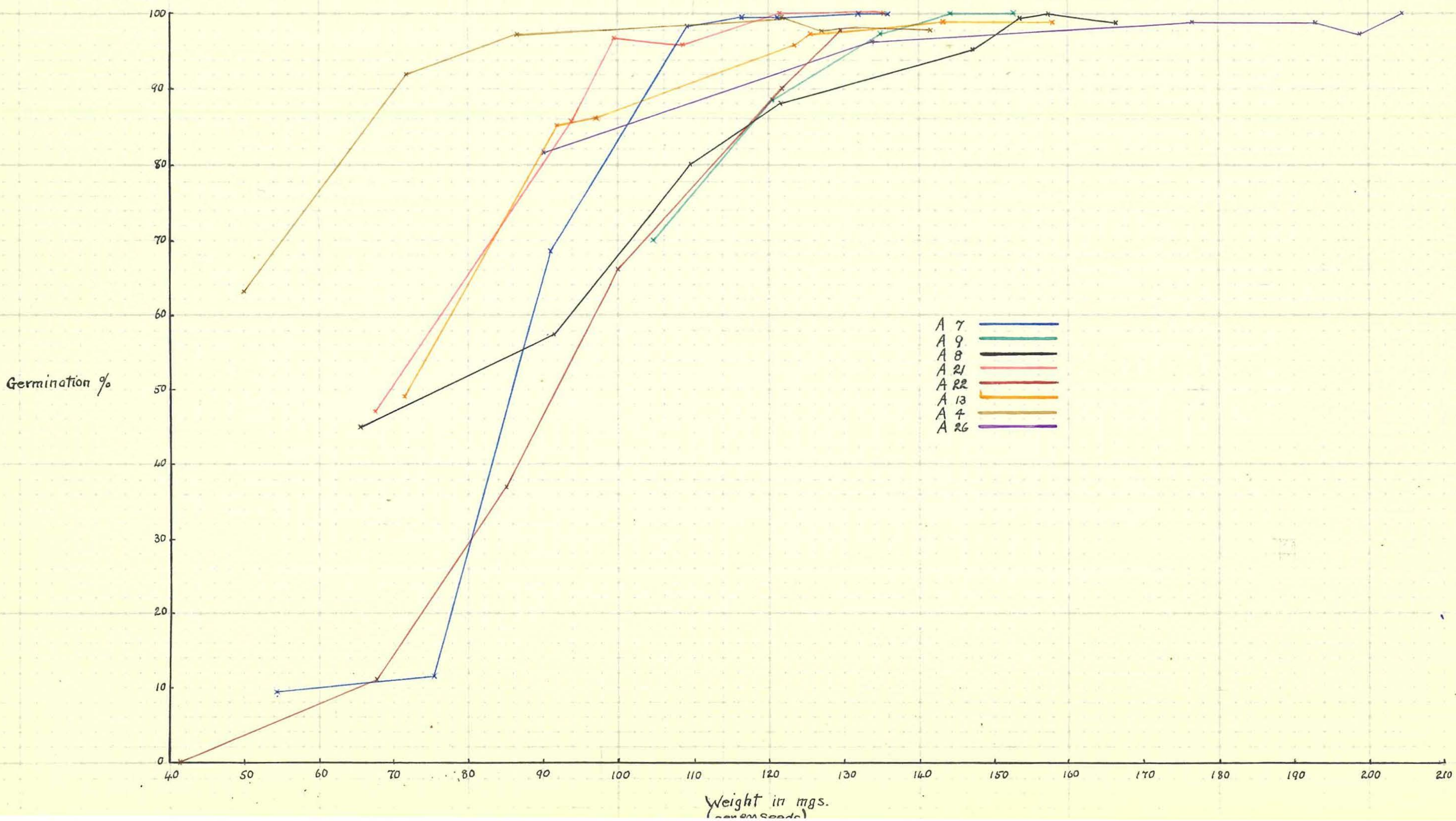
In Fig 11 (page 58), the different colour groups of the tested seeds from the eight plants are plotted against the weights in milligrams of two hundred seeds of the respective groups.

In each plant, as the seeds become darker in colour there is uniform increase in weight, up to a maximum, after which, except in Plants A 21 and A 22, the seeds become lighter in weight. In different plants this maximum weight may be attained in seeds of different colour groups. For example, in Plants A 7 and A 8 the heaviest seeds are group k; in A 9 and A 13, group h; and in A 4 and A 26, group e. In Plants A 21 and A 22 the darkest coloured seeds tested were the heaviest.

Seeds of the same colour groups but from different plants often show a fairly wide range in weight. The group a seeds of Plant A 26, for example, are more than double the weight of an equal number of seeds of the same group from Plant A 22. A marked difference in weight also occurs between more mature seeds of comparable colour groups from these two plants.

Fig. 12.

GERMINATION CAPACITY OF SEEDS OF DIFFERENT WEIGHT.



The Relation of the Weight per 200 Seeds to the Germination Capacity:

Fig. 12 (page 60), shows the relation between the weight of 200 seeds and the germination capacity.

In each plant, the increase in weight and germination percentage is coincident until the maximum germination is reached. Even after this, seed weight continues to increase.

In different plants, seeds of similar weight may exhibit very different germination figures. For example, seeds of Plant A 4 weighed 71.7 mgs. per 200 and germinated 92%, while in Plant A 7 200 seeds weighed 75.4 mgs. and germinated only 11.5%. Moreover, seeds from different plants although of the same colour group and similar weight may show wide differences in germination capacity. This is well illustrated by reference to group c seeds of Plant A 7,A 4, and A 22. These seeds in each case were of approximately the same weight per 200, being 91.1 mgs. in A 7, 86.6 mgs. in A 4, and 85.2 mgs. in A 22. But the germination percentages of these group c seeds from the different plants were not comparable, being 68.5% in A 7, 97.5% in A 4, and 37.0% in A 22.

Discussion of Results:

As was pointed out in Part 1. the main factor contributing to the increase in intensity of seed colour of an individual plant is maturity. This is substantiated by the results shown in Fig 11, where the increase in colour intensity can be correlated with an increase in the weight of the seeds. After the maximum weight is reached, however, there is usually a decrease in weight as the colour becomes darker. This decrease could be explained by assuming a loss in moisture content of the seeds during the final stages of ripening -- a natural process in the ripening of seeds. There is no decrease in weight, however, in the seeds of Plant A 21 and A 22, but it is quite possible that there would have been a decrease at a later stage even allowing for the fact that the heaviest seeds of Plant A 21 were very dark in colour. We have seen that the decrease takes place at different stages in different plants so that this stage of decreased weight may have been reached in these two cases had the seeds remained longer on the plant

In each plant studied the enhanced vitality and germination capacity of the seeds with increase in weight of the caryopsis and colour intensity of the flowering glume can be attributed to increase in maturity of the seeds.

When the seeds of different plants are compared, however, it is obvious that germination capacity is reflected in neither seed weight nor colour of the flowering glume, as seeds of the same weight and colour group from dfferent plants may exhibit entirely different germination figures. It seems that here again there is evidence of different strains which

differ markedly in their capacity to produce high- or low-germinating seeds in the lighter coloured groups.
Although in some plants the germination percentage of seeds of such light colour groups as c and d may be very high, in others high germination capacity is present only in much darker coloured seeds. It is apparent that in samples of mixed origin only the darker seeds can be relied on to give high germination figures. This is in accordance with the present trend of the seed trade in favouring the darker coloured samples.

Conclusions:

1. With increase in intensity of flowering glume colour there is an increase in seed weight up to a maximum, after which the seeds become lighter in weight. It is concluded that the main factor responsible for increase in intensity of colour is maturity, although, as shown in Part 1., there are other contributing factors.

2. In any one plant, as the flowering glume increases in depth of colour there is:
(a) Increase in the germination capacity of the seeds up to a maximum which is maintained with further increase in colour intensity.
(b) Increase in the vitality of the seeds as assessed by the speed of germination.

3. Within the species there appear to be different strains. Seeds of comparable colour groups from the various strains exhibit wide divergencies in weight.

4. In different plants neither seed weight nor flowering glume colour is a criterion of germination capacity. It seems that the strains show wide difference in their capacity to produce high - or low - germinating seeds in the lighter coloured groups.

5. In seeds of mixed origin it appears that

only the darker seeds can be relied on to give high germination figures.