The Active Affects of Shelterbelts on Environment on The Semiarid Region in Northeast China

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Abstract

Since the shelterbelt Systems of 1,092,260 ha has been established for thirteen years from 1978 having formed 526,541 networks protected 13,619,400 ha. land in western part of Northeast region of China. According to the research work we did in the last five years. The results of research project showed that the shelterbelts has improved the environment significantly. A parameter of comprehensive effects of temperature, moisture and wind in the networks ($E_c = 246.52 - 12.17E + 0.58T + 6.58U$) which is an active method to estimate the affects on shelterbelt on farmland, it's around 21.1–30.9mm / month improving the moisture state in dry season helping the crop yield increasing on the average by 19.8%. The effective accumulated temperature ($\geq 10^\circ\text{C}$) increase by 71°C , the cropland area where suffered wind and frost damage decrease by 80–90%, the grass coverage on the pastureland and grass production increase by 13% and by 49.4–72%, rough protein, rough fat and nitrogen-free extract of grass increase by 3.34%, 2.4% and 8.4% separately. A large number of fixing sand plantation has been established for over thirty years on shifting sand land in Kerqin sand land, most sand dunes were stable, a great results got from 2,000ha, experimental area in this region, the atmospheric transport dust decrease by 2,253t / y, adsorbed dust 11.1t / y and people's eyes sick decrease by 75%. The sandy ecological system develops a relative stable plantation system, the grass, shrubs increase to 200 species from 20 species, insects increase to 400 from 30 species, birds 60 species and other animals increase to 20 from a few species, the fungi increase to over 200 species.

Key words: Shelterbelt networks,
Comprehensive effects.

1. Site and Study Method

The six experimental sites was located in Zhao Zhou, Zhaodong, Da-qing, Qing-gang counties in Heilongjiang Province and Zhelimu Inner Mongolia in a semiarid area in Western part of Northeast region of China where the average rain fall per year was 350–500 mm, per year, evaporation as 4 times the rainfall, and the average wind speed at low height from ground was 4.1m / s, with a maximum is 35m / s, annual mean temperature are 2°C – 3.6°C , sunshine are about 120 to 140, the main soils are chernozem, grassy marshland chernozem and sandy soils, the main wind directions are Southwest and

northeast.

The Automatic instruments and conventional instruments were used for observing climate factors, two layers were identified, 1.5m and 5m height from ground surface, for observing temperature, pressure, relative humidity, dew point, wind direction and wind speed, direct radiation, total radiation, scatter and reflection radiation were taken every other hour from morning until night, in the end of June for 10 days, at 1H and at the center point of shelterbelt networks. Observations of snow depth and snow pressure were taken at 08:00 on 5th, and 25th of every month from the time of accumulation to thawing of the snow the next spring, and set up plots at the distance in every five times of tree height crossing two lines on farmland. The five sample plots were set up at 1,5,10,15,20 and 25 times of the tree height at the west of shelterbelt for observing the photosynthetic and biomass and growth of crop, in different growing stages. The methods of analysis of starch, anthrone colorimetric method using a model-721 spectrophotometer and protein, fat-Soxhlet extraction-ultraviolet spectrophotometric method using a Model-751 UV spectrophotometer.

The shelterbelt networks on farmland are 400×500 , 500×500 m and average tree height are 10-12m, 7-10m in width of shelterbelt, and 0.64-0.71 permeabilities.

The fixation forest age on sand land is about 30 years.

2. Research Result

(1) Climatic effect of Shelterbelt networks on farmland

There were many studies have provide a larger amount of data for the design of shelterbelt networks. Although some distribution fields of climatic factors in shelterbelt networks have been observed, up to now, the experiments were limited to either short period or tunnel tests simulating one direction of wind. In fact, the actual wind has many different directions in the shelterbelt networks. The periodic growth of the crops in shelterbelt networks is comprehensively affected by climatic factors including all direction winds, moisture, temperature, evaporation, evapo-transpiration and biomass of crops. The results of this experiment provided not only a theoretic basis for understanding the comprehensive effects of climate factors on crops, but also a practical basis for determining the effects of shelterbelt networks. According to the system data of analysis on all direction wind speed, moisture and temperature field on the two verticals.

The results on climatic effect of shelterbelt showed that during growing period, average wind speed of all directions in the networks decreases by 7.3-16.0% comparing with open area, the greatest decreasing value could be 27.5-33.2%; air temperature average increase by 1.1-13.3%, the greatest increasing value could be 3.7-19.4%; the effective accumulated temperature ($> 10^{\circ}\text{C}$) increase by 71°C , the cropland area where suffered wind and frost damage decrease by 80-90%, the air moisture average increases by 13.8-20%, the greatest increasing value could be 30.4-33.2%.

The simple and active methods for measuring and estimating the effects on the farmland has been set up.

The formula modified by H.L.Penman drying parameter is:

$$E_c - 1 / 2[1.6(10T_i / D)^a + 1.05(E^a - E^b)(1 + 0.5U)] (\text{unit: cm / month})$$

Where, E_c is the parameter of comprehensive effects, U is the wind Speed at 1.5m from the ground (m / s); $E^a - E^b$ is the saturation deficit (mm); T is monthly average air temperature; I is the thermo-index;

T_i is the average air temperature in month, $a = 6.75 \times 10^{-7}T^3 - 7.71 \times 10^{-5}T^2 + 1.79 \times 10^{-2}T + 0.49$.

Since the variables are average values for a month which result is from comprehensive effects, E_c is a parameter of the comprehensive benefits of temperature, moisture, and wind speed in the network, A regression was made as:

$$E_c = 246.52 - 12.17E + 0.58T + 6.58U$$

Figure 1 shows the distribution field of this parameter in a network as the distribution field of comprehensive benefits. That is a parameter of all direction comprehensive climatic effects of temperature, moisture and wind in the networks.

The smaller the value of the parameter, the higher the comprehensive effects from all direction. The functions of the shelterbelt networks mainly are preventing wind, keeping soil moisture during the growing season the mean comprehensive effects parameter value are 21.2–30.9 mm/month, corresponding to supply average soil moisture deficiency in the semiarid sandy area in May–September (zhao-zhou area)

The function of water preservation which can be represented by a comprehensive effects parameter could be useful for increasing crop yield on the average by 19.8% about 1500–22500 kg/yr. in a network. This is an important reason for ensuring crop yield increasing, relaxing Spring drought in the sandy semiarid area in Northeast China.

(2) Shelterbelt effect on soil moisture

Because of the prevention wind and conservation of soil moisture, and remaining stubble of crops for collecting snow, the farmland in the networks has more effective moisture content, 0–10cm, 11–50cm soil layers of soil average moisture increase by 11.3–20.0%, 10.9–15.9% respectively, the optimum affect in Spring sowing period (May), during that time, 0–10 cm, and 11–50 cm soil layers, the soil effective moisture increases by 22.0–42.0%, 17.8–21.7% respectively. The optimum section position of soil moisture (in the network) located in the distance from shelterbelt about 5–15 times of the tree height (H) in meters, the lowest value located in 25H.

The research work came of the same thing to show that average soil organic matter increases by 0.12%, the average effective nitrogen, effective phosphors, and effective potassium increase by 13.7 p.m., 3.9ppm and 18.7ppm respectively, the soil salt content in the solonized soil area of network decreases by 60–78% compared to the open area, the shelterbelts improved the physical and chemical characteristics of soil, and have provided scientific theory basis for crop yield increasing of shelterbelts effects.

(3) Effects of shelterbelt on physiological and ecological characteristics and biomass of crops

According to the effects of comprehensive meteorology and the improvement of soil physics and chemistry, thus all this effects of shelterbelt bring about improving the physiological and chemical

Figure 1: E_c distribution during growing season May–September in the network

characteristics. it could increase photosynthetic rate, respiratory rate and decrease evapotranspiration rate of crops during the growing season, therefore, the growth rate increase by 10.1% (corn), 15.4% (soybean), 3.3% (chinese sorghum) 15.5%, (millet), compared to the open area, every growing stage could be earlier in 4–5 days. the shelterbelts effects could alleviate or dispel the "noonnap" in photosynthetic rate phenomenon of crops, alleviating this daily slow down in photosynthetic, increases the utilization of solar energy, increases crop growth and grain quality. on the basis of system material analysis: the mean starch content of corn seeds increases by 3.5%, with 8.5% and 10.9% at 5H and 10H respectively, the mean protein content increases by 31.3%, with a 52.1% and 64% increase respectively at 5H and 10H, increase in protein content is a primary indicator of output and quality. In corn seed, the mean fat content was 4.11%, which was 6.2% higher than that of the control field. The total organic compounds increased by 5.5%, with the maximum of 14.2% at 10H. Lysine, 2,6-Diaminocaproic acid and Tryptophan increase by 17.2% and 13.19% respectively, many kind of vitamin contents increase by 16.7–32.0%. The weight of thousands seeds increase by 23.5%, the optimum effects for crop yield and quality in the 5–15H from the leeward side of shelterbelts.

(4) Effect of shelterbelt on the pasture land

During the nutrition period, the *Amuroliptidium chinense* and *Salsola clooina* of grass of average growth height are 4.04cm and 1.59cm higher than in unsheltered area, evapotranspiration value of *Lespedeza dahurica* of short shrub products dry matter are 32.2g, products dry matter are 15.5g in each 1 kg water, but in unsheltered area are only 6.3g.

Shelterbelts on the pastures land could increase the rough protein and decrease nitrogen-free extract of grass, during the plant nutrition period the energy of grass on the certain area (ha), rough protein increase by 563.7 MJ / ha (by 3.34%) nitrogen-free extract increase by 405.3 MJ / ha (by 8.4%) rough fat increase by 17.37 MJ / ha (by 2.4%)

(5) Effects of Sand-fixation Plantion

The research results of shelterbelts have been got on the sandy land in western part of Northeast Region for thirty years. It showed that shelterbelt system of sand fixation land (2.00 ha) decreased fine dust 2.253 t / yr. collected dropping dust in the air 11.1t / yr, because of sand dust in the air has been cleaned by shelterbelt, the people's eyes sick decreased by 75%.

And it improved the succession of sandy plant, animal, insects and microbe flora, It developed a relative stable plantation ecological system from weak sandy ecological system, the vegetation and shrubs increase by 200 species from 20, insects by 400 species from 30. birds increase by sixty, and animals increase by twenty from a few.

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