Evaluation for seed purposes in Alaska of various forage species harvested at different maturity levels and subjected to diverse treatments

by John E Osguthorpe

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Agronomy
Montana State University

Abstract:
The objective of this study was to determine the maturity of seed of fourteen crops harvested at different dates, and to investigate the effect of freezing and artificial drying on germination of the seed-produced.

No significant differences existed in the seed weights of any individual crop under the diverse treatments at a given location.

Anthesis was earliest where a greater number of daylight hours forced plants from vegetative to flowering stage sooner.

Using-field cured results as a basis for comparison, early-light frost of short duration was found to pose no great problem to the production of seed of acceptable germination. Grains were not affected by freezing, grasses required a slightly longer period to mature, and legumes were either unaffected or needed from one to ten days longer period to reach standard germination.

For both the field cured and frozen lots, an acceptable seed weight indicates mature seed, as acceptable germination has also been attained.

Oven drying had a definite damaging effect retarding germination in all species studied at all locations, except Meadow foxtail at Fairbanks All crop seeds had reached standard germination before the last harvest date, except the seed of Perennial vetch grown at Matanuska. Acceptable seed weight was attained five days earlier than acceptable germination in the oven dried lots.

Results Of this study show that extreme caution should be exercised in applying experimental conclusions from the United States proper to Alaskan agriculture.

EVALUATION FOR SEED PURPOSES IN ALASKA OF VARIOUS FORAGE SPECIES HARVESTED AT DIFFERENT MATURITY LEVELS AND SUBJECTED TO DIVERSE TREATMENTS

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All Bozeman data from "Annual and Seasonal Precipitation at Six Representative Locations in Montana" Montana Agricultural Experiment Station Bulletin #447. 1947. "Climatological Data", an annual summary; USDA 1942 and 1948.

ABSTRACT

The objective of this study was to determine the maturity of seed of fourteen crops harvested at different dates, and to investigate the effect of freezing and artificial drying on germination of the seed produced.

No significant differences existed in the seed weights of any individual crop under the diverse treatments at a given location.

Anthesis was earliest where a greater number of daylight hours forced plants from vegetative to flowering stage sooner.

Using field cured results as a basis for comparison, early light frost of short duration was found to pose no great problem to the production of seed of acceptable germination. Grains were not affected by freezing, grasses required a slightly longer period to mature, and legumes were either unaffected or needed from one to ten days longer period to reach standard germination.

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INTRODUCTION

Experience with Alaskan agriculture has demonstrated that farming practices and crop varieties recommended for the United States proper can not generally be applied in the Territory without modification. In the forage field, particularly, it is imperative that hardy strains of specially adapted seed sources be available for the further development of commercial agriculture in Alaska. Since it is reasonably certain from previous harvest and yearly observations that many species can, and do, produce live, viable seed, the question is when and how to harvest. Thus, the object of this study was to determine the dates, or time of season, and stages of maturity when certain field crops can be profitably harvested for seed (i.e. have attained standard acceptable seed weight and germination), and to investigate the effects of refrigeration and oven drying on these results. These last two conditions were included in the problem to cover those years when frost might occur before seed maturity, or when inclement weather would make it necessary to dry crops artificially.

To make conclusions reached in this study most useful to Territorial agriculture, the two chief farming regions in Alaska, each the site of an Experiment Station, were selected as locations for this project. The first area, the Tanana Valley (Fairbanks, Alaska), lies 240 miles directly north of the second location, the Matanuska Valley (Palmer, Alaska), and definite ecological differences exist between the two valleys. (Climatic data is presented in Appendix.) Since the writer is stationed in the Tanana Valley, a greater number of species were observed at this site.

A third area was included in the project as a comparison between Alaska and the United States proper. The area selected, the Montana Agricultural Experiment Station, located in the Gallatin Valley at Bozeman, Montana, approximates territorial climatic factors more closely than other main Agricultural Experiment Stations.

REVIEW OF LITERATURE

Much literature has been written, especially on cereals, and although there is a variation in results in different localities with different varieties, the general conclusions reached will give some indications of practices and procedures to follow in evaluating this work. Few references could be found that pertained directly to the problem, particularly on freezing and oven drying of immature legumes and grasses.

Bartel (3) found in Baart wheat that seed obtained four to eight days after flowering were generally green in color, the color being entirely in the aleurone layer. None of the four day old seed germinated, but some were viable at eight days. Plants pulled with soil adhering produced mostly white seed, regardless of exposure during drying. Green seed remained low in germination. Germination was not given for the white, but it is assumed that it was considerably higher. Baart harvested sixteen days after flowering showed 61% green seed and germinated 54%; white Sonora showed 92% green seed and gave 4% germination.

It was concluded by Harlan and Pope (6) that the embryo of the immature barley kernels allowed to air dry on the culm would continue to grow for at least eight days after sampling. The embryos of immature kernels dried in the glumes will grow about as much as those dried on the culm. They also observed (7) that nine out of ten barley seeds germinated when harvested five days after they were pollinated. The kernels had been harvested in the head and allowed to air dry in paper envelopes. When florets picked from the head at harvest were tested, the viability was zero in all samples taken on the fifth to eighth day from pollination. Of the nine day kernels, three out of ten germinated.

Wilson and Raleigh (19) observed that premature cutting, until about six days before maturity, resulted in lowered grain weight. This was true for both wheat and oats. No recognizable difference in 1,000 kernel weights was noted for grain from plants dried in the oven immediately upon harvest, dried in the shock in the regular manner, in shock with culm bases in water, and in bags under the eaves of a building.

Timmons and Clapp (18) found that temperatures in the field ranging from 27 to 31°F caused floret sterility, depending on the stage of growth. The fact that some florets were sterile, while others on the same head and sometimes in the same spikelet developed normal kernels, indicated that the wheat flower remained for only a very short time in the stage which was most susceptible to freezing injury.

It was reported by Goodwin (5) that mature wheat, after having been subjected to 150°F for two hours, germinated as well as the untreated wheat from the same lot.

The percentage of germination was not materially changed when mature seed of wheat, barley, Sudan grass, Kentucky bluegrass, and Johnson grass were dried to less than one percent of moisture, according to the conclusions of Harrington and Crocker(8).

Suneson (17), working with wheat and barley, found different varieties vary in their susceptability to frost at the heading stage, but that the difference is only 2 to 3°F and does not seem sufficient to encourage breeding for greater hardiness.

In working with small grains, Keisselback and Helm (12) observed plump, mature, small seed produced as large a yield as large, mature seed, if the rate of seeding by weight was noted. Seed for seed, the larger, plumper seed yielded from ten to twenty percent more per area. Depth of planting up to five inches made no appreciable difference in yield.

Hottes and Wilson (11) worked with wheat on the problem of resistance to high temperatures, and found it to be inversely proportional to the water content of the seed. Seed heated in an oven or open container undergoes constant changes in water content, and this water is constantly carried off as vapor.

In testing temperatures at which weed, garden and field seeds would be killed, Hopkins (10) found that corn was killed at 70°C or lower, wheat at 95°C and wild oats at 105°C with moisture at 12.5 and heated for two hours.

Getty (4) observed that when sorghum was harvested after being frosted the seed showed a proportionately lower rate of germination when compared to that cut before frost. In the milk stage to the hard dough stage, the germination after frosting was zero, while that cut before the frost was 68 and 87% germination respectively. When cut for seed at full maturity, the frosted showed 81% germination as against 90% for the unfrosted.

Research on corn having a moisture content of approximately 8 to 19% was carried on by Alberts and Flint (1). This corn was subjected to 125°F for three hours and showed no loss in vitality. The maximum amount of heat that could be applied to corn without injuring its vitality was dependent not only upon its moisture content at the time of treatment, but also upon the previous storage temperature.

Experiments were conducted by Herman and Herman (9) with crested wheat to determine the effect of maturity at the time of harvest on germination. Nine days after anthesis, when the seed was in the premilk stage, 200 spikes were harvested every three days until the seed was in the soft dough state. Even then, harvests were made at six day intervals until 50% shattering. Seed stored in paper bags at room temperature was later tested between paper towels at 20-22°C in four lots of 100 seeds each. The results of all lots were averaged.

Testing began immediately after harvest and continued every seven days for eleven weeks, lengthening after that period. As no germination occurred in seed of the premilk stage through the five weeks after harvest, tests were discontinued. None were made of the early milk seed after the eleventh week, as all tests up to that date were low, and no increase had occurred for several weeks. Percentages of germination in all tests made immediately after harvest were noticeably low, as compared with those of subsequent tests. This was especially marked preceding and through the development of soft dough, when initial tests showed almost no germination. Seed in all stages of maturity increased in percentage of germination after storage, but the length of storage required to reach maximum germination was proportionally less as the maturity of the seed increased. Ripe seed attained maximum germination after two weeks of dry storage following harvest. Maximum germination percentages increased with greater maturity of seed through the late milk stage, but beyond that differences in stored seed were not significant.

Germination tests were conducted in which seeds from each harvest were chilled at 8 to 10°F for one week before germination. In seed which had been stored for five weeks, the low temperature had very little effect. In seed tested immediately after harvest, low temperatures reduced the germination up to and including seed from the soft dough stage, stimulated germination in seed in the hard dough, and had little more effect than a week of dry storage on mature seed, except that which was heavily shattered.

These investigations by Herman and Herman (9) indicated that seed of high viability may be obtained by harvesting as soon as the early dough development, and that vigorous seedlings could not be expected from seed harvested earlier than the hard dough stage.

McAlister (14) used Agropyron cristatum, smithii and trachycaulum Bromus inermis, marginatus and polyanthus, Elymus glauca, and Stipa virudula. to study the viability of pre-milk, milk dough and mature stages of development. Seeds were stored 4, 9, 15, 22, 40, 51 and 58 months and then tested under greenhouse conditions for soil germination.

In the greenhouse tests, the pre-milk and milk seeds were inferior in most instances, both in viability and longevity, to seed harvested either in the dough or mature stages. Seeds of Bromus marginatus and Bromus polyanthus collected in the milk stage and even pre-milk stage, however, gave as high germination during the entire storage period as the mature seed. Dough stage seed had similar viability and longevity to the mature seed in all species.

In field plantings the immature seeds were generally much inferior to those harvested at maturity as far as seedling emergence was concerned. The only immature seeds which gave as large a number of seedlings as the mature seed during three years following collection of seed samples were those of the dough stage of Bromus marginatus. No difference in size or relative survival could be detected by McAlister (14) at the end of the seedling year between plants produced from mature or immature seeds.

Under field conditions at Logan, Utah, Keller (13) reports that several forage grasses would mature viable seeds on culms detached prior to pollination and placed with cut ends in tap water in proximity to appropriate pollen sources. Agropyron ciliare, A. cristatum, A. trachycaulum, Bromus carinatus, B. inermis, Hordeum jubatum, Festuca elatior and Phalaris tuberoso were used in these experiments. Viable seeds were also produced on culms of A. semicostatum, which had already begun to flower when detached.

Most lots of seed from detached culms weighed from 40 to 83% of those matured on intact culms. Seeds from detached culms of A. ciliare, A. brachyculum, H. jubatum and F. elatior germinated approximately as well as those from the control lots of the same species. Germination was fairly high for the other species with the exception of B. inermis, which gave values of 25 to 35%. Grass seed production on culms detached prior to pollination constitutes an extension of technique which may be useful in practical breeding operations.

Alfalfa seed was graded into seven color separates by Stewart and Carlson (16), and the power of each to germinate on blotters, and to establish plants through 3/8 inches of sandy loam soil was carefully measured.

True color germinated 87% using 100 seeds; shrivelled green germinated only 17%; shrivelled brown germinated 22%. The other colors graded down fairly evenly from the true color to the shrivelled brown. When compared to unseparated bulk seed, true colored and light brown seeds were heavier, light green seed was about equal in weight, and all discolored seeds were noticeably lighter. Green seeds of any shade were lighter than corresponding brown seeds. Discolored seed seemed to germinate more slowly than did the brighter colored fraction.

Battle (2) gathered Red clover stems bearing freshly opened flowers from plants growing in the field. The stems were severed just above the crown, placed in H_2O, and later removed to a 2% sucrose solution. The bottoms of the stems were charred to prevent plugging of conducting tissue and all old leaves removed. All wilted or unopened florets were removed, and the remaining florets pollinated with a toothpick. It was found that seed matured in about eighteen days, the same time as required in the field. Seed yields varied with the plants, but in general were slightly larger in size and weight and as readily germinable as field grown seed.

Some interesting observations were made by Stewart (15) when working on the germination of green and brown seed of alfalfa. There was a marked reduction in percentages of germination and a lack of vitality in germinator tests and in flats, where they had to come through 3/8 inches of moist, sandy loam soil. When germinated between blotters, the average percentage of strong sprouts for shrivelled green seed was 19.6 and the shrivelled brown seed was 3.7%. However, where they had to establish themselves through 3/8 inches of soil, 24.5% of the green shrivelled and 8.7% of the brown shrivelled established themselves.

MATERIALS AND METHODS

The study was carried out in three localities with the bulk of the work being done in the Fairbanks area. Species used in these three areas are listed in Table I.

Table I Species included in study, locations planted and sources of seed.

Common Name	Botanical Name	Seed Source
	FAIRBANKS, ALASKA	
Grains		
Wheat (Khogot)	*Triticum aestivum*	Siberian origin
Barley (Edda)	*Hordeum vulgare*	Swedish origin
Oats (Golden Rain)	*Avena sativa*	Swedish origin
Grasses		
Kentucky Bluegrass	*Poa pratensis*	Commercial seed
Timothy	*Phleum pratense*	Commercial seed
Meadow foxtail	*Alopecurus pratensis*	Commercial seed
Smooth bromegrass	*Bromus inermis*	Northern strain
Bluejoint	*Calamagrostis canadensis*	Native
Legumes		
Perennial vetch	*Vicia cracca*	Native
Red clover	*Trifolium pratense*	Siberian origin
Yellow Blossom alfalfa	*Medicago falcata*	Siberian origin
Blue Blossom alfalfa	*Medicago sativa*	Commercial seed
Alsike clover	*Trifolium hybridum*	Commercial seed
White clover	*Trifolium repens*	Commercial seed
	MATANUSKA, ALASKA	
Grains		
Wheat (Khogot)	*Triticum aestivum*	Siberian origin
Barley (Edda)	*Hordeum vulgare*	Swedish origin
Grasses		
Meadow foxtail	*Alopecurus pratensis*	Commercial seed
Smooth bromegrass	*Bromus inermis*	Commercial seed
Legumes		
Perennial vetch	*Vicia cracca*	Native
Yellow Blossom alfalfa	*Medicago falcata*	Siberian origin
	BOZEMAN, MONTANA	
Grasses		
Timothy (Hopkins)	*Phleum pratense*	Foundation seed
Smooth bromegrass (Lincoln)	*Bromus inermis*	Foundation seed
Legumes		
Red clover	*Trifolium pratense*	Commercial seed

To make methods used in this study as uniform as possible, a standard procedure was followed at all three locations.

All tagging was done at five day intervals. Sufficient heads, racemes or panicles were marked for the entire seven harvest dates on one day, as the various crops arrived at specified tagging stages. Approximately 200 panicles per species of grasses and 275 spikes or racemes per species of grains and legumes were tagged.

Conditions for determining the time of tagging varied with the three groups. Of the grasses, Timothy, Meadow foxtail and Smooth bromegrass were tagged when one half of the infloresence had flowered, while Calamagrostis and Kentucky Bluegrass were tagged when the lowest panicle internode emerged from the boot. All grains were tagged when pollen was shed in the center of the spike, but not yet shed at the tip or the base. With each legume the racemes were selected when approximately one fourth of the terminal buds remained to open.

Five days after tagging the first grain harvest was taken, while ten days elapsed between tagging and the first harvest of grasses and legumes. Seven consecutive harvests, five days apart, were made from each crop.

Table II lists actual dates of tagging and harvest.

Table II Dates of tagging (T) and harvest (H) at Fairbanks, Matanuska and Bozeman during the summer of 1951.

	JUNE					JULY							AUGUST					
Location	6	11	16	21	26	1	6	11	16	21	26	31	5	10	15	20	25	30
Fairbanks																		
Alsike clover		T		H	H	H	H	H	H	H								
Meadow foxtail		T		H	H	H	H	H	H	H								
White clover				T		H	H	H	H	H	M	M						
Bluejoint					T		H	H	H	H	H	H	H					
Kentucky Bluegrass					T		H	H	H	H	H	H	H					
Edda barley					T	H	H	H	H	H	H	H						
Smooth bromegrass						T		H	H	H	H	H	H	H				
Golden Rain oats							T	H	H	H	H	H	H	H				
Perennial vetch							T		H	H	H	H	H	H	H			
Khogot wheat								T	H	H	H	H	H	H	H			
Yellow Blossom alfalfa								T		H	H	H	H	H	H	H		
Timothy								T		H	H	H	H	H	H	H		
Blue Blossom alfalfa								T		H	H	H	H	H	H	H		
Red clover									T		H	H	H	H	H	H	H	
Matanuska																		
Meadow foxtail	T		H	H	H	H	H	H	H									
Khogot wheat								T	H	H	H	H	H	H	H			
Edda barley								T	H	H	H	H	H	H	H			
Smooth bromegrass								T		H	H	H	H	H	H	H		
Yellow Blossom alfalfa										T		H	H	H	H	H	H	H
Perennial vetch											T		H	H	H	H	H	H
Bozeman																		
Smooth bromegrass									T		H	H	H	H	H	H	H	
Timothy										T		H	H	H	H	H	H	H
Red clover										T		H	H	H	H	H	H	H
	6	11	16	21	26	1	6	11	16	21	26	31	5	10	15	20	25	30
	JUNE					JULY							AUGUST					

M is missing plot

Each five day period these crop harvestings were taken from the field to a laboratory where each species was divided into three equal lots. The first lot (one third of all the sample harvested) was placed in a refrigerator set at 26°F and left for two hours. This practice was arbitrarily chosen as best approximating a light frost under field conditions. At Bozeman the material was frozen at the same temperature for twelve hours. The second lot was placed in a drying oven set at 110°F for 24 hours. This method was arbitrarily determined by recording the length of time required to dry a sample of alfalfa (equal in weight to these harvestings) to a moisture content low enough for safe storage. This practice was devised to simulate artificial drying, which is necessary in cases of inclement weather during harvest periods to dry crops for threshing or to prevent them from spoiling in the stack. The last harvest portion of each species was placed in a loose mesh cotton bag and left in the laboratory, or placed outdoors and protected from rain. This method approximated conditions of field curing as closely as possible, and was considered the check treatment. After lots one and two (frozen and oven dried) had been subjected to their respective treatments, they were placed outside with the third lot (field cured) for additional drying (thirty day minimum) to equalize moisture content as much as possible.

When the minimum thirty day drying period was over, all lots (frozen, oven dried and field cured) for each species were brought into the laboratory and divided into three equal subsamples for threshing and weighing. Each portion of each variety and treatment was threshed by hand. As conditions warranted this procedure would differ with the species, but never within the same species or lot.

After threshing 100 seeds were counted out at random from each subsample. Grains and legumes were counted out without regard to size, soundness, shape or color, as long as the seed was not broken. This work was done on a frosted glass table using an overhead light. With all grasses indirect lighting under a frosted glass was used to separate the sterile florets from the sound seed. In the early stages of harvesting it was extremely difficult to detect the caryopsis, and a large percentage of sterile florets were put in with the supposedly sound seed.

The three seed subsamples within each lot of each species were weighed separately on a torsion balance in milligrams per 100 seeds. In the few cases in which 100 seeds were not obtained from the sample, the weight was computed to the equivalent of 100 seeds. The seed weights of the subsamples were then combined to determine the average seed weight for each individual crop under a specific treatment (frozen, oven dried and field cured). An analysis of variance for seed weight was computed for the two criteria, dates of harvest and post harvest treatments (frozen, oven dried and field cured).

Germinations were then run under a standard set of procedures (blotter method) used by the Montana State College Grain Laboratory at Bozeman, Montana. Germinations were determined for all species, treatments and harvest dates separately.

In arriving at a figure for germination, the bulk method of computing was used. Thus, in the case of legumes, readily germinable and hard seed were added together. It was assumed that the hard seed would have germinated if it had been properly treated.

The final step was to determine seed maturity for each of the three treatments (frozen, oven dried and field cured) at all harvest dates, or days after anthesis. This analysis was based upon two factors, standard seed weight (in milligrams per 100 seeds) and acceptable germination.

In establishing an acceptable standard seed weight, the calculated seeds per gram standards as set up by the Federal Seed Act Regulations, dated August 4, 1945, were used. A few minor changes were made when it was obvious that the scale would not apply. Yellow Blossom alfalfa, being much smaller than common alfalfa, was figured at double the rate of seed per gram. For oats and wheat of the varieties being used, one fourth more seed per pound was added, since they are considerably smaller than common varieties. Perennial vetch, being less than half as large as common or winter varieties, was computed at twice the number of seeds per gram for this species. All others were computed according to standard.

A composite of standards from states and regions having similar climatic conditions to Alaska was used as a basis for establishing an arbitrary line of acceptable germinations. Further work will have to be done before a set of standards can be definitely established.

Table III presents the standard seed weights and acceptable germinations used in this study to determine seed maturity.

Table III Acceptable standard seed weights in milligrams per 100 seed and acceptable germination percentages used to determine seed maturity.

Species	Seed Weight	Germination
Grains		
Barley	3300	90
Oats	2500	90
Wheat	1500	90
Grasses		
Smooth bromegrass	330	75
Meadow foxtail	83	60
Timothy	40	90
Legumes		
Common alfalfa	200	85
Yellow Blossom alfalfa	100	85
Alsike clover	66	85
White clover	66	85
Red clover	160	85
Vetch	660	85

In all methods described in this study, the human error factor has entered into the work. The widely distributed areas made it necessary for different personnel to evaluate anthesis. Also, techniques in tripping and tagging were performed by different individuals. Variation in ovens and refrigerators added to the possible degree of error. Threshing, weighing and germination tests, however, were uniform for all locations, since they were carried out by one person using a standard set of operational procedures.

EXPERIMENTAL RESULTS

No significant differences in seed weights were found between treatments, i.e. field cured, frozen or oven dried. The mean squares for seed weight at different dates of harvest were significant for all species at all locations.

Typical Seed Weight Development

Table III lists the acceptable standard germinations and seed weights established as a basis for determining seed maturity in this study. Table IV gives the actual seed weights (per 100 seeds in milligrams) for each five day harvest period after anthesis for all crops used in the problem. On the basis of the data presented in these two tables, the days required to reach minimum acceptable seed weights were computed and plotted on figure 1.

The number of days required by the cereals to reach acceptable seed weight standards were similar. Wheat and barley at both Fairbanks and Matanuska reached the designated standard weight in 15 to 20 days, while oats took 25.

Grasses separated into two distinct groups. Smooth bromegrass at all three locations (Fairbanks, Matanuska, Bozeman) reached acceptable seed weights in a 15 to 21 day period following anthesis, with Matanuska requiring the longer period. Thirty to 35 days were required for Timothy at Bozeman and Meadow foxtail at Fairbanks and Matanuska to reach an acceptable seed weight. It is interesting to note that Timothy required only three days longer then Smooth bromegrass in the time required to reach an acceptable seed weight at Fairbanks, while at Bozeman the Timothy re-

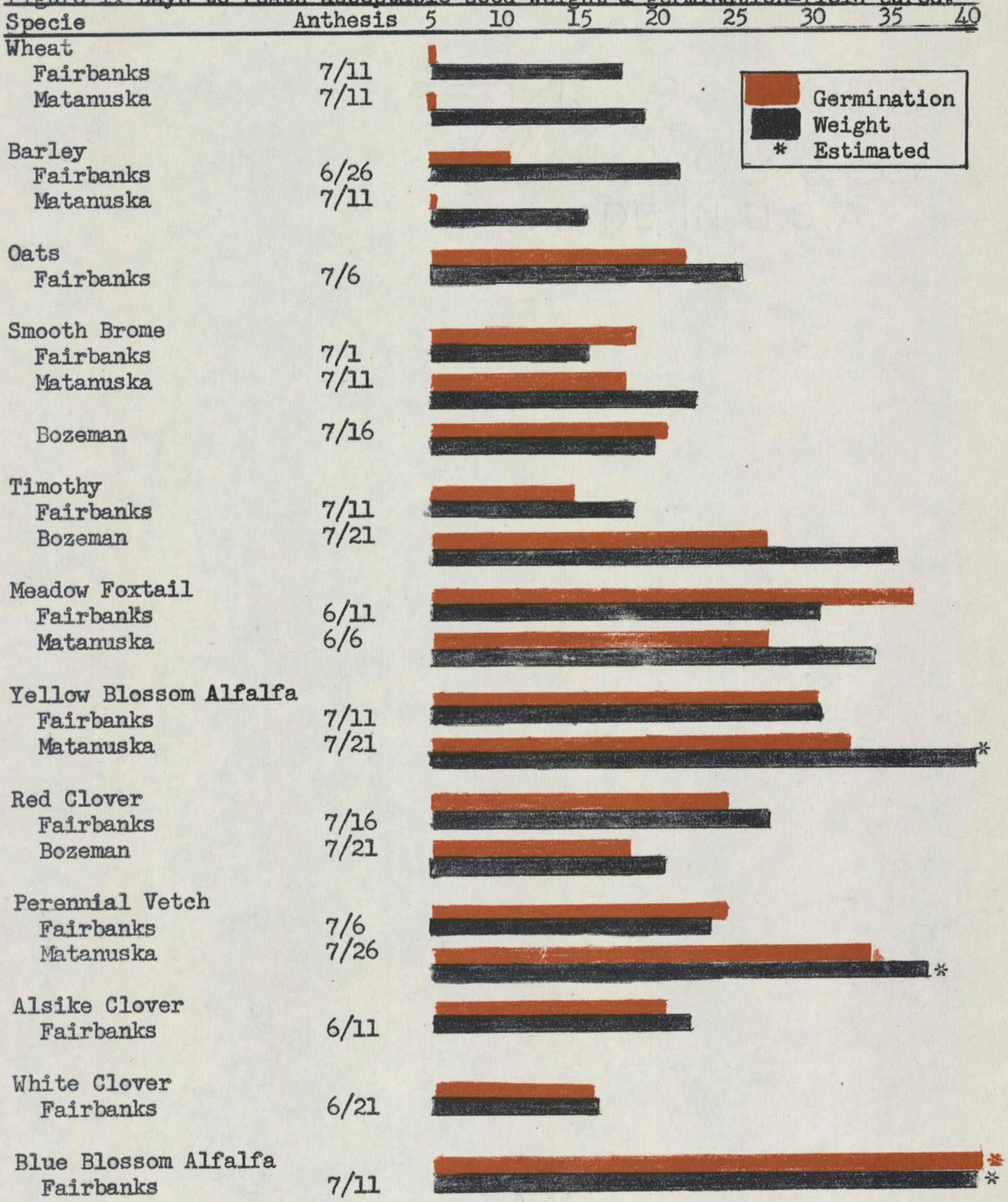
Table IV Average seed weight under all treatments and field cured seed germination percentage.

		Date	Weight per 100 Seeds in mg.								Germination Percentage							
	Area	of	Days after Anthesis								Days after Anthesis							
Crop	Grown	Anthesis	5	10	15	20	25	30	35	40	5	10	15	20	25	30	35	40
Wheat	Fbks	7/11	414	977	1418	1725	2018	2129	2091		92	99	100	100	100	100	100	
	Mat	7/11	503	877	1312	1658	1975	1545	1557		98	100	99	100	100	100	100	
Barley	Fbks	6/26	527	1223	1964	3130	3906	3913	3908		13	93	99	100	100	100	100	
	Mat	7/11	1785	2508	3312	3900	4055	4073	4108		98	100	100	100	100	100	100	
Oats	Fbks	7/6	684	1112	1765	2358	2473	3163	3347		0	34	50	92	90	99	98	
Smooth brome	Fbks	7/1		197	328	420	452	446	440	445		58	58	89	95	91	87	82
	Mat	7/11		213	275	313	352	378	420	387		55	60	67	61	90	89	79
	Boz	7/16		NS	190	341	401	418	388	391		NS	35	78	84	84	82	82
Timothy	Fbks	7/11		17	26	49	58	63	69	72		77	93	96	98	97	99	96
	Boz	7/21		8	20	23	31	38	40	M		14	78	83	87	97	80	M
Meadow foxtail	Fbks	6/11		48	45	87	74	93	93	105		2	2	20	20	49	57	72
	Mat	6/6		NS	35	41	51	76	86	99		NS	0	4	50	84	98	98
Yellow Bl. alf.	Fbks	7/11		10	21	37	68	100	135	112		0	0	0	42	91	92	88
	Mat	7/21		2	12	23	47	66	85	91		0	0	0	28	82	94	95
Red clover	Fbks	7/16		36	46	85	141	193	173	166		23	15	55	90	94	82	97
	Boz	7/21		NS	97	160	219	223	229	M		NS	78	95	98	98	98	M
Perennial vetch	Fbks	7/6		120	445	443	808	1158	948	745		0	56	78	89	98	98	100
	Mat	7/26		NS	13	98	158	352	566	M		NS	0	0	0	56	99	M
Alsike clover	Fbks	6/11		35	38	62	79	86	89	77		14	6	95	100	97	97	100
White clover	Fbks	6/21		36	63	95	80	85	M	M		38	86	97	97	99	M	M
Blue Bl. alf.	Fbks	7/11		6	21	48	105	113	130	160		0	0	0	16	44	58	68

LEGEND: Fbks is Fairbanks, Alaska
Mat is Matanuska, Alaska
Boz is Bozeman, Montana

NS is no seed
M is missing plot

figure 1. Days to reach acceptable seed weight & germination-field cured.



quired 16 days more than the Smooth bromegrass.

Calamagrostis and Kentucky Bluegrass were tagged at the early stages of flowering. Harvests were started ten days later. Maturity was extremely slow as shown by the low seed weights and germinations, but both were increasing rapidly on the last harvest date.

Legumes showed a greater range than either grasses or grains in the number of days necessary to attain acceptable seed weights. White clover from Fairbanks took the shortest time, reaching standard seed weight in only 15 days, and Alsike an additional six days. Perennial vetch at Fairbanks required 23 days, while the same species at Matanuska did not mature in 40 days. Red clover required a week less to reach an acceptable seed weight at Bozeman than at Fairbanks, the latter requiring 22 days.

Alfalfa is slower than most legumes to reach an acceptable seed weight. Yellow Blossom alfalfa appears to reach the minimum standard seed weight much sooner than the blue flowered alfalfa, the latter not maturing at Fairbanks in the 40 days alloted to this study. The yellow flowered species, however, had reached an acceptable seed weight ten days before.

Matanuska Yellow Blossom alfalfa lots failed to reach acceptable seed weight by the end of the harvest period (40 days after anthesis).

These differences are shown graphically by the bar graphs in figure 1.

It appears that in the case of forage crop seed, maximum seed weights will be developed more rapidly from anthesis at Fairbanks than at Matanuska. This is true for three of the four species studied in 1951. The fact that precipitation at Matanuska was below normal during the early part of the 1951 growing season should be noted as one contributing factor.

It is interesting to observe that the rate of endosperm development is rather constant for the various species grown at both Fairbanks and Matanuska. That is, a ranking at either location would in general hold true for any of the species.

A Bozeman and Fairbanks comparison exhibits a much greater variation between rankings of the three species at the two locations. Red clover developed rapidly at Bozeman and Timothy very slowly; at Fairbanks Timothy developed rapidly and Red clover much more slowly. The rate of development of Smooth bromegrass was the same at both locations. It should be noted that anthesis of Smooth bromegrass at Bozeman in 1951 was from 20 to 30 days later than in any other year during the past seven year period. Timothy was one to two weeks later than normal.

Typical Germination Development

Table IV includes percentages of germination of field cured lots for all crops at all three locations with the average seed weights previously described. Each field cured (air dried) germination percentage is then used as a check for the frozen and oven dried germinations, since field curing is the practice most commonly followed during an average year. These comparisons are made first.

Under field conditions all cereals at both Fairbanks and Matanuska reached minimum acceptable germinations within ten days after anthesis with the exception of oats (Fairbanks), which took 20 days.

Barley was somewhat slower to develop an acceptable germination at Fairbanks than at Matanuska.

At Fairbanks the relative development of germination in the small

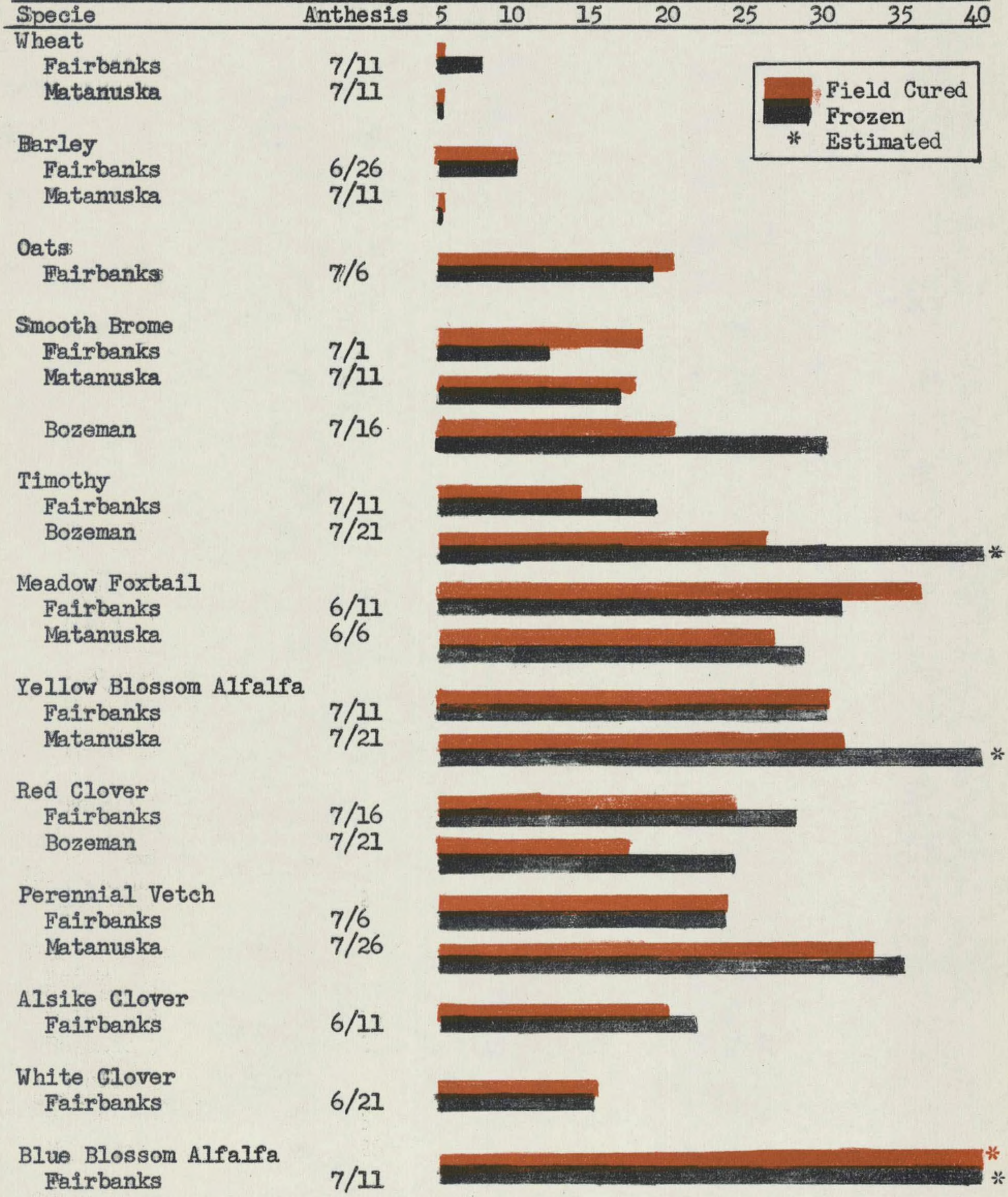
Table V Germination percentages of field cured and frozen seed at different maturity stages.

Crop	Area Grown	Date of Anthesis	Germination % of Field Cured Seed, Days after Anthesis: 5	10	15	20	25	30	35	40	Germination % of Frozen Seed, Days after Anthesis: 5	10	15	20	25	30	35	40
Wheat	Fbks	7/11	92	99	100	100	100	100	100		80	99	94	100	100	98	99	
	Mat	7/11	98	100	99	100	100	100	100		100	93	99	100	91	100	100	
Barley	Fbks	6/26	13	93	99	100	100	100	100		10	93	98	100	100	100	100	
	Mat	7/11	98	100	100	100	100	100	100		97	94	99	100	98	100	100	
Oats	Fbks	7/6	0	34	50	92	90	99	98		3	33	77	96	97	100	100	
Smooth bromegrass	Fbks	7/1		58	58	89	95	91	87	82		73	76	70	88	89	92	91
	Mat	7/11		55	60	67	61	90	89	79		5	66	74	53	86	80	80
	Boz	7/16		NS	35	78	84	84	82	82		NS	20	22	64	75	86	82
Timothy	Fbks	7/11		77	93	96	96	97	99	96		72	64	97	99	98	98	99
	Boz	7/21		14	78	83	87	97	80	M		14	54	71	76	83	83	M
Meadow foxtail	Fbks	6/11		2	2	20	20	49	57	72		1	0	11	36	56	74	75
	Mat	6/6		NS	0	4	50	84	98	98		NS	0	0	26	75	87	90
Yellow Bl. alfalfa	Fbks	7/11		0	0	0	43	91	92	88		0	0	0	44	88	92	92
	Mat	7/21		0	0	0	28	82	94	95		0	0	0	2	28	79	79
Red clover	Fbks	7/16		23	15	55	90	94	82	97		0	30	72	83	86	79	94
	Boz	7/21		NS	78	95	98	98	98	M		NS	0	42	93	95	96	M
Perennial vetch	Fbks	7/6		0	56	78	89	98	98	100		0	70	64	95	99	88	98
	Mat	7/26		NS	0	0	0	56	99	M		NS	0	0	0	29	87	M
Alsike clover	Fbks	6/11		14	6	95	100	97	97	100		0	11	80	97	96	99	99
White clover	Fbks	6/21		38	86	97	97	99	M	M		9	93	98	97	99	M	M
Blue Bl. alfalfa	Fbks	7/11		0	0	0	16	44	58	68		0	0	0	35	39	63	65

LEGEND: Fbks is Fairbanks, Alaska
Mat is Matanuska, Alaska
Boz is Bozeman, Montana

NS is no seed
M is missing plot

figure 2. Days to acceptable germination when seed is field cured & frozen.



grains would be in order: wheat, barley, and oats with wheat developing the most rapidly.

In general the small grains developed an acceptable germination much sooner than either grasses or legumes. Time of harvest of small grains would probably be determined by seed weight rather than germination as development of an acceptable weight lagged considerably behind germination.

In all three areas Smooth bromegrass required 18 to 20 days to reach the standard germination. Timothy, Alsike clover and White clover at Fairbanks require 15 to 20 days. All other species attained the minimum within 36 days, excepting Blue Blossom alfalfa (Fairbanks), which failed to reach an acceptable seed germination by the end of the harvest period (figure 1).

Legumes for the most part developed an acceptable germination and an acceptable seed weight at about the same time. With perhaps the exception of Meadow foxtail at Fairbanks, an acceptable seed weight indicated an acceptable germination in all species.

<u>Effect of Freezing on Germination</u>

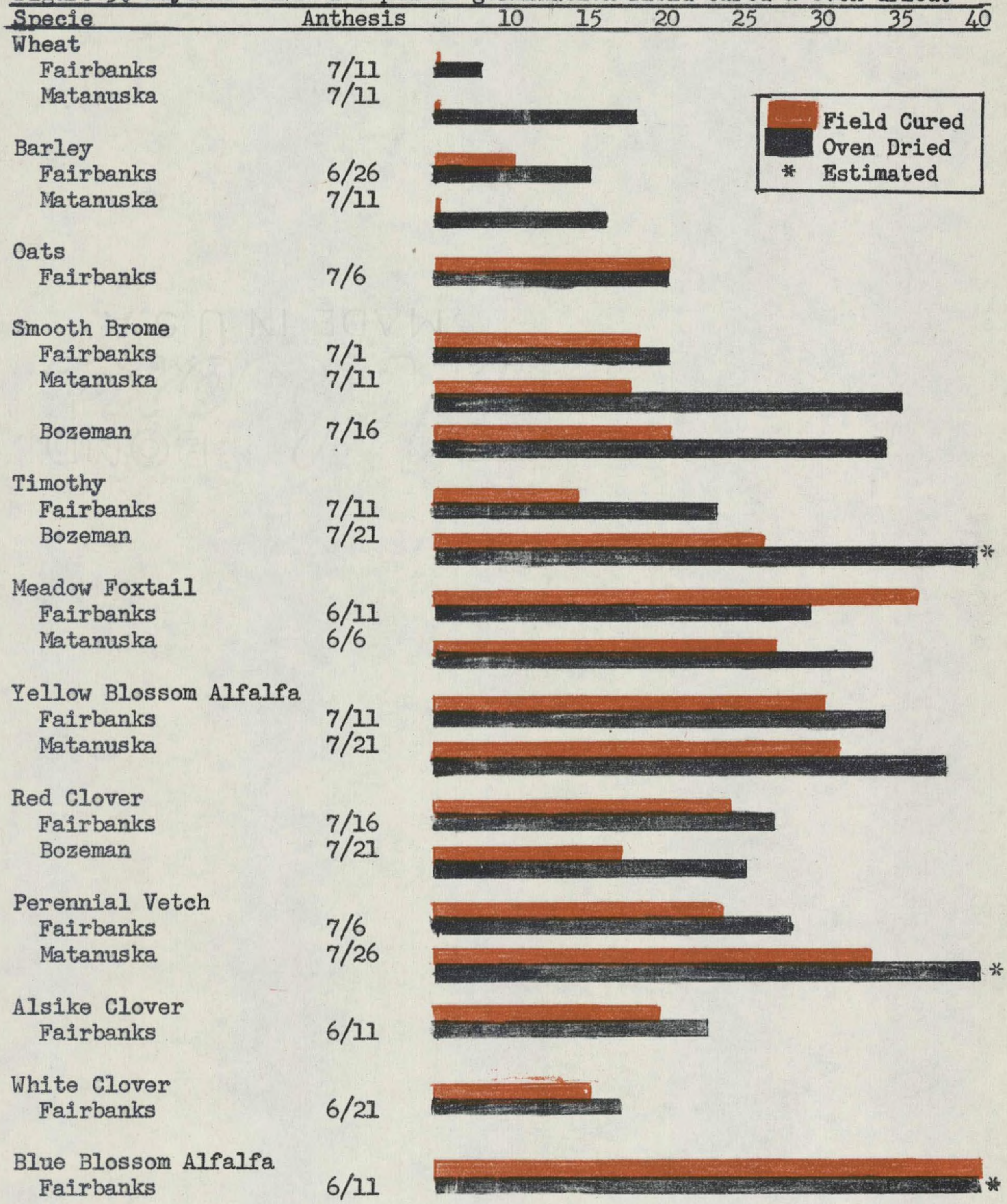
Freezing had no effect on germination of small grains at any location or stage of maturity studied. (Table V and figure 2) The effect on grasses was variable. Smooth bromegrass and Meadow foxtail at Fairbanks showed a result in reverse to the other grasses, reaching an acceptable germination five days earlier than field cured samples. The remainder of the grasses at all locations were one to five days longer in attaining standard germination, except the lots of Timothy and Smooth bromegrass at Bozeman. It should be noted that these samples were left at 26°F for twelve hours instead of the prescribed two hour period. This would apparently account

Table VI Germination percentages of field cured and oven dried seed at different maturity stages.

Crop	Area Grown	Date of Anthesis	Germination % of Field Cured Seed — Days after Anthesis 5	10	15	20	25	30	35	40	Germination % of Oven Dried Seed — Days after Anthesis 5	10	15	20	25	30	35	40
Wheat	Fbks	7/11	92	99	100	100	100	100	100		70	99	100	99	100	99	100	
	Mat	7/11	98	100	99	100	100	100	100		26	0	52	90	100	100	100	
Barley	Fbks	6/26	13	93	99	100	100	100	100		0	0	89	99	100	100	100	
	Mat	7/11	98	100	100	100	100	100	100		37	0	88	98	99	100	100	
Oats	Fbks	7/6	0	34	50	92	90	99	98		0	1	49	91	98	92	99	
Smooth bromegrass	Fbks	7/1		58	58	89	95	91	87	82		0	55	76	77	89	88	57
	Mat	7/11		55	60	67	61	90	89	79		0	0	8	18	41	71	68
	Boz	7/16		NS	35	78	84	84	82	82		NS	0	27	57	56	80	79
Timothy	Fbks	7/11		77	93	96	96	97	99	96		10	3	78	97	97	98	94
	Boz	7/21		14	78	83	87	97	80	M		1	0	0	5	49	46	M
Meadow foxtail	Fbks	6/11		2	2	20	20	49	57	72		0	1	23	23	71	64	60
	Mat	6/6		NS	0	4	50	84	98	98		NS	0	0	0	0	92	92
Yellow Bl. alfalfa	Fbks	7/11		0	0	0	43	91	92	88		0	0	0	0	65	88	98
	Mat	7/21		0	0	0	26	82	94	95		0	0	0	0	0	73	90
Red clover	Fbks	7/16		23	15	55	90	94	82	97		15	23	59	82	91	85	90
	Boz	7/21		NS	78	95	98	98	98	M		NS	22	52	87	97	97	M
Perennial vetch	Fbks	7/6		0	56	78	89	98	98	100		0	0	45	72	97	100	100
	Mat	7/26		NS	0	0	0	56	99	M		NS	0	0	0	0	4	M
Alsike clover	Fbks	6/11		14	6	95	100	97	97	100		29	23	57	98	98	98	98
White clover	Fbks	6/21		38	86	97	97	99	M	M		84	79	94	90	100	M	M
Blue Bl. alfalfa	Fbks	7/11		0	0	0	16	44	58	68		0	0	0	17	35	52	35

LEGEND: Fbks is Fairbanks, Alaska
Mat is Matanuska, Alaska
Boz is Bozeman, Montana
NS is no seed
M is missing plot

figure 3. Days to reach acceptable germination-field cured & oven dried.



for the injury to germination at early stages. In the case of legumes, no appreciable differences in germination due to the freezing treatment were noted with the exception of Yellow Blossom alfalfa at Matanuska.

Germination of seed that had developed an acceptable seed weight was not affected by the light freezing treatment so that an acceptable weight indicated an acceptable germination even with a light frost. With a more prolonged freezing exposure, as at Bozeman, an acceptable seed weight was not an indication of an acceptable germination, particularly in the case of the two grasses studied. Seed must be more mature to withstand a light frost of long duration without a depressing effect on germination.

Effect of Oven Drying on Germination

Oven drying reduced germination of all species in the earlier stages of maturity at all three locations. Delay in reaching a stage which could be oven dried without appreciable loss in germination was very pronounced in some cases, delaying development of an acceptable germination as much as 15 days, or twice the normal length of time usually required. The exception to this tendency was Meadow foxtail at Fairbanks, which reached the acceptable standard germination six days earlier than the field cured lot.

Grain of acceptable seed weight can be safely oven dried with the temperatures used in this study. Legumes of acceptable seed weight can also be oven dried at these temperatures without damaging effects, excepting Yellow Blossom alfalfa at Fairbanks, Perennial vetch at both Fairbanks and Matanuska and Red clover at Bozeman. These legumes require approximately five days longer to attain acceptable seed germination when oven dried.

An acceptable seed weight in Meadow foxtail indicated that the seed could be oven dried without danger of obtaining below standard germination. Other grasses required a greater degree of maturity than that indicated by the seed weight.

Before oven drying, leaving seed in the field for five days after it has reached acceptable seed weight, will assure good germination, using germination seed weights and length of exposure as presented in this study.

DISCUSSION

In evaluating the data presented in this problem, ecological differences existing between the three areas should definitely be considered. A brief survey of climatological facts will provide a better understanding of the results of the study. (Appendix figures 4. and 5.)

The Agricultural Experiment Station in the Tanana Valley, where the major part of the tests were conducted, is located six miles out of Fairbanks deep in the interior of Alaska (nearest North latitude is 65°). It is a region with some permafrost, but in spite of the frozen subsoil the practicability of agriculture has been adequately demonstrated. Over a 34 year period, the average January temperature has been -11.6°F with -66°F as the lowest temperature on record. A comparatively heavy snowfall protects perennials from the effects of these low temperatures. Snow begins to fall in October, and gradually accumulates during subsequent snowfalls until the snow cover measures about four feet. There is seldom a thaw, never a complete one, and winter winds are rare, so the ground is not exposed during the cold months. Spring break-ups are relatively swift, occurring usually in late April or early May. Peak temperatures occur in July with 60°F as average and 99°F as the maximum recorded temperature in 34 years. Total precipitation ranges from 8.5 to 16 inches with an average over the years of 11.87 annual rainfall. Since approximately half of this comes during the growing season and there is a favorable evaporation-precipitation ratio, this rainfall is sufficient. The peak precipitation comes in early August, but drops in September, permitting field curing of crops during a normal year. The most significant climatic factor in this Fairbanks region is the number of daylight hours (sunrise to sunset). On May 1 there are 17 hours of daylight in this area; this increases to 20 hours and 34 minutes on June 1 and 21 hours and 18 minutes by July 1; then by August 1 the number of daylight hours has dropped back to 18 hours and 16 minutes. On June 21, the longest day, the sun is up 23 hours and 40 minutes. Twilight (sun no more than 12° below horizon) is continuous during the brief period that the sun is down, so that crops are growing all but a brief period during a 24 hour day. Plants will, therefore, mature in this area when it is impossible for them to mature during the same number of days in a more southerly latitude.

The Agricultural Experiment Station in the Matanuska Valley (nearest North latitude is 61°), where a second part of the data was gathered for this problem, is located about 50 miles by road from Anchorage and the Cook Inlet and 125 air miles from the open south coast of Alaska. It is bounded on three sides by mountains, and lies on the line of change between coastal and interior climatic conditions. Over a 19 year period, the average January temperature had been 12.6°F with -36°F as the lowest temperature on record during this time. The snow cover is frequently melted or reduced to a sheet of ice by winter thaws, and wind storms blow (not as common) with sufficient force to expose cleared ground. Perennials have been killed or weakened as a result. The average frost-free growing season at Matanuska is 108 days of mild temperatures with a July average of 56.5°F and a record high of 91°F. Rainfall is moderate, ranging from 13 to 18 inches annual total precipitation, and more than half of this falls during the summer months, August and September particularly. Thus, artificial drying is sometimes required for curing hay. The mild summer temperatures and frequently overcast skies tend to keep evaporation percentages low, so rainfall is adequate. In this latitude there is still a great variation in day length between summer and winter. By May 1 there are about 15 hours and 30 minutes of daylight, increasing to approximately 18 hours and 30 minutes on June 1. After the summer solstice on June 21, the days decrease at the same rate as the increase during May and June. These long days lengthen the photosynthetic period in plants and induce quick growth.

Comparison of the two Alaskan locations shows several significant differences between their climates. Matanuska does not experience the extremes of temperatures, having a milder winter and longer growing season with heavier rainfall than at Fairbanks. Because Fairbanks lies 240 miles to the north of Matanuska, its days (sunrise to sunset) are longer. Fairbanks normally has warmer summer temperatures. These last two factors would account for the earlier maturity of longer season crops, such as grasses and legumes. Grains mature at approximately the same time at both Matanuska and Fairbanks; the latter area is usually earlier by one week. For all crops except Meadow Foxtail, the germinations and seed weights were higher at Fairbanks than at Matanuska on any given date (figures 1, 2 and 3, Tables IV, V and VI). By the close of the harvest period, however, weights and germinations of seeds are nearly equal at both locations, with Matanuska attaining this maturity later during the harvest period.

It should be noted that the summer of 1951 when this study was conducted, was not average at Matanuska. The rainfall was less than average until the middle of the growing season.

The Montana Agricultural Experiment Station in the intermountain Gallatin Valley (closest North latitude is 46°) is located at Bozeman (altitude 4,795 feet) in the southwestern part of Montana. This area was used as a comparison between Alaska and the United States proper. The differences in climatic conditions (Appendix figures 4 and 5.) and variations in results of this study show very definitely that some agricultural information from the states must be modified to apply to the Territory. Bozeman has a milder, moister climate with a somewhat longer frost-free growing season of 115 days. The average annual precipitation is 17.5 inches with 64 percent falling between April and September. Evaporation percentages are higher here than in the two Alaskan locations. Over a 39 year period the average January temperature was 20.8°F and the average July temperature was 64.6°F. The snow cover is adequate, for the temperatures are moderate compared to Fairbanks' readings. Winter thaws often occur, but perennials are not seriously affected. The hours of daylight at Bozeman fall far short of those in Alaska, being but 15 hours and about 30 minutes on the longest day of the year, June 21. This is evident in the earlier dates for anthesis for the Alaskan plantings. The combination of longer growing season and slightly warmer summer temperatures at Bozeman are advantages in maturing the longer season legumes.

Certain farm practices that had been followed in Alaska previously should be changed in light of this study. It is evident from the results on Blue Blossom alfalfa at Fairbanks that, if 1951 was an average year as the climatological factors seem to prove, it should not be cut until September 1 or later. Otherwise acceptable seed weight and germinations will not be attained. Yellow Blossom alfalfa, on the other hand, can be cut two or three weeks earlier, subjected to a light frost, artificially dried or field cured, and it will still show a germination of 90 percent or above in the Fairbanks area. In Matanuska similar results could be expected with Yellow Blossom alfalfa if it were harvested one to two weeks earlier than it has been. Results of this study would indicate that wheat, oats and barley can be cut for seed purposes at least ten days sooner than the present practice, since they are fully mature and can be subjected to any one of the treatments, field cured, frozen or oven dried without damage.

SUMMARY

Fourteen field crops were studied at three locations, Fairbanks and Matanuska, Alaska, and Bozeman, Montana, to determine when each crop could be most profitably harvested for seed, and what different effects field curing, a light frost or artificial drying would have on the maturity of that seed. Seven consecutive harvests were taken from each crop at five day intervals after anthesis. These harvestings were divided into three equal lots for comparison under the three treatments of freezing, oven drying and field curing. Factors noted were: date of anthesis and number of days required to reach standard seed weight and acceptable germination. Variations in results at the three locations are compared.

An analysis of variance indicated that there were no significant differences in seed weights whether frozen, oven dried or field cured. The rate of endosperm development was shown to be rather constant for the various species grown at both Fairbanks and Matanuska. Bozeman and Fairbanks showed a greater variation in seed weights between the same crops studied at the two locations.

Dates of anthesis were five to ten days earlier in the Fairbanks area than in the Matanuska area for the same species of plants with the exceptions of Khogot wheat and Meadow foxtail, which were approximately equal. At the Bozeman site, anthesis was five to fifteen days later than at Fairbanks for like species.

Germination percentages from the field cured lots were used as a check or basis of comparison with frozen and oven dried lots. In general the field cured small grains developed acceptable germinations earlier than

other grasses and the legumes. Since the development of standard seed weights lagged considerably behind acceptable germinations for these small grains, time of harvest would be determined by seed weight. Field cured results for grasses varied, but legumes, for the most part, reached acceptable germinations and seed weights at about the same time.

Freezing had no effect on germination of small grains at any location or stage of maturity. Results for grasses differed, but a one to five days longer period was generally required for frozen lots to attain acceptable germinations when exposed to frost. Smooth bromegrass and Meadow foxtail at Fairbanks were the exceptions, maturing five days earlier than field cured samples. Legumes were either unaffected or required a one to ten day longer period. As with the field cured lots, acceptable seed weights indicated acceptable germinations.

Artificial drying had a definite retarding effect on percentages of germination for all species at all locations, excepting oven dried Meadow foxtail at Fairbanks, which attained acceptable germination six days earlier than the field cured lots. However, all crops except Perennial vetch at Matanuska had reached acceptable percentages of germination by the sixth harvest date, thirty-five days after anthesis. The Fairbanks lots were the earliest. Standard seed weights were reached five days sooner than acceptable seed germinations. The best practice would be to leave the seed in the field for this five day period before oven drying.

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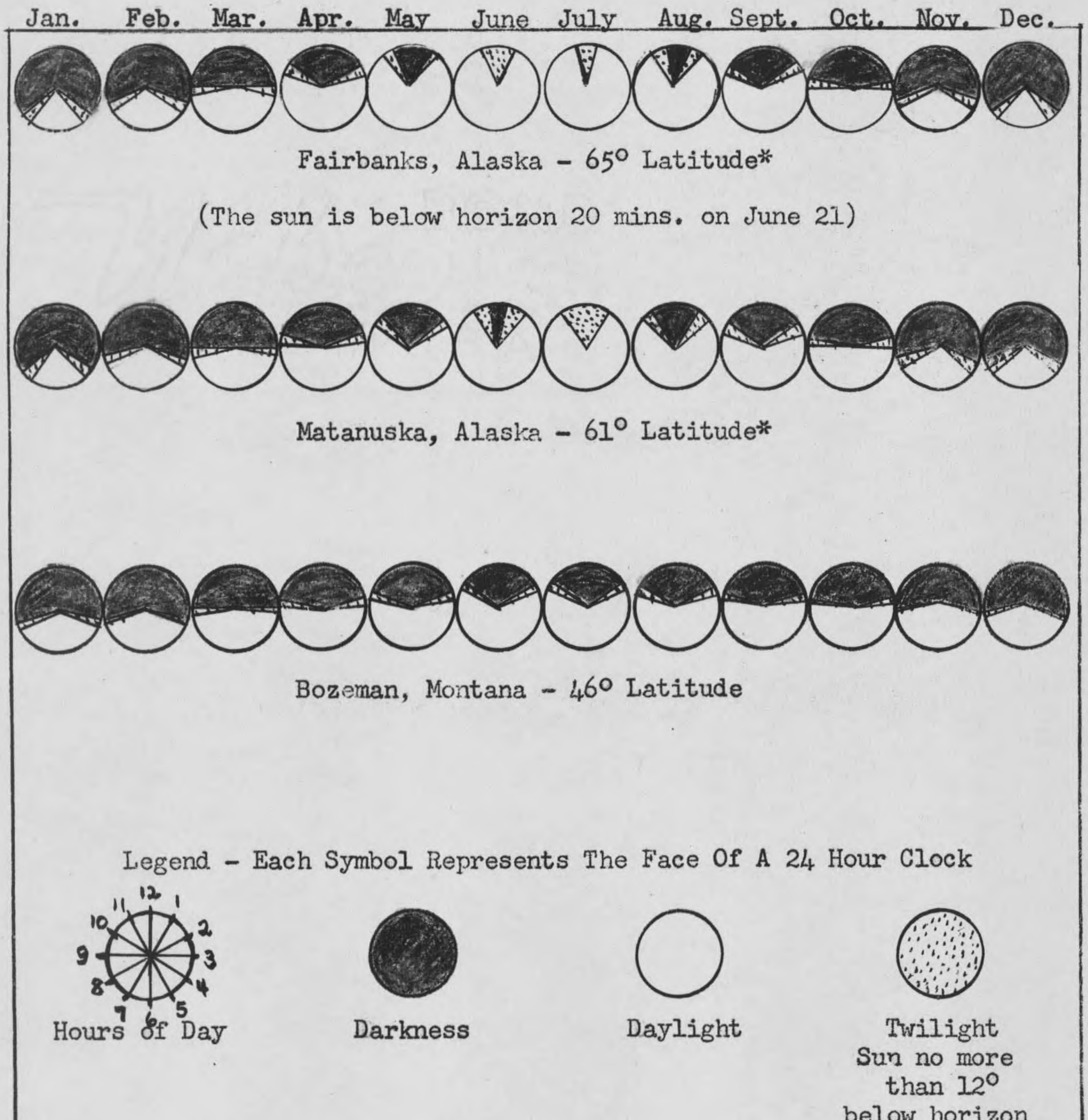
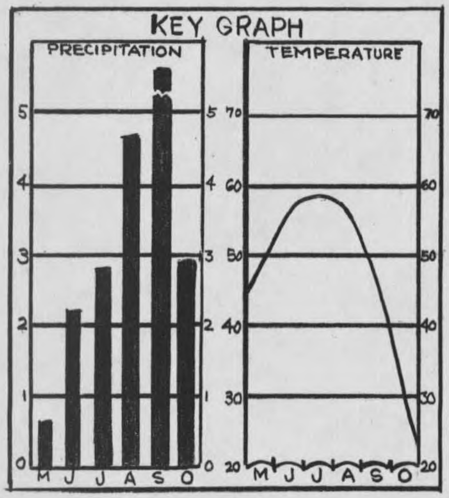


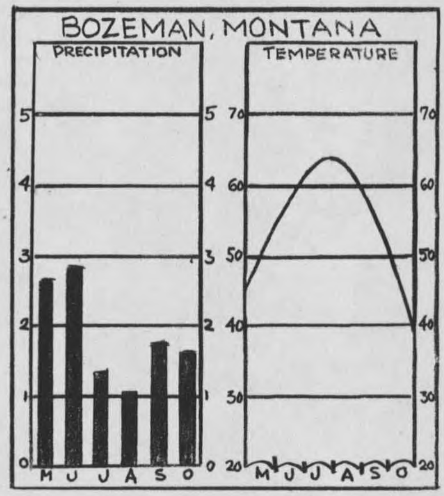
DARKNESS, TWILIGHT AND DAYLIGHT ON THE FIRST DAY OF EACH MONTH AT FAIRBANKS, MATANUSKA AND BOZEMAN

figure 4

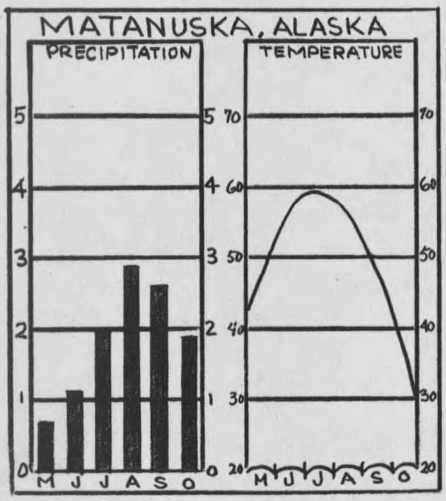


Vertical columns denote monthly precipitation- May through October (in inches)

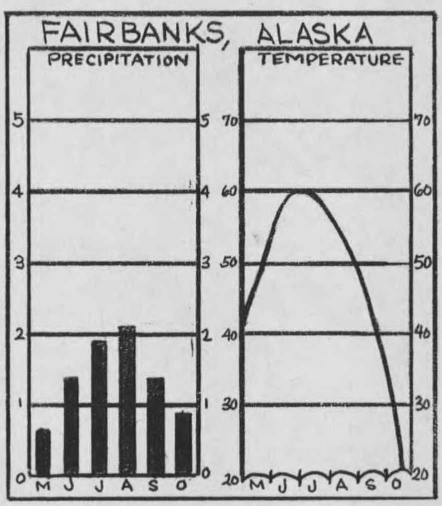
Curve shows normal monthly mean Temp. May through Oct. (in degrees F.)



Elevation --- 4895 ft.
Growing season (frost free) 115 days
Average last 32° Temp. in Spring - May 24
Average last 32° Temp. in Fall - Sept. 16



Elevation --- 152 ft.
Growing season (frost free) -- 108 days
Average last 32° Temp. in Spring - May 26
Average last 32° Temp. in Fall - Sept. 11



Elevation --- 440 ft.
Growing season (frost free) 96 days
Average last 32° Temp. in Spring - May 24
Average last 32° Temp. in Fall - Aug. 28

CLIMATIC DATA FOR BOZEMAN, FAIRBANKS AND MATANUSKA
FIGURE - 5