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SNOW COVER IN THE SIBERIAN FOREST-STEPPE

I. V. Zykov

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16. Abstract

A study is made of the snow cover on an experimental agricultural station in Mariinsk in the winter of 1945-1946. Conditions of snow cover formation, and types and indicators of snow cover are discussed. Snow cover structure and conditions and nature of thawing are described.

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SNOW COVER IN THE SIBERIAN FOREST-STEPPE /375*

I. V. Zykov

1. General Remarks

The snow cover in the Siberian forest-steppe has a diverse, and for individual sectors of farming (perennial grasses, winter crops) decisive vital value. One can say without exaggeration that in the harsh Siberian climate, the harvest of fields, expansion of the species composition of crops, bacterial life of the soil, reserve of soil moisture in the spring are directly related to the condition of the snow cover, the time of its formation and thawing, etc.

It is important for practical problems of farming to trace the natural situation in which the most favorable snow cover is formed and which methods of snow accumulation are the most efficient where there is little snow.

We studied the snow cover on an experimental agricultural station in Mariinsk, whose physical and geographic conditions are characteristic for the West Siberian forest-steppe.

The relief of the territory here is slightly wavy, a considerable part is steppe and plowed. However on the open locality, there are small groves, usually with bushes. There are individual sections with grassy vegetation mainly cereals and wormwood. Here the plowed and completely open fields of varying size extend from 300 to 2000 m which allowed us to trace the formation of the snow cover depending on the magnitude of sections with general equal conditions.

Various types of territory and farming lands were observed.

A detailed study was made of the snow cover in the winter of 1945 - 1946. It should be said that qualitative and comparative

*Numbers in margin indicate pagination in original foreign text.

indicators of one year will be characteristic for other years, which we became convinced of by comparing the previous observations. There could only be a difference in the quantity of solid atmospheric precipitation. The correlations of different types of snow covers essentially were uniform.

2. Conditions of Snow Cover Formation /376

The features of snow cover formation in the described territory are determined by two factors: very limited quantity of atmospheric precipitation in winter and the presence of strong winds in winter which blow the snow into gulleys and groves. As a result of the combination of these two phenomena, the snow cover of open localities, especially those devoid of surface vegetation is very unstable, and snow distribution on the surface is very nonuniform.

We will cite quantitative indicators governing the height, degree of stability of the snow cover and its condition under natural forest-steppe conditions. The average period for beginning of winter in this region (daily average stable temperatures below 0°) is 24 October, the end 11 April, with winter lasting 170 days. The quantity of atmospheric precipitation averages for the last 15 years (in mm) 28 in November, 12 in December, 9 in January, 6 in February, 8 in March, and a total of 63 mm for the winter months which is 16% of the average annual sum of precipitation (387 mm). In the winter of 1945 - 1946, the numbers are respectively the following: 20, 10, 13, 3, 4, i.e., totalling 50 mm, with average total for 1945 of 453 mm. The limited quantity of winter precipitation determines the low snow cover. The greatest average height of the snow cover on the closed section by the beginning of thawing is usually 50 cm with density 0.23.

Strong stable winds of westerly and southwesterly direction are inherent to the described territory of the forest-steppe. We noted velocities up to 30 m/sec. Prolonged winds with velocity $\geq$ 10 m/sec are very frequent. They sometimes blow for several days. We noticed that as soon as the wind velocity exceeded 10 m/sec, and especially 15 m/sec, dust storms began in the open places in the summer, and in winter snow was completely removed from the surface without grassy vegetation or stubble. After the snow is removed on sections with loose soil, dust storms begin, i.e., pronounced wind erosion is observed.

In 1945 - 1946, even from average observations, there were days with winds greater than 10 m/sec: 10 in November, 4 in December, 15 in January, 7 in February, 10 in March, and 12 in April. There were respectively 4, 0, 4, 3, 6 and 7 with wind greater than 15 m/sec. We have repeatedly noted that on exposed localities, the freshly fallen snow usually only lies for several days. As soon as strong winds begin, the snow disappears from the fields and they become bare. During winter, the wide space of the field is exposed of snow cover several times, therefore we cannot speak of snow cover as a constant quantity in this case.

Snow is nonuniform even on a very limited territory because of winds. In the latter case, surface vegetation and local relief influence the formation of the snow cover. The microrelief under field conditions has special value; we have been convinced in experimental plantings of how with other conditions equal the elevated localities /377 of the microrelief (crests with elevation in 1 ha by 40 - 80 cm) were places with winter crops.

3. Types and Indicators of Snow Cover

Observations of the snow cover were made from types of terrestrial vegetation and different forms of artificial snow retention.

The following were observed: for forest vegetation--garden with protective band (control), exposed garden characterizing a thinned out forest, grove with dense vegetation made of bushes and trees (birch, aspen); for steppe vegetation--sections with wormwood and grasses; different types of field--exposed section of winter wheat, section with stubble, perennial grass fields (lucerne, sainfoin), strips made of sunflowers, continuous planting of sunflowers; of the snow retention forms--vertical sheafs arranged in checkerboard order every 5 - 8 m, banks made of haystacks 80 cm high 8 m apart from each other, penetratable shields, snow piles, scattered brushwood, etc. The results of decade snow surveys are presented in Table 1.

TABLE 1.

	December			January			February			March			Last day of stable snow cover
	1	2	3	1	2	3	1	2	3	1	2	3	
1. Garden (control)	20	23	33	40	43	43	45	42	48	47	45	15	7/IV
2. Grove	54	83	109	122	148	160	187	175	193	205	200	175	22/IV
3. Open garden	8	12	20	19	20	23	24	18	19	19	12	—	28/III
4. Air hole	20	22	35	43	49	52	55	50	54	55	50	15	6/IV
5. Windbreaks	18	18	28	29	24	24	29	27	29	31	28	—	29/III
6. Sunflower plowed field	21	27	33	37	37	41	44	42	47	47	44	12	4/IV
7. Fallow	5	5	14	14	14	17	9	5	8	8	5	—	24/III
8. Oat stubble field	15	16	26	20	19	19	18	12	19	17	16	—	26/III
9. Open winter crops	1	3	5	0	0	6	2	0	4	2	1	—	22/III
10. Winter wheat on stubble	14	16	20	16	17	19	21	16	20	21	20	—	26/III
11. Sheafs	No observ.			11	12	16	16	10	16	16	8	—	29/III
12. Hay (stacks)	No observ.			18	25	25	27	22	26	28	20	6	2/IV
13. Sown grasses	16	16	24	24	24	24	24	18	20	21	16	—	27/III

4. Snow Cover Structure /378

The snow cover structure is generally compact, while the structure of the snow particles is broken up and powdery. The snow cover in appearance is similar to unstructured, finely powdered podzolic soil. The main reason for this condition of the snow cover is the influence of constant strong winds. The fallen snow is quiescent for no more than 2 - 3 days. It then begins to be transferred from p'ace to place by the winds, ground down into snowy dust, i.e., loses its initial shape and lies near dense obstacles; usually snow drifts are near fences, in gulleys, and in the groves they are so dense that they withstand the weight of man. Snow on the open forest steppe localities is similar to sand dunes.

The second reason for the compacted state of the snow cover is the presence of thawing in winter. According to multiple-year indicators, the absolute maximum for the winter period is:

October	23.1
November	11.3
December	2.5
January	1.5
February	5.0
March	11.0
April	24.0

During each winter month, there could be a positive temperature. This is observed less often only in January. Sometimes thaws occur several days continuously which strongly compacts the snow cover, and on the exposed areas where there is little snow, thawed patches appear in February and March.

A considerable quantity of dust falling into the snow cover creates increase in density. As already noted, on the field spaces that are exposed to the winds, plowed for fall fields or with lost crops harvested in fall, if there is no snow retention on these sections, the snow cover is not retained and there is strong destruction of the upper soil layer.

Soil particles are removed together with the snow by winds and are deposited on the snow cover in entire layers. A cross section

of the snow cover on a field with sunflower stubble:
0 - 17 cm[1]--pure snow; 18 - 24 cm--ice crust with considerable admixture of earth particles, the snow has a dirty appearance; 25 - 36 cm--snow layer with considerable admixture of earth dust, variegated color of the layer; 37 - 45 cm--pure snow; 46 - 48 cm--ice crust; 49 - 50 cm--snow of loose structure with earth dust particles.

Snow drifts in groves, in wind break strips and under snow-retention shields, on stubble fields, and in hollows of exposed areas have a similar composition.

The earth dust in the latter case even dominates, forming small dune-shaped accumulations. In the examples of hollows, we were convinced how the winds level the earth's surface: in some cases, even now one can define the boundaries of the hollows which are still very shallow, but at one time considerable in size and depth. Snow cover /379 without admixture of dirt and with normal particle structure is only noted in a garden which in addition to dense vegetation, has a protective band of trees on the side of the dominant winds of the western quarter.

5. Conditions and Nature of Thawing

The snow cover of our forest-steppe was characterized by rapid thawing in spring. The snow cover on some sections is removed at different times; as is apparent from the aforementioned table, the difference in the thawing times between the exposed section without snow retention and the grove is an entire month (22 March and 22 April). Specific features of the Siberian forest-steppe, strong winds and contamination of the snow cover with dirt particles, accelerate thawing which becomes very intensive on exposed field areas.

As an illustration we will present Tables 2 and 3 with indicators

[1]Counting from the surface of the ground. Measurement on 20 March.

of the weather elements and thawing processes in the second half of March and the first half of April.

As is apparent from the table, it is sufficient to have one day with daily average positive air temperature for the snow cover mainly to thaw on the winter crops; only individual plots of field remain with cover of 3 - 4 cm which on another day also completely thawed. Subsequent days of daily average air temperature were below 0°, but the diurnal positive maximum determined the rapid thawing on other sections.

The field sections were freed of snow cover generally by the end of March. More time was required to thaw the snow cover of other types. Moreover, there was a return of cold days and fairly abundant snow fell again. We will give the weather index for the first half of April (Table 3).

The role of winds should be particularly stressed in evaluating the process of thawing. They areborne from the dry steppes of Kazakhstan, providing air with reduced moisture content. The relative average air humidity of April is 50 - 60%, with minimum (from observations at 13:00) to 25%. The stream of dry and warm air of the forest steppe sometimes provides a very rapid transition of snow to the gaseous state (vapor).

6. Reserves and Assimilation of Snow Melt Water

The remarkable Russian climatologist A. I. Voyeykov concentrated on the great climatological importance of the snow cover.

The snow cover is very important in the water balance of the forest steppe. The landscape change in the forest steppe is considerably pronounced today. This situation possibly developed as a result of the onset of the steppe onto the forest, i.e., natural displacement. At the same time considerable territories were worked for agricultural /381 crops. The open, exposed spaces generally are expanding. This situation naturally changes the climate. This is expressed as an increase in thermal energy and the climate of the near-earth air layer, decrease in the quantity of atmospheric precipitation, increase in the coefficient of evaporation, and changes in the distribution of the snow cover. As a consequence of change (dessication) of the climate and its elements, there is a decrease, and even dessication of the natural and artificial reservoirs in the Siberian forest steppe. One could cite a number of examples that we observed in the Kii River basin: thus, the Alchedat stream dried up (Chebulinskiy region) which back in 1939 was on the map. Near Marinsk, a vast swamp dried up on which back in the 1920's, migratory water fowl stopped. In the vicinity of the city, small streams dried up whose traces remained in the form of hollows and chains of groves predominantly made of willow bushes. Near Ivanovok (Chebulinskiy region) lakes dried up that back in 1938 were reservoirs, although small; now they are dry peat bogs. The ponds are drying up.

TABLE 2. WEATHER INDICATORS IN THE SECOND HALF OF MARCH OF 1946

Date / Phenomena	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
daily average t° air	−10,3	−10,6	−12,5	−8,9	−6,2	−7,2	−7,0	+0,1	+0,8	−0,8	+0,1	−5,8	−6,5	+0,7	+0,4	−0,8	−1,0
Minimum	−10,3	−12,6	−18,5	−15,0	−8,5	−8,7	−12,7	−2,5	−4,4	−4,0	−0,6	−8,5	−12,5	−2,5	−1,5	−2,5	−3,5
Maximum	−8,0	−7,6	−6,5	−4,7	−4,2	−4,2	−1,8	+2,0	5,5	1,2	2,2	1,5	1,5	2,5	3,5	1,5	2,0
Precip. type	•	•						⁚									
Precip. sum	0,4	1,4						0,9		0,1	0,1					0,1	0,3
other phenomen.	[illegible]			+				9	÷	7		8,10	13	3	5,11		
Last day stable snow cov. (see table 1)															-		

An important aspect of moisture accumulation for fields is retention on the fields of fallen snow, the use of different forms of snow accumulation on the catchment area of artificial reservoirs.

TABLE 3. WEATHER INDICATORS IN THE FIRST HALF OF APRIL OF 1946

Date / Phenomena	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Daily av.t° air	−1,2	−1,0	−0,6	1,6	−0,7	−0,8	0,0	−1,6	−2,6	−1,0	1,8	2,2	4,7	5,1	3,0
Minimum	−5,3	0,5	−2,5	−1,5	−1,0	−1,6	−2,3	−2,0	2,8	−4,5	−5,0	−4,5	− 0,5	2,5	−2,4
Maximum	0,0	3,0	4,0	5,5	0 0	1,2	4,0	3,0	5,0	2,5	4,0	8,3	11,2	8,5	9,0
Precip. types	⁚	⁚	⁚				•	•	⁚					•	
Precip. sum	0,7	2,4	3,9				1,8	0,8	1,0					4,7	
Other phenom.		12	+	+ 6		> 4	* 1	*	*						
Last day of stable snow cov.															

TABLE 4.

Type	Height (cm)	Density in %	Water quant. in T/ha	includ.% of control
Garden (control)	40	0,22	990	100,0
Windbreaks	28	0,25[1]	700	70.7
Sunflower	44	0,25[2]	1100	111,0
Fallow field	05	0,23	115	11,6
Sown grasses	16	0,24[3]	384	38,8
Oat stubble	16	0,23	368	37,2
Sheafs	10	0,27[4]	270	27,3
Snow-retaining banks	20	0,24	480	40,5
Winter crops without snow retention	0,1	0,23	23	2,3

[1]With measurement of snow density, 0.12 was subtracted for dust.
[2]0.05 for dust.
[3]0.04 for dust.
[4]0.04 for dust.

It is easy to see that artificial snow retention significantly improves the balance of snow melt water. We measured and calculated the snow melt water on the studied types of snow cover in the beginning of snow thawing (20 March). A very instructive pattern was obtained. Here are these data for 1 ha (measurements of snow cover density were made before the beginning of thawing) (Table 4).

As is apparent from the table, only the continuous planting of sunflowers yielded an exceeding above the control (garden-forest). The negligible reserve of snow melt water on an open field section (winter crops on fallow land without snow retention) is graphically seen. It is also seen that snow and snow melt water are considerably accumulated in the groves which are dish-shaped, usually closed low areas, and basins in the local relief. /382

One should also note that the coefficient of absorption of this moisture by the soil is very low. With a small snow cover, the thawed moisture evaporates without reaching the soil, so that the upper soil layers remain fairly dry. This occurs, first, because of strong freezing of the soil with a thin snow cover and slow thawing of it, in which the soil because of its physical condition does not succeed in absorbing the snow melt water. Second, strong and dry southwesterly winds are an important factor.

It is quite natural to conclude that the most complete use of snow melt waters for agriculture primarily requires the formation of an optimal snow cover which will govern the lower freezing of the soils while simultaneously improving the snow melt water balance.

7. Snow Cover in the Life of Crops

The opinion exists that winter crops in the Siberian forest steppe are not stable because of an insufficient snow cover.

We can indicate a number of cases of freezing of the winter crops from a light snowfall. But we could also cite a sufficient number of examples where the crops hibernate successfully under a snow cover.

Minimum air temperatures in the Siberian forest steppe are extremely severe for winter crops. Here are the absolute minimum temperatures for a number of years for Marinsk:

January	-52.0
February	-42.9
March	-39.4
April	-28.2
May	-13.2
October	-28.9
November	-43.0
December	-48.4

At these temperatures, only a sufficient and timely snow cover could protect the winter plants from freezing.

It is a feature of the Siberian forest-steppe climate that snowfall in the beginning of winter is preceded by very low air temperatures; low temperatures equally occur after removal of the snow cover, as a result of which precipitation and freezing of the winter crops occur both in fall, and especially in spring. It is therefore essentially important to have a snow cover which is retained as long as possible in the spring. According to multiple-year data, a stable snow cover on protected sections was established on 25 October with amplitude from 10 October to 14 November. Negative daily average /383
air temperatures (beginning of winter) were the average for half of October. The descent of the snow cover on the protected sections on the average occurs in the middle of April with amplitude from 7 April to the beginning of May. The average period for the beginning of spring occurs on 12 April, however with mandatory return of the cold.

When there is a normal snow cover, there is no precipitation and freezing. Experiments with winter wheat with snow cover of 50 - 70 cm show that the plants hibernate completely satisfactorily. The experience of the Marinsk agricultural experimental station showed even more: winter wheat during the 1945 - 1946 winter on a fallow field completely died, there was no snow retention here, but on the stubble fields it was retained without considerable loss and yielded a harvest of 15 quintals per hectare. The height of the snow cover on the stubble field for the winter on the average was stable as 20 cm. Loss of wheat on the stubble field only occurred in one place on an elevated relief where the snow is blown off.

Here are several illustrations of the role of the snow cover during the 1945 - 1946 winter. According to spring tests for regeneration of the winter rye on a fallow field without snow retention there was 25% loss of the bushes, but on a stubble field only 2%. There was 34% death of the stalks on the fallow field and 5% on the stubble field. The harvest on the experimental plots for the fallow field was 8.1 quintals, for the stubble field 15.5 quintals per hectare.

Wild forms of red clover develop normally if there is only a snow cover 60 - 70 cm high, which I personally observed many times on the edges of groves and on meadows with sparse bushes.

It is true that the 1945 - 1946 winter on this territory of Siberia was generally milder than usual, as is apparent from Table 5.

Minimum temperatures in this winter were also somewhat higher than the absolute multiple-year. Thus, in October, the minimum temperature was -9.6° (multiple year -28.9°); in November -34.5° (-43.0°); December -38.0° (-48.4°); January -40.0° (-52.0°) and February 36.3° (-42.9°); March -29.2° (-39.4°); April -7.5° (-28.2°).

There could be considerable losses in winter with lower freezing temperatures.

8. Snow Cover and Soil Freezing /384

TABLE 5.

	October	November	December	January	February	March	April
Multiple-year...	1,8	—9,6	—16,5	—19,5	—16,1	— 9,5	+1,2
1945/46	4,7	—9,0	—18,4	—13,7	— 9,3	—10,6	+1,7
Deviation ...	+2,9	+0,6	— 1,9	+ 5,8	+ 6,8	— 1,1	+0,5

T. D. Lysenko in speaking about Siberia indicated the negative influence of deep freezing of the soil and low temperatures on the bacterial world and the soil microflora. This phenomenon reduces the period of intensive life of the soil.

Freezing of the soil (soil type degraded chernozem) with thin snow cover extends to depth 20 cm in the second 10 days of November, increases to 40 cm in the third 10 days of November, and reaches 80 cm in the first 10 days of December.

As shown by observations, on level relief with snow cover of 30 cm, soil freezes to 120 - 150 cm. On areas devoid of snow cover of elevated relief, the soil freezing reaches 200 cm. With snow cover of 100 cm, the frozen soil layer did not exceed 50 cm, and in the groves where the snow layer is 150 - 200 cm, the frozen layer only forms a small crust, and temperature on the soil surface under the snow does not drop below -1°.

The snow cover in limits of 100 cm of thickness thus will guarantee complete preservation of the hibernating crops.

9. Snow Cover and Wind Erosion of Soils

As noted above, on the forest-steppe territory, wind erosion of soils is observed even in winter. The latter is exclusively due to the nature and condition of the snow cover.

Fields with fall plowing, as well as those for plowed crops and previous sections for vegetables are exposed to wind erosion, generally loose soil which in winter is devoid of snow cover. Under the influence of low temperatures, the upper, more valuable particles of soil are diffused and they are easily removed by the wind. Strong winds together with the snow carry a mass of ground dust.

Wind erosion inflicts enormous damage on our fields, depriving them of valuable soil particles. If we assume that during the winter on elevated relief areas, up to 5 cm of the soil layer is removed, this is a loss of land of 600 T per hectare.

The harmful consequence of wind erosion is that the dispersed dust contaminates the snow cover, making it unstable and accelerating its thawing in spring. If it is possible to set up snow-accumulating devices earlier (before the first snowfall) on areas exposed to wind erosion, the wind conditions in the near-earth air layer for elementary mechanical reasons sharply, wind erosion in the fall is excluded, and the snow cover is laid down uniformly.

The presence of even stubble, and the more so significant vegetation or enclosures fosters the creation of a snow cover which solves a very important problem of farming the forest-steppe.

10. Methods of Snow Accumulation /385

One can say without particular exaggeration that the problem of harvesting in the Siberian forest-steppe is directly related to the snow cover. The snow cover which preserves the hibernating crops must therefore be a minimum of 50 cm. Devices for snow retention must be installed before the beginning of snowfall which will facilitate earlier accumulation of the necessary snow cover and guarantee its normal structure.

A number of farms of the Siberian forest-steppe and experimental stations have verified the following snow accumulation devices: 1) different types of surface vegetation, forest tracts, naturally growing grasses, sown grasses, residues of sunflower plantings, windbreak strips made of sunflowers, stubble (late-summer residues); 2) artificial forms--shields, clumps of brushwood, snow clumps, straw sheafs (placed vertically), straw bundles (placed in banks), and snow piles.

We will note the methods which have justified themselves the most.

The forest bands for diverse purpose have a radical effect on the snow accumulation. With height of 2 - 3 m, the bands form snowfields (including "loop" up to 100 - 150 m wide). If rows of artificial enclosures are constructed between the forest bands, then on a vast space one can create considerable and stable snow cover. However the forest strips should be able to be blown through since otherwise they form banks from the leeward side and do not make a loop. This occurs, in particular, with bands with continuous rows of conifers. It is preferable for the forest bands to have deciduous species and for the band width to be in limits of 8 - 10 m.

Sown grasses that mature by autumn (we had experience with lucerne and Sainfoin) create an even snow cover with normal structure, only to the height of the grass. In any case, dense perennial grasses 30 - 40 cm high preserve the subsequent maturation of grasses.

Residues of sunflower plantings, as seen from the previous descriptions, if their area is considerable, form a high level snow cover with normal structure. In our experiments, the residues of the sunflower plantings yielded the greatest quantity of snow melt water of all the forms of snow accumulation and significantly slower melting rates, although there were whole layers of earth from dust storms in the snow cover.

The presence of dust layers stresses the capacity of this form of snow retention to retain even fine ground dust.

Groves made of sunflowers, as experience has shown, also have a significant effect, although they have a shortcoming, uneven snow cover due to nonuniform density and height of the stalks, distance between the groves and the size of the area occupied by the groves. The larger the total area of the grove, the more uniform and stable the snow cover on this territory. The stalks should be maintained /386 in rows. The best interval between groves is 6 - 8 m, taking into consideration that the average height is about 80 cm.

Stubble fields (stubble residues) also promote the formation of an even snow cover with normal structure. However, the insignificant height of the stubble yields a low snow cover with small quantity of snow melt water. In addition, the soft stubble of barley does little to promote the retention of snow. A higher stubble from oats and spring wheat should be left.

Of the artificial methods of snow retention, enclosures are the most effective which has been verified in broad practice. Of the several variants of experiments, the most effective were the following two: enclosures set up in continuous rows with 10 m intervals, average height of the snow cover is about 60 cm, space between the enclosures is filled fairly uniformly. The second variant has a distance between the rows of 20 m, length of the "loop" 18 m, average height of the snow cover between the rows 35 cm. Based on experience, one should set up enclosures in a continuous line, 1-meter in height, penetrable, with distance between the rows of 15 m. If there are hollows between the rows of enclosures, the area between the rows can be considerably expanded, by installing enclosures on the brow of the basins.

Banks made of straw bundles are similar to the enclosures as a method of snow retention, but they are impenetrable. In our experiments this method yielded a good result. With height of the bundles 50 cm and distance between the rows 8 m, the snow cover was continuous, with average height of 28 - 30 cm. Winter wheat hibernated without losses. The difference in the heights between the beginning and the end of the loop was up to 15 - 20 cm. We consider it possible to increase the height of the straw bundle to 80 cm which guarantees a snow cover of a minimum 50 cm with 10-meter interval between the rows. The straw bundles can be replaced by straw enclosures which have been made stable.

Other methods of snow retention that we tested were not very effective or were expensive. Thus, the snow piles were dispersed by the wind. The snow clumps placed in rows could be effective, but when there is a shortage of snow on the fields they have to be removed from the groves and snow retention is set up significantly later when the exposed fields could already suffer from cold or wind erosion.

Brushwood in the forest steppe is a scarce material; brushwood piles are not very stable and form a loop that does not exceed 5 m, usually 2 - 3 m. It is necessary to cover the field almost completely with brushwood in order to create a snow cover.

The method of snow retention by straw sheafs in checkerboard order was not sufficiently effective. With strong winds the sheafs are unstable and some type of reinforcement is necessary. The sheafs form two narrow loops, from 1 to 2 m. The length of the loop, with height of the sheafs 77 - 80 cm is usually 5 - 8 m, and the loop has the shape of a pyramid. The height of the snow in the loop at the /387 base is 50 cm, at the end 5 - 10 cm, i.e., the sheafs create a very uneven snow cover with bare spots where the hibernating crops could be exposed to partial loss or complete freezing. During the spring thawing, the ends of the loops disappeared very rapidly, although the bases stayed even longer.

Our conclusions on methods of snow accumulation and snow retention in the forest steppe are not innovative, but they were made on the basis of observations and experiments under specific conditions.