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STUDIES ON THE POTENTIAL OF GRAIN PRODUCTION IN THE NORTHEAST REGION OF CHINA

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ABSTRACT: Northeast region covers an area of 1.24 million km, making up 12.9% of the total area of China, with a population of 103 million, 9.9% of the total population of China. The grain commodity rate is over 35%. It is one of the very important regions of grain production in China. As population and grain demand unceasingly increase, the potential of grain production, and the commodity grain provided for the nation are the major problems about grain consumption and distribution in the future. And they directly affect the realization of national planning objective of grain production.

The analysis of grain production conditions and history indicates that: 1) The increase of total grain output is mainly dependent on the increase of grain yield per unit area, but not the enlargement of grain sown area. 2) The factor to affect grain yield per unit area are materials input, correct policies, yearly climatic variation. 3) By the year 2000 and 2010 the total grain output in this region will be respectively 66.16–66.29 and 71.68–72.89 million tons. 4) According to the results of research, the potential of increasing grain output in Heilongjiang and Jilin provinces is the greatest in the future.

The key measures to raise grain yield include increasing material and energy input, strengthening the base construction of farmland, emphasizing the increasing of yield per unit area of medium and low yield fields, and controlling the amount of farmland which are taken up by any other activities.

KEY WORDS: grain production, commodity rate, Northeast region

I. INTRODUCTION

The Northeast Region of China (NER for short),include Liaoning, Jilin, Heilongjiang Provinces and the east inner Mongolia. With vast plain, fertile soils and good climate being all favorable for grain production, it is one of the most important grain production bases of China. Its grain output makes up 1/ 8 of the whole country's and the amount of commodity grain offered by it to the country is the largest. In a sense, the grain yield in this region is directly related to the whole country's grain output. As is known, China is a developing country and is facing up with more and more pressure of demand for food from its growing population. Therefore, giving answers to the questions "How big is the potential of grain production in the NER?" and "How much commodity grain will it offer to the country in future years?" is extremely necessary. It will be in respect with this region's, even the entirely country' level of grain consumption, unified planning and controlling. So, this paper will focus on the studies of grain production potential (GPP for short) in the NER in order to reach some useful conclusions to serve the related decision–making and planning.

II. THE ANALYSIS TO THE TOTAL GRAIN OUTPUT OF THE NER IN PAST YEARS

Since liberation, the grain output in the NER had been on the high–speed increase. By 1987, the total grain output (including soybean) was up to 50,597,000 tons, 3.26 times of that in 1949, average increase rate during this period was 3.08% per year. From 1983 to 1987, since the agricultural responsibility system was enforced and the peasants' enthusiasm for grain production was brought into full play, the increase rate of grain output was even faster, as high as 7.20% per year! Because of the NER's large area and the striking difference in grain production conditions among its subregions, the contribution proportions to the total grain output for the provinces are certainly quite different. In 1987, Heilongjiang made up 34.34% of the total, Jilin 33.12%, Liaoning 25.22%, but the east Inner Mongolia only 7.32%.

It is known that the total grain yield "Y" depends on the grain sowed area "S" and its yield per unit area "f", that is:

$$Y = S \times f \tag{1}$$

If the method of factor resolution to analyse the increase of total grain yield is used, according to formula (1) and the historical date of grain production, the results can be got in Table 1.

From Table 1, it is clear that the rise of "f" had played a key role in the increase of grain output both to the NER and to all its subregions, to the former, $c_2$was as high as

Table 1 The results of factor resolution on total grain yield in the NER

Region	Y(87)−Y(49) (thousand tons)	S(87)−S(49) (thousand hectares)	f(87)−f(49) (ton / ha.)	c_1 (%)	c_2 (%)
The NER	35075	270	2.18	0.76	99.24
Heilongjiang	11601	1992	1.28	18.30	81.70
Jilin	12168	−710	3.72	−6.38	106.38
Liaoning	8708	−1232	3.15	−13.15	113.15
East Inner Mongolia	2598	220	1.27	5.42	94.58

Notes: $C_1 = \frac{(S(87) - S(49)) \times f(49)}{Y(87) - Y(49)} \times 100\%$

$C_2 = \frac{(f(87) - f(49)) \times S(87)}{Y(87) - Y(49)} \times 100\%$

Sources: 《Yearbook of the Northeast Economic Region》, Statistics Press of China, 1988.

99.24%, therefore, to raise the grain output in future, laying stress on the raise of f is out of question. Considering that the reclaimable wasteland is very little until now, this point should be more emphasized.

III. THE ANALYSIS TO THE FACTORS AFFECTING THE GRAIN YIELD PER UNIT AREA

According to the analysis results above, "f" was the key factor to the increase of total grain output in the NER. But which factors affected the raise of "f" greatly? By the way of progressive regression analysis, the notable factors were as follows:

1) Material and technology inputs: This factor was very positively related to the value "f", 50−70% of total change amount of "f" was due to it.

2) Policies on agricultural production: A favorable agricultural policy has an obvious effect on the raise of "f". The survey shows that the enforcement of agricultural responsibility system since 1983 was one of the most important factors to cause the rapid increase in "f" from 1983 to 1987, the increase amplitude was from 450 kg / ha to 750 kg / ha.

3) Climate conditions: The regional climatic conditions determine its accumulated temperature, precipitation, sunshine radiation and even its soil's fertility and natural calamities. According to the results of regression analysis, in the North and East of the NER, inadequacy of accumulated temperature (during the period of daily mean temperature $> = 10$ C) was the key factor restricting the growth of "f", but in its west and southwest, scarce precipitation from May to September was also a limiting factor. Meanwhile, yearly

climatic variation also influenced the stable growth of "f" greatly. In 1985, owing to the unusual climate, "f" reduced about 18.6%. In 1972, "f" also dropped about 21.0% because of the frostbite strike.

4) Other factors include the level of intensive farming, irrigation condition and the proportion of high-yield grain crops' sowed area to the whole sowed area: About 5–15% of the total amount of increase in "f" was caused by them.

So, through the analysis above, keeping a stable increase in material and technology inputs, enforcing a correct agricultural production policy and emphasizing the farmland's basic construction are the key steps to make "f" increase progressively.

IV. FORECAST ON GPP IN THE NER

Analysis on Probability of Enlarging "S".

According to formula (1), broadening "S" is helpful to raise the total grain output, but going this way should have lots of reclaimable wastelands to back up. At present, there are about 8,000,000 hectares of wasteland in this region, 90% are distributed in Heilongjiang and in the east part of Hulun Buir League (East Inner Mongolia), but most of those regions are either fully covered with swamp or easy to be stricken by frostbite, reclaiming them is not only difficult but needs a great deal of investment. It may cause the contradictions running for land use among agriculture, forest and husbandry too. For example, about 1,330,000 ha of forest land, grassland and lakes had been encroached upon from 1949 to 1987 in Heilongjiang Province because of the reclamation to enlarge cultivated land, which had resulted in the eco-environment from bad to worse. Today, the area of arable land easy to be hit by drought and waterlogging is 6 times of 1950's in Heilongjiang. Therefore, in the view of protecting eco-environment and fully tapping the present cultivated land's production potential, the stress to increase total grain yield in the NER should be laid on the raise of the present arable land's yield per unit area in future.

Analysis on Probability of raising "f"

Since it is difficult to broaden food crop's sowed area, the way of increasing total grain output is only to raise "f". According to the historical date, in 1987 the average "f" in the NER was only 3.17 t/ ha, the highest "f" (in 1984) was no more than 3.23 t/ ha, they were both less than 1% of photosynthesis potential. More practically, using the formula Lieth *, the highest climate probable "f" for each subregion could be calculated out. (Table 2)

From Table 2, the highest "f" in history for each subregion and the whole region is all less than 50% of the climate potential (f(c)) of itself. Jilin (the highest) is also merely 43.44%, which represents that there is still a great potential in the raise of "f" theoretically. On the other hand, based on the investigations done, about 88% of the arable land still belong to either mid or low-yield area, raising "f" in large amplitude is practicable if correct steps are adopted in grain production. At present, the "f" in many counties and townships

has been up to 6–7.5 t/ ha, some fragments even up to 9.75 t/ ha, which was a good evidence.

Table 2 The highest climate potential "f(c)" in each regions

Region	the NER	Heilongjiang	jilin	Liaoning	East inner Mongolia
f(c) (t)	10.43	9.71	11.05	12.92	8.55
$\frac{f(c)}{highest\ "f"} \times 100\%$	30.97	24.61	43.44	36.22	22.34

Notes: The Formulae lieth are as follows:

$$Y(t)(t/\ ha) = 30.0 \times (1 + e^{1.315-0.1119T})^{-1}$$

$$Y(p)(t/\ ha) = 30.0 \times (1 - e^{-0.000644P})$$

here: T— mean annual temperature

P— annual precipitation

choice of the less between Y(t) and Y(p) as the highest climate "f".

Forecast on Total Grain Output in the NER

Until now, it has discussed the probabilities of enlarging "S" and raising "f", but what levels on earth will they keep in the future years? and how much the total grain yield "Y(t)" will be in the year "t"? To answer those questions, we have set up many forecast models in consideration of natural and economical conditions. In addition, the present level of grain production was also taken into consideration. The simulating results showed that Logistic Curve was the best model to predict the increase of "f" and one element regression model was the best to predict the developing trend of "S". Therefore, the two methods above built up the bases of the following forecasts.

1. Forecasts on Total Grain Yield Taking the NER as a Whole

1.1 The Establishment of Forecast Model about "f(t)"

According to the Logistic Curve model and the historical date of "f(t)" (here "f(t)" means the grain yield per unit area in the year "t") for the whole region, the forecast model of "f(t)" was built up in the form of

$$f(t) = \frac{10.43}{1 + e^{3.933410354 - 0.03464183124t}} \qquad (2)$$

here, "t" is the future year. The regression coefficient r(f) (for model (2)) is equal to 0.9338362, representing this model's high reliability.

1.2 The Establishment of Forecast Model about "S(t)"

From 1949 to 1957, the grain sowed area ("S(t)") in the NER had increased gradually with the enlargement of cultivated land,then it began to decrease because of the broadening of land occupied by nonagricultural basic construction. It is widely thought nowadays that the dropping trend of "S(t)" may not be reversed for a long time. Under that estimation and with the historical date, "S(t)" with the time "t" going on can be reached:

$$S(t) = 19105.30 - 38.3t \tag{3}$$

here r(s) (regression coefficient) $=-0.8665235$, also displays the model's high reliability.

1.3 The forecast of total grain output (Y(t)) in the year "t"

Based on Models (2) and (3), "Y(t)" in different "t" years can be easily calculated out. The results are as in Table 3.

Table 3 The forecast value of Y(t) in the year t

t (year)	1995	2000	2005	2010
Y(t) (thousand t)	55,680.5	61,254.0	67,141.6	72,897.8

Table 3 shows that by 2000, the total grain yield in the NER will be 61,254,000 tons, and by 2010, it will be 72,897,800 tons.

2. Forecast on Total Grain Yields in Subregions of the NER

By the use of the methods above, the forecast models of grain output for each subregion may be reached as in Table 4.

From Table 4 several conclusions might be reached:

1) the Y(t) for each subregion will be advancing up with the time going on. By the end of this century the grain yield separately for Heilongjiang, Liaoning, Jilin and the east Inner Mongolia will increase about 25.85%, 7.59%, 31.46% and 22.29% compared with that in 1987. If a perspective to the difference in increase amplitude among subregions is viewed, we will know that the relative increase ranges of grain output for Liaoning, Heilongjiang and the east Inner Mongolia are bigger but Jilin smaller, the reason of which is that in 1987 Jilin met a good harvest (its f(t) was 20.43% more than that in a common year), but Heilongjiang and East Inner Mongolia had a common harvest year. However Liaoning was hit by climatic calamity in the same period. In addition, the difference in increase among subregions should be owing to the difference of their increase potential too (see Table 2);

2) After making an analysis to different years' grain yield, it was found out that the absolute amount of increase every five years in all subregions but in Heilongjiang would be smaller and smaller as the time going on (see Table 5), that was partly since those subregion's "S(t)" would reduce with the arable lands turned into nonagricultural use, and on the other hand, with the gradual growth of "f(t)", the difficulties in raising "f(t)" would be more and more too.

Table 4 The forecast models of f(t) and s(t), and the total grain output for each province

Items		Heilongjiang	Jilin	Liaoning	East Inner Mongolia
Forecast model "f(t)"		9.71/ (1+q1)	11.05/ (1+q2)	12.92/ (1+q3)	8.55/ (1+q4)
Forecast model "s(t)"		5309.5−23.53t	4495.4−11.54t	6239.6−36.98t	2989.8−12.14t
Regression coefficient r(ft)		0.8822	0.8847	0.9600	0.8789
regression coefficient r(st)		0.8383	−0.8764	−0.9804	−0.8989
Total grain output "Y(t)" the year "t"	1995	17376.0	16758.0	12763.0	3700.0
	1995	19667.0	16023.0	15754.0	4118.0
	2000	21868.0	18030.0	16778.0	4525.0
	2010	24230.0	19971.0	17488.0	4933.0
		26748.0	21779.0	17828.0	5333.0

Note: $q_1 = e^{3.397-0.0252t}$ $q_2 = e^{5.026-0.0498t}$

$q_3 = e^{5.0712-0.05115t}$ $q_4 = e^{4.4041-0.0355t}$

Table 5 The absolute amount of increase in grain production each five years for each subregion (thousand tons)

Period	Heilongjiang	Jilin	Liaoning	East inner Mongolia
1995−2000	2200.7	2006.3	1024.7	406.4
2000−2005	2361.9	1940.9	709.3	408.1
2005−2010	2517.6	1808.1	340.4	406.1

Note: Based on Table 4.

3) According to the results of the subregions' forecast, the total grain yield for the whole region can be easily got as in Table 6.

Table 6 The total grain yield "Y(t)" of the NER in the year "t" (thousand tons)

t	1995	2000	2005	2010
Y(t)	55562.6	61200.7	66620.9	71687.6

Note: coming from the results of the subregions' forecast

Comparing Table 6 with Table 3, there is little difference between them, so the practical grain output in the future year "t" will basically conform to what has been forecasted above and the forecast results are highly believable.

3. The Revision of Forecast Results Considering the Unusual Climate Years Happening

The forecast results above only reflect the general developing trends of "Y(t)" in common climate years, but until now the fields in the NER are still weak in combating natural disasters and unusual climate often causes a great wave in grain yield. So, to the forecast of future grain production, considering the climate variation is necessary. As the year 2005 and 2010 are both a long time from now, this paper focused on the revision of forecast results in 1995 and in 2000. Through climate variation prediction (based on Grey System Theory), the final results showed that the year 1995 would be a normal climate year and its grain output unchanged like the former forecasts, but 2000 a favorable climate year and its grain output would be 8.22% more than the forecasts in this year. That is: by 1995 and 2000, the total grain yield in the NER will respectively be up to 55,562,500–55,680,500 tons and 66,159,500–66,294,800 tons.

V. THE CALCULATION OF NET EXPORT AMOUNT OF GRAIN FROM THE NER IN FUTURE YEARS

The net export amount of grain "Y(et)" in the future year "t" is equal to the total grain yield "Y(t)" minus the total grain consumption amount "Y(ct)" in the NER, that is:

$$Y_{(et)} = Y_{(t)} - Y_{(ct)} \tag{4}$$

Here, "Y(ct)" is composed of five aspects as following:

. the average provisions per head

. grain for forage

. grain for seeds

. grain reserves

. grain for other demands (from industry, natural loss and draught animal forage, etc.)

After the predictions on each aspect's demand above, the "Y(et)" was finally calculated out as in Table 7.

Table 7 The net export amount of grain "Y(et)" and net commodity rate of grain " " in the year "t" (thousand tons, %)

Item	1995	2000	2005*	2010*
$Y_{(t)}$	55562.6–55680.5	66159.5–66294.8	66020.9–67141.6	71687.6–72897.8
$Y_{(et)}$	49209.0	51580.0	54789.0	58588.0
$Y_{(et)}$	6353.6–6471.5	14579.5–14714.8	11831.9–12352.6	13099.6–14309.8
E (%)	11.44–11.62	22.04–22.20	17.76–18.40	18.27–19.63

Note: $E = (Y_{(et)} / Y_{(t)}) \times 100\%$

* the items in 2005 and 2010 are the general developing trends of themselves (not revised)

From Table 7, the year 1995 will be a common climate year and the "Y(et)" will be 6,353,600–6,471,500 tons, the year 2000 will be favorable in climate and its "Y(et)" will be 14,579,500–14,714,800 tons (4,952,800–5,040,800 tons more export than in a common year); As to 2005 and 2010, in common years they will be 11,831,900–12,352,600 tons and 13,099,600–14,309,800 tons respectively.

VI. SEVERAL SUGGESTIONS ON FURTHER TAPPING THE GPP IN THE NER

1. Augmenting the Inputs of Materials and Technology into Grain Production

More inputs of materials and technology is the key step to raise "f(t)". For example, based on our studies, augmenting 1 kg of fertilizer at present will increase 8.99 kg of grain yield in Heilongjiang and 6.89 kg in Jilin, 3.27 kg in Liaoning, 4.68 kg in the East Inner Mongolia. But in fact the amount of fertilizer input in the NER was still not only very little but also a great difference, amount for the whole region was only 0.33 tons/ ha, it was even

below 0.15 tons/ ha in Heilongjiang and the East Inner Mongolia. As to the technology input, it was very intensive too. Therefore, to the stable growth in future grain production emphasizing the inputs' augmentation of them is essential.

2. Strengthening the Basic Construction of Farmland, Enhancing Its Abilities of Combating Natural Disasters and Laying Stress on the Raise of "f(t)" in the Mid– and Low–Yield Arable Lands.

At present, the level of basic construction of farmland in the NER is still very low, only 11.8% of its total are both stable and high in grain yield. Its North and East are liable to be stricken by frostbite and its west and southwest are often to be distressed with droughts. As to the plains (including the Sanjiang Plain, Songnen Plain and the Songliao Plain), the flood is also a threatening factor (parts of them are threatened by drought too). Therefore, taking different steps actively in terms of each subregion's different conditions to keep grain production from natural calamities should be paid much attention to.

As mentioned above, the cultivated lands belonging to mid– and low–yield still make up a large proportion of its total in the NER today. Considering that the increase of grain output in future will mainly depend on the two provinces of Heilongjiang and Jilin, they should be taken as the focal places in raising "f(t)" to achieve the best satisfying effect in the growth of grain production of the NER.

3. Continuing to Perfect Agricultural Policies and Bringing Them into Full Play

It has been proved that the carrying out of policies encouraging peasants to produce grain had a striking favorable effect on the growth of grain production. Therefore, continuing to make the best of the policies in grain yield increase should be insisted on constantly. Here the two points will be emphasized:

1) Keeping the policy of land contract constant and unchanged at least for 30 years in order to get rid of the peasants' worry about its duration.

2) Building up and perfecting the spreading and training systems of agricultural science and technology so as to improve the whole peasants' knowledge and enhance their level of scientific farming. Only in this way, can the stable growth of grain production in the NER be gradated and its contribution to the whole country's grain production be greater and greater!

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