Title: A METHOD OF FORMING TURF IN THE SEMIARID STEPPE OF SOUTHERN KAZAKHSTAN (USSR-Kazakh SSR) by V. Ye. Kazakov

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A METHOD OF FORMING TURF IN THE SEMIARID STEPPE OF SOUTHERN KAZAKHSTAN

V. Ye. Kazakov

The sowing of Gramineae-Leguminosae grass mixtures forms the basis of the grass-field rotation system and (helps) solve~~s~~ two fundamental problems of agricultural production: 1) Progressive improvement of soil fertility, and 2) Increase in livestock production.

The turf created by growing Gramineae-Leguminosae perennial grasses is a principal factor in the progressive improvement of soil fertility. By turf (travyanoy plast) is meant the upper soil horizon which contains a large quantity of living and dead roots and the sprouts of vegetation. All these roots represent the basic material from which humus is formed as a result of the activity of anaerobic bacteria. It is perfectly clear that the greater this root mass in the soil ~~becomes~~, the more perfectly the turf will develop and the more fertile the soil will become.

Due to the singular climatic conditions which prevail in the semi~~desert~~arid-steppe zone, turf is usually not created either by nature itself in natural settings or by the growing of perennial grasses as now practiced.

According to the teaching of V. R. Vil'yams, the soil and its fertility are formed under the influence of biological processes which take place mainly as the result of the activity of vegetation and of macro- and microorganisms. All other factors of soil formation - climate, local relief, mother rock, and others - play their part in soil formation in relation to the manner in which they affect biological processes in the soil.

The entire soil formation process proceeds on the basis of internal conflicts, which are the motiv~~e~~ (driving) force for the continuity and noninterruption of the process. The main opposing soil formation processes are: 1) Formation and accumulation of organic matter, and 2) Disintegration and dispersion of organic matter.

Depending on external conditions such as the nature of the soil, its origin, local relief, and especially climate, either processes of organic matter formation and accumulation, together with which, under given conditions, soil structure is created and soil fertility progressively increases, or processes of organic matter disintegration and dispersion, together with which, soil structure is destroyed and soil fertility steadily declines, may predominate in the soil evolution process.

In the warm climate of the semi~~desert~~ arid steppe zone of southern Kazakhstan, processes of disintegration and dispersion of organic matter predominate over processes of ~~its~~ creation of organic matter. This phenomenon is observed not only on fields devoted to grain and industrial crops, but also on wasteland, and not infrequently on fields covered with perennial grasses under conditions of agricultural practice now in vogue.

Because of extremely unfavorable external environmental factors such as very high temperature, very low relative ~~moisture~~ humidity of the air, and very ~~small amount of~~ slight precipitation (especially in the summertime), steppe vegetation experiences a low degree of development, grass cover is usually very patchy, the sparsity of vegetation causes high soil temperatures, and evaporation of moisture from soil and vegetation is intense. The precipitation absorption capacity of ~~that kind of~~ this almost bare and, at the same time, very compact soil is extremely low. Under ~~such~~ these conditions, steppe grasses ~~struggle~~ have difficulty in ~~to~~ completing their life cycle ~~of~~, abbreviate their vegetative period (this results in a reduction of their above- and below-ground mass), and not infrequently dry up early in summer. The small mass of roots developed by the sparsely-standing and poorly-developed plants quickly mineralizes under aerobic conditions and there is no increase in the humus content of the soil. Even though soil has lain idle as wasteland or fallow for a long time, grass cover does not develop nor does the structure of the soil improve to any noticeable degree. There is a slight improvement in the amount of mineral feeding elements, but this is due in some degree to ~~that technicality which~~ factors operat~~es~~ing in nature when the soil ~~"rests"~~ lies idle.

Almost the same thing happens when fields are planted to perennial grasses under conditions of agricultural practice now in effect. Present practice does not call for the sowing of grass mixtures but for the sowing of one kind of leguminous grass; the seed sowing rate is so low that an extremely sparse stand of grass results. All current agricultural regulations recommend the sowing of 10-12 kilograms of alfalfa seed per hectare on fields where irrigation is practiced and 5-7 kilograms on fields where dry farming is carried on. At these rates, not more than 4-4.5 million germinated seeds are sown on a hectare of irrigated land and only about two million on a hectare of dry-farmed land. But since field germination of perennial grass seeds is low, the number of plants sprouting is about half as great as the number of seeds sown and the stand obtained is very sparse. The sparsity of the stand results in the following consequences: when sown without a cover crop, the grasses yield hardly any hay at all during the first year and are very weed-infested; when sown under a grain cover crop on irrigated land, the grasses are sharply decimated by interspecies competition; and when similarly sown on dry-farmed land they are killed almost completely. In succeeding years, the stand continues to decline, becomes more weed-infested, and little hay is obtained - and that of low quality. As a result of the sparse stand, the soil is not enriched with any appreciable quantity of roots; ~~these~~ the roots are only loosely

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interlaced; and no turf is formed. Soil covered by sparse grass stand is not conditioned for absorbing the maximum possible amount of water. ~~with the result that~~ Consequently it heats up under the sun's scorching rays and the water is quickly evaporated. In the absence of turf, atmospheric oxygen freely penetrates the soil and the roots present in small quantity are fully mineralized. Thus, there will be no appreciable humus accumulation in the soil even two to three years after grass ~~was sown.~~ has been sown.

Concerning the accumulation of root masses in the soil, V. R. Vil'yams wrote: "It must be remembered that the main missions of a grass field are the accumulation in the soil of as large a quantity of organic matter as possible and at the same time as wide a distribution of the organic matter in the soil as possible. Both missions are accomplished by the roots of perennial grasses: they simultaneously break up the soil and consolidate it. Thus far, it has not been possible to find a substitute for this service performed by roots."

Creation of turf and basic improvement of soil fertility in semi~~desert~~ arid steppe zones is possible only if by some means the processes of organic matter disintegration and dispersion are weakened and the processes of organic matter formation and accumulation are strengthened. Such a means is the creation of a heavy and thick vegetative cover by sowing Gramineae-Leguminosae grass mixtures.

Only a heavy and thick vegetative cover can ~~in short order~~ mat the soil, create high-quality turf, enrich the soil with a large quantity of organic matter, create stable soil structure, and assure a large, high-quality hay harvest from the very first year after grasses have been sown.

The thicker the stand of Gramineae-Leguminosae grasses on a field, the more quickly the soil will be enriched and a change in the climate take place. In experiments carried out on piedmont chestnut soils (underlain with gravel near the surface), on light chestnut carbonated soils in the semi~~desert~~ arid zone, and on sierozem soils in the desert zone of Alma-Ata Oblast, a thick vegetative cover of Gramineae-Leguminosae grasses (created by increasing the amount of seed sown) ~~and by more or less even sowing of seed on the fields)~~ always showed a great effect on all environmental conditions of the fields, particularly on soil temperature, air moisture near the ground, and on soil moisture. For example, in experiments conducted on piedmont chestnut soils when the heavy vegetative cover of Gramineae-Leguminosae grasses was two years old, surface soil temperature at 1300 hours in June, July, and August was 20 percent (7-10 degrees) lower and relative moisture of the air near the earth was 25 percent higher than when the vegetative cover was sparse (See Figure 1).

At the same time, soil moisture in the 0-70 centimeter deep layer was greater under a thick than under a sparse stand. The excess moisture under the thick stand amounted to 3-4 percent of the weight of the dry soil (See Figure 2).

It is perfectly clear that when perennial grasses form a heavy vegetative cover, they create for themselves favorable conditions for survival by moderating the harmful effect of a hot climate. The heavy grass stands of the experiments not only did not "burn up" but grew considerably better than did grasses in sparse stands. Grasses in sparse stands do not put up a fight against the heat in the air with the result that the scorching heat penetrates the soil.

By retarding heating of the soil, thick vegetative cover reduces evaporation of moisture in the soil and therefore the soil (shielded by such cover) is more easily able to absorb moisture and conserve it for growth purposes. This proposition was propounded by V. V. Dokuchayev, A. A. Izmail'skiy, as well as by V. R. Vil'yams

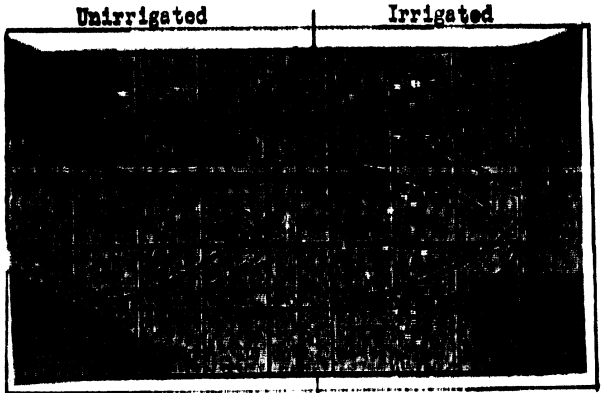

Figure 1. Effect of Thickness of Perennial Grass Stand on Soil Temperature and Relative Air Moisture Near the Surface of the Soil, 1300 Hours, Second Year after Seeding (Kazakhstan Agricultural Institute, 1947)

1. Soil temperature and air moisture on fallow
2. Same, under sparse stand of grass (29 centimeters)
3. Same, under average stand of grass (9 centimeters)
4. Same, under thick stand of grass (4 centimeters)

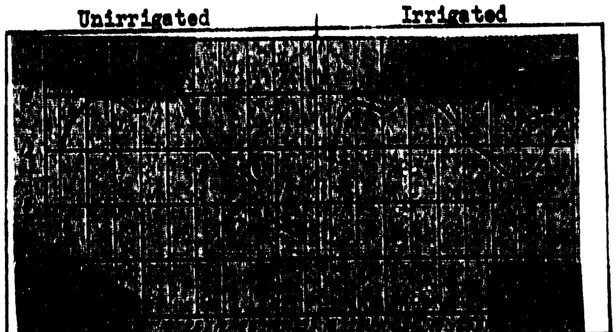

Figure 2. Effect of Thickness of Perennial Grass Stand on Soil Moisture, Second Year after Seeding (Kazakhstan Agricultural Institute)

1. Moisture under sparse stand
2. Moisture under average stand
3. Moisture under thick stand

in his celebrated study of the turf period in the soil formation process.

Soil microorganisms increase considerably when organic matter is plentiful. And with a thicker stand of Gramineae-Leguminosae grasses there is an increase of organic matter - in the form of living and dead roots.

For example, in experiments on unirrigated piedmont chestnut soils, three years after being seeded, sparse stands had accumulated 43.8 centners of dry root matter per hectare while thick stands had accumulated 94.2 centners in the 0-20 centimeter deep soil layer. Under irrigation, sparse stands accumulated 110.7, thick stands 217.9 centners per hectare in the 0-30 centimeter deep soil layer. Other details are shown in Table 1.

Table 1. Root Accumulation by Sparse and Thick Grass Stands on Piedmont Chestnut Soils Underlain with Gravel (Grass Mixture Consisted of Alfalfa (Medicago sativa), Crested Wheat Grass (Agropyron cristatum), and Couch Grass (Agropyron repens)

Seeding Rate per Hectare		Unirrigated: Dry Roots in 0-20 cm Layer (centners per ha)			Irrigated: Dry Roots in 0-30 cm Layer (centners per ha)		
Millions of Germinated Seeds	Kilograms, with 100% Germination	1946*	1947*	1948*	1946*	1947*	1948*
3.47	8.3	19.7	24.1	43.8	21.7	40.3	110.7
5.24	12.9	21.3	30.0	59.5	23.2	62.1	187.3
10.87	26.5	24.8	56.1	83.3	25.1	70.0	217.9
17.54	43.1	28.8	59.3	82.3	34.2	79.0	199.7
26.32	65.1	34.0	63.1	87.0	34.6	111.3	217.4
34.50	85.9	38.3	73.6	94.2	43.5	106.2	170.3

* 1946: first year after seeding; 1947: second year after seeding; 1948: third year after seeding.

In experiments on unirrigated sierozem soils, two years after seeded sparse stands had accumulated 83.1 centners of roots per hectare; thick stands 110.5 centners in the 0-30 centimeter deep soil layer. Under irrigation, sparse stands had accumulated 58-65 centners; thick stands 70-88 centners per hectare in the same soil layer (See Table 2).

Table 2. Root Accumulation by Sparse and Thick Grass Stands on Sierozem Soils (Grass Mixture: 35 Percent Alfalfa, 65 Percent Crested Wheat Grass)

Seeding Rate per Hectare: Millions of Germinated Seeds	Seeding Rate per Hectare: Kilograms, with 100% Germination	Unirrigated and Unfertilized 1947*	Unirrigated and Unfertilized 1948*	Unirrigated but Fertilized with NPK 1947*	Unirrigated but Fertilized with NPK 1948*	Irrigated but Unfertilized 1947*	Irrigated but Unfertilized 1948*	Irrigated and Fertilized with NPK 1947*	Irrigated and Fertilized with NPK 1948*
		Roots in 0-30 Centimeter Layer (centners per hectare)							
3.33	6.3	63.0	83.1	55.8	88.8	74.6	58.6	58.9	65.3
4.96	10.1	74.3	104.1	64.7	103.2	89.1	61.5	96.9	72.5
9.92	20.2	84.8	110.5	73.8	106.1	95.3	65.3	102.2	88.6
19.84	40.4	88.2	106.1	59.2	98.6	102.4	70.0	96.6	84.3

*1947: first year after seeding; 1948: second year after seeding.

It is striking that the amount of root matter accumulated by the grass on irrigated sierozem soils two years after seeding not only was not greater but was considerably less than the amount accumulated after one year of life. ~~The reason for~~ this result was due apparently to the fact that 1948 was a very dry and hot year and that irrigation created conditions in the soil which promoted deterioration of root matter. Future experiments will permit a closer determination of the causes of this phenomenon.

A very important fact connected with root development by varyingly thick grass stands must be mentioned. Experiments indicated that as the stand becomes thicker the percentage of fine roots increases - an important factor in soil structure development. Table 3 gives the data.

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3.33	6.3	63.0	83.1	55.8	88.8	74.6	58.6	58.9	65.3
4.96	10.1	74.3	104.1	64.7	103.2	89.1	61.5	96.9	72.5
9.92	20.2	84.8	110.5	73.8	106.1	95.3	65.3	102.2	88.6
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Table 3. The Nature of Perennial Grass Root Systems in Relation to Thickness of Stand (Percentage of Fine Roots Less than One Millimeter in Diameter)

Composition of Mixture	On Piedmont Chestnut Soils (3-year-old grass)					On Sierozem Soils (2-year-old grass)				
	Seeding Rate (Millions of Germinated Seeds per ha)	Unirrigated		Irrigated		Seeding Rate (Millions of Germinated Seeds per ha)	Unirrigated		Irrigated	
		0-20 cm	20-46 cm	0-20 cm	20-46 cm		0-20 cm	20-46 cm	0-20 cm	20-46 cm
Alfalfa and Crested Wheat Grass	3.47	22.3	20.3	21.4	6.2	3.33	43.8	56.5	43.3	43.5
Same	10.87	24.2	21.2	24.6	16.5	9.92	62.8	59.0	55.0	54.0
Same	34.50	26.9	23.1	26.7	18.0	19.84	66.8	72.0	65.0	53.5

The accumulation by a thick grass stand of large amounts of roots, which serve to create good turf, leads to a considerable increase in the amount of humus in the soil. Data concerning humus accumulation in chestnut soils are shown in Table 4.

Table 4. Effect of the Thickness of a Grass Stand on Humus Accumulation in Irrigated Piedmont Chestnut Soils (Grass is Three Years Old)

Seeding Rate per ha		Humus in Absolutely Dry Soil in Layers Indicated (%)				Percent
Millions of Germinated Seeds	Kilograms, with 100% Germination	0-10 cm	10-20 cm	20-30 cm	0-30 cm	
3.47	8.3	2.07	2.03	1.37	1.82	100
10.87	26.5	2.59	2.31	1.81	2.24	123
34.50	85.9	2.17	2.28	1.50	1.98	109

Table 4 shows that the greatest increase in the most valuable component of soil - humus - takes place during the third year after seeding when grass mixtures are sown at the rate of 10.87 million germinated seeds per hectare. In this connection, it should be noted that the sharp increase in humus content occurs only when the grass has become three years old; it was not detected under two-year-old grasses either in chestnut or sierozem soils. It is believed that during the first two years of the life of grasses, only the prerequisites for humic matter accumulation are created in the soil.

It should also be noted that when the stand is very thick, as when 34.5 million germinated seeds were sown per hectare, considerably less root matter accumulated in the soil than when the optimum number was sown. As a result, humus content in the soil under this very thick stand was little more than under the sparse stand.

While the question of establishing soil fertility through grass stands of varying thickness was being investigated, the matter of the effect of turf on the wheat harvest was dealt with. In late fall 1947, land on which grass had grown for two years was plowed and in spring 1948, both hard and soft wheat were sown on it. Table 5 shows the results.

Table 5. Spring Wheat Harvest (Centners per Hectare) on Land on Which Grass Had Grown for Two Years. Soil: Piedmont Chestnut, Underlain with Gravel.

Grass Seeding Rates per hectare: Millions of Germinated Seeds	Grass Seeding Rates per hectare: Kilograms, with 100% Germination	Unirrigated, Type Eritrospermum 0841: Harvest	Unirrigated, Type Eritrospermum 0841: %	Unirrigated, Type Gordeiforme 0189: Harvest	Unirrigated, Type Gordeiforme 0189: %	Irrigated, Type Gordeiforme 0189: Harvest	Irrigated, Type Gordeiforme 0189: %
3.47	8.3	11.8	100	6.4	100	10.5	100
5.24	12.9	13.7	116	7.4	116	11.3	108
10.87	26.5	16.3	138	9.1	141	12.1	115
17.54	43.1	14.5	123	9.4	147	14.5	138
26.32	65.1	13.5	114	8.0	125	14.3	136
34.50	85.9	11.2	94	8.2	128	13.0	124

Note: for several reasons beyond control of the ~~writer~~ author, irrigated wheat in this experiment was irrigated only once. The single irrigation was clearly insufficient and led to comparatively small harvests.

It is apparent from Table 5 that the harvest obtained in 1948 from land on which a thick stand of grass had stood was 38-47 percent greater than the harvest received from land which had been occupied by a thin stand of grass. The harvest yielded by land on which an excessively thick stand of grass had grown was smaller than the harvest from land occupied by the optimum stand. Comparison of these harvest data with root accumulation data reveals a direct relation between root accumulation and harvest.

Experiments have shown that the size as well as the quality of the hay harvest increases with the thickness of the stand (up to a definite limit). For example, in experiments on unirrigated piedmont chestnut soils underlain with gravel, sparse grass mixture stands, three years after being seeded, yielded a hay harvest of 78.4 centners (together with weeds, which had grown freely and occupied every bare spot), while thick stands yielded a weed-free hay harvest of 114.0 centners per hectare. Corresponding hay harvest figures from irrigated land were 144.3 and 208.8 centners per hectare. Hay harvest data are shown in Table 6.

On sierozem soils (Table 7), sparse unirrigated and unfertilized stands yielded a 2-year harvest of 43.9 centners of very weedy hay per hectare while thick stands yielded 55.4 centners of very clean hay. Sparse unirrigated but NPK-fertilized stands yielded 70.0 centners, thick stands yielded 96.7 centners of high-quality hay. Sparse, irrigated but unfertilized, stands yielded a 2-year harvest of 77.7 centners, thick stands 112.7 centners per hectare. Sparse irrigated and NPK-fertilized stands yielded a 2-year harvest of 135.3 centners, thick stands 182.4 centners per

Table 6. Hay Harvest (Centners per Hectare) from Varyingly Thick Grass Stands on Piedmont Chestnut Soils Underlain with Gravel (Grass Mixture: Alfalfa, Crested Wheat Grass, and Quack Grass)

Seed Sowing Rate per ha		Unirrigated						Irrigated					
		1946*			1947*	1948*	Three-year Harvest	1946*			1947*	1948*	Three-year Harvest
Millions of Germinated Seeds	Kilograms, with 100% Germination	Total Weight	Including Clean Hay	Including Weeds	Hay from 2 Cuttings	Hay from 1 Cutting		Total Weight	Including Clean Hay	Including Weeds	Hay from 3 Cuttings	Hay from 3 Cuttings	
3.47	8.3	13.6	3.6	10.0	36.5	23.3	78.4	17.0	5.6	11.4	48.5	78.8	144.3
5.24	12.9	12.4	5.9	6.5	40.1	32.6	85.1	17.4	9.0	8.1	55.4	101.2	174.0
10.87	26.5	11.9	5.8	6.1	48.2	38.4	98.5	17.4	10.1	7.3	60.0	131.4	208.8
17.54	43.1	10.8	6.1	4.7	52.6	36.9	100.3	18.8	12.7	6.1	66.3	113.6	198.7
26.52	65.1	12.9	7.3	5.6	61.4	39.7	114.0	20.1	15.4	4.7	67.1	102.6	189.8
34.50	85.9	11.5	8.7	2.8	48.1	38.8	98.4	18.3	15.4	2.9	68.6	108.3	195.2

* 1946: first year after seeding; 1947: second year after seeding; 1948: third year after seeding.

Table 7. Hay Harvest (Centners per Hectare) from Varyingly Thick Grass Stands on Sierozem Soils (Grass Mixture: 35% Alfalfa and 65% Crested Wheat Grass)

Seed Sowing Rate per ha		Unirrigated and Unfertilized					Unirrigated but Fertilized with NPK					Irrigated but Unfertilized					Irrigated and Fertilized with NPK				
		1947*			1948*	Two-year Harvest	1947*			1948*	Two-year Harvest	1947*			1948*	Two-year Harvest	1947*			1948*	Two-year Harvest
Millions of Germinated Seeds	Kilograms, with 100% Germination	Total Weight (1 cutting)	Including (%) Clean Hay	Including (%) Weeds	Hay (2 Cuttings		Total Weight (1 cutting)	Including (%) Clean Hay	Including (%) Weeds	Hay (2 Cuttings)		Total Weight (2 cuttings)	Including (%) Clean Hay	Including (%) Weeds	Hay (2 Cuttings)		Total Weight (2 cuttings)	Including (%) Clean Hay	Including (%) Weeds	Hay (3 Cuttings	
3.33	6.3	17.5	23	77	26.4	43.9	30.9	24	76	39.1	70.0	33.8	30	70	43.9	77.7	47.9	24	76	87.4	135.3
4.96	10.1	21.5	32	68	29.8	51.3	37.0	32	68	44.9	81.9	45.4	35	65	53.0	98.4	59.5	34	66	104.8	164.3
9.92	20.2	24.2	43	57	31.2	55.4	45.7	43	57	47.5	93.2	51.9	44	56	57.4	109.3	65.9	40	60	116.5	182.4
19.84	40.4	26.2	64	36	28.1	54.3	48.8	60	40	47.9	96.7	57.7	58	42	55.0	112.7	60.9	60	40	91.2	152.1

* 1947: first year after seeding; 1948: second year after seeding.

hectare. Additional details about hay harvests produced experimentally on sierozem soils are shown in Table 7.

It must be pointed out that all sparse stands yielded very weedy hay while thick stands yielded clean, high-quality hay. The ratio of leaves to stalks in thick stands was either equal to or greater than that in sparse stands.

As can be seen from Tables 6 and 7, one cutting of hay was obtained during the first year (after seeding) ~~(from all~~ unirrigated stands, two cuttings from irrigated stands. The hay harvest (from thick stands) ~~during the first year~~ was as great as 20-35 centners per hectare without irrigation; up to 49 centners without irrigation but with fertilization; up to 58 centners with irrigation but without fertilization; and up to 66 centners per hectare with both irrigation and fertilization. While mineral fertilizers used in connection with perennial grasses ~~sharply~~ greatly increased the hay harvest, they caused hardly any increase in the root mass in the soil.

When grass seed is sown either straight or in mixture, an optimum thick stand for one year is obtained in most cases by sowing about 20-25 million germinated seeds per hectare; for two years by sowing 15-17 million seeds; for three years by sowing 11-12 million seeds. For the southern part of Kazakhstan, then, it is ideal to sow 11-12 million germinated seeds on unirrigated land; 10-11 million on irrigated. When the mixture consists of alfalfa and crested wheat grass, this amounts to from 23 to 25 kilograms per hectare with 100 percent germination of the seeds.

These grass-mixture sowing rates are also recommended as practical for kolkhozes and sovkhozes in the southern part of the Kazakh republic.

Chair of General Agriculture,

Kazakh Agricultural Institute,

Alma-Ata

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