The Assembly and Application of High Yield Cultivation Technics for Mechanized Dry Farming in Heilongjiang Province of China

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Abstract

On the basis of a brief introduction of the mechanized dry farming in Heilongjiang Province, the author states the developing process from the combination of single technics of farm machinery and agronomy to the technical assembly of high yield cultivation technics and its mathematical expression. According to the main temperature accumulated zones, 5 typical comprehensive technical assembly models for the mechanized cultivation technics and their agricultural machinery systems have been listed. They are: the Heihe "261" wheat and soybean model; the Yi'an big ridge double row film mulching corn model; the Yongchang high yield mechanized soybean model; the Shuangcheng 3-depth precision sowing corn model; the wheat, soybean and other grain crops six year rotation model for Keshan state farms. The author conclude that the application of mechanized high yield cultivation technical assembly is the key point to transform the Heilongjiang province from big agriculture to strong agriculture, we have to take "high yield, high quality, high efficiency, sustain-ability and earning foreign currency" as the general target and carry out the corresponding policy and measures for the further development of agriculture.

Key words mechanized dry farming high yield cultivation technics assembly model measure

1 A brief introduction of the mechanized dry farming in Heilongjiang Province

Heilongjiang province is the important base of marketing grain production and important export base of soybean. The acreage of cultivated land in this province is 9 million hm^2, the major crops are soybean, corn, wheat and paddy rice, about 3 million hm^2 for soybean, 2.5 for corn, 1.2 for wheat and 0.8 for paddy rice. They occupy 33%, 27%, 13% and 8% of the whole cultivated land respectively. It is shown by these figures that dry farming occupies the major portion in this

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in this province. The agricultural mechanication starts early, the agricultural machinery equiped and the level of agricultural mechanization are comparativly higher in whole China. Now it has been the important technical and material support of the agricultural production in the whole province.

On the implementation of agricultural machinery, by the end of 1995, the whole province has own the total farm power of 12.258 million kw, average 1.4kw/hm^2. There are 517 thousand farm tractors, among them 39 thousand are big crawler type, 41 thousand big and mediun wheel type, and 437 thousand small type. Three are 179 thousand big and mediun type matched farm machinery, 378 thousand small types. There are 13 thousand grain harvest combine.

On the level of agricultural mechanization, field operations such as plowing, sowing, cultivation, harvesting and farm transportation are mainly fulfiled by machine, the extent of mechanization is 79.2%, 69.4%, 83%, 30.6% and 85.1% respectively. Threshing and processing for soybean and forage crop, all have realized mechanization.

Agricultural mechanization plays a prominent role in developing "high yield, good quality, high efficiency" agriculture.

2 From the combination of single technics in agricultural machinery and agronomy to the comprehensive technic assembly for mechanized high yield crop production.

2.1 The meaning and development of the conbination of farm machinery and agronomy technics.

The combination of farm machinery and agronomy technics is to satisfy the technical demand of agricultural biology by the power and mechnical structure of farm machinery to ensure high crop production. From this view, agronomy is the production technology, farm machinery is the tool to fulfil them. So, farm machinery submits to agronomy, agronomy relies on farm machinery. Their mutual combination and adaptation will promote and supplement each other.

From the view of system engineering, the target of developing agriculture modernization should be: "high yield, high quality, high efficiency, high sustentation and earning foreign exchange". Various technical measures in three systems of agricultural biology, agricultural engineering and agricultural economy available in local place and at that time should be assembled optionally. Thereby, the best comprehensive effect could be obtained through the combination of agricultural machinery and agronomy, the hardware and the software technics.

The technical assembly of modern agricultural production should obey the following three basic principles: the first is the optimum principle of composite profit of agricultural production system. Better or best structure of agricultural production

are adjusted and set up, on the basis of subjective and objective conditions in local place and at that time, seek for the productive technical measures effective in different regions, and assemble them reasonably to form a comprehensive high yield technical model for the mechanized crop production. The second is the mutually adaptable principle of relevant productive technics. Technical assembly should be carried on the same level of productive forces. In other words, all technics should belong to about the same level. Such as, the labour and animal power level, the mechanized and automated level. The third is the principle that all must be in the light of local conditions and time. The combination and assembly of agricultural machinery and agronomy technics will be different in deepth and range, and also the function appeared.

The combination of agricultural machinery and agronomy had been put forward in the course of mechanization of agricultural production and developed ceaselessly with the constant deepening of understanding in production activity. In the initial stage, the level of science and technology on both agronomy and agricultural machinery equiped were low at that time, the combination of them were merely on certain single technic, and limited in the way of modifying the good practice in traditional agriculture. Thereby the field operations and farm management were rather extensive. Afterwards, the agricultural production approaches had been developed and renewed along with progressing of agricultural science and technology. So in the procedures of crop production, such as the flat plowing changed to the combination of subsoiling, turning and harrowing or rotortilling; the shallow application of fertilizer or with seed changed to deep application on ridge side and to apply according to fertilizer prescription, sowing seed by row changed to drop seeds precisely into the hills of same space and distance etc. During this period, the combination of farm machinery and agronomy had begun to change from single technic to the combination or assembly of many technics.

The foregoing process showed that the combination of farm machinery and agronomy began to go in a new period of technics assembly. The trend of its development is to realize the following three transformations, they are : the transformation of the combination of single technics to comprehensive assembly of many technics; the transformation of technical assembly at low level to high yield cultivation model of high and new technical assembly; the transformation of some partial assembly on a single machine with combined operations to a complete set of technical assembly on the machine with all relavent operations.

Along with the advance of science and technology and the development of crop production, the dry land high yield mechanized cultivation technics of the

elemental, partial and serial technical assembly had been approved beneficial significantly and extended all through Heilongjiang Province. They are compiled in table 1, to show the general picture of the technical assemblies adopted in Heilongjiang Province.

2.2 Mathematic description of technical assembly in mechanized agricultural production system.

In order to make agricultural system turn well and obtain optimum overall function, we have to apply the science and technology in the field of agricultural biology, engineering and economic management, and the comprehensive assembly of three of them. The optimum overall function in of any systems relies on the coordination of the individual effect of the composed elements. According to the principle of non-additive effect of systems, the functions of single element complement with each other forming the relation effect $1+1>2$.

The technic input in the big system of agriculture is composed of three sub-systems of agricultural biology engineering and economic management which form the integer technical set. It can be described as following: $\begin{cases} C=B\cup E\cup M \\ W=B\cap E\cap M \end{cases}$

In the formula, B is agricultural biological technical set = {seed selection and breeding, multiple cropping, soil utilization and nursing protective cultivation, reasonable crop rotation, biological prevention of plant diseases and pests, $\cdots$}, that is: $B=\{b_i \mid i=1, 2, \cdots, n\}$

E is agricultural engineering technical set = {new technic and new implement, development and utilization of water and soil resources, prevetion of natural disasters, facility agriculture, renewable energy resources, comprehensive utilization and procession of natural resource and agricultural product, $\cdots$}, that is $E=\{e_j \mid j=1, 2, \cdots, p\}$.

M is agricultural economical management technical set = { technical management and coordination, optimum management technics of energy saving and safety production, $\cdots$}. that is $M=\{m_k \mid k=1, 2, \cdots, q\}$.

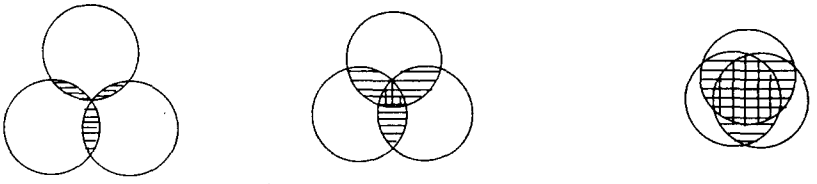
$i \neq j \neq k$, constituent number of every technical set is limited.

C is the union set composed of three technical sets, W is the intersection set.

Thus, the technical assembly for selection would exist many situations depending on the local conditions, time and the level of productive force.

Under certain conditions, the more advanced technology, the more technical subsets that B、E、M three technical sets may contain through their mutual intersection (infiltration and combination) of two even three of them, new technical sets could be formed with higher technical level. The corresponding agricultural production will be propelled to a new stage. These can be described by

Venn's diagram as shown in figure 1. (a)、(b)、(c).



(a) (b) (c)

figure 1. technical assembly diagram of three stages in agricultural production system

Picture 1(a) shows the primitive agriculture where B、M、E three technical sets had just been formed in primitive state. There were mainly the union set, the intersection set was empty, and a few intersect of two sets shown by the single shadow lines in picture (a). This is the technical assembly at low level.

(b) shows the traditional agriculture, there are obvious progress among the infiltration and combination of three technical systems shown by single and double shadow lines. This is the technical assembly at middle level.

(c) shows the modernized agriculture, there are technical sets at high level with a large amount of the infiltration and combination among the three sets, many new comprehensive technical assembly will be formed.

3 Typical exampls of the mechanized high yield technical assembly models and their machinery systems

3.1 The temperature accumulation zones and the crop regions in Heilongjiang Province

The temperature of the north area is very different with the temperature of the south area in Heilongjiang Province. The average temperature of one year is -5 ℃ ~ 4 ℃ , the period of no frost are $100 \sim 140$ days. The activity temperature accumulated of 10 ℃ Higher all year is $1500 \sim 2700°$. Every $200°$ interval is one zone according to accumulated temperature, there are six temperature accumulated zones from south to north: The active accumulated temperature is above $2400°$ in the first and the second temperature accumulated zones of south area, the period of no frost are $124 \sim 145$ days, they occupy 43.5% of farming land in Heilongjiang Province, and they produce mainly corn, soybean, paddyrice and coarse cereals; The active accumulated temperature is $2000 \sim 2400°$ in the third and fourth temperature accumulated zones of north area, the period of no frost are $105 \sim 135$ days, they occupy 49.7% of farming land in Heilongjiang Province, and produce mainly wheat and soybean; The active accumulated temperature is lower $2000°$ in the fifth and sixth temperature accumulated zones in the northest, the period of no frost are $80 \sim 115$ days, they only occupy 6.8% of farming land in

Heilongjiang Province and can only plant premature wheat and very premature soybean.

According to general cultivate method, different temperature accumulated zones should be planted different crops and its different varieties, it is formed assembly project and model of mechanized high yield cultivate techincs in local area; But it can be realized to plant in changed area by all kinds of technical assembly, this creats mechanized high yield cultivat model.

3.2 Model example

(1) The Heihe "261" spring wheat and soybean model carry out intensive management of land connected, the technics of increasing production are assembled scientifically which are dry farming little tillage, precision seeding, deep fertilizering, medicine weed killing, crop stalk back to field and so on. The mechanical system of wheat and soybean production is choosed and formed that chief part is large type agricultural machinery, standard production is realized. The city have thirty-four villages or farms, they planted wheat ten thousand hm^2 altogether in 1990, the output per unit was 2911.5 kg/hm^2; They planted soybean 1453 hm^2, the output per unit was 2374.5 kg/hm^2. This created high yield achievement of dry farming in very cold area.

(2) The Keshan state farms wheat, soybean and other grain crops six year rotation model (the fourth temperature accumulated zone) carried out six area crop rotation all-round (wheat-other grains-soybean-wheat-wheat-soybean); the combination of deep and shallow tillage, the combination of bedding and platting, matched plowing system of the combination of the turning, loosening and harrowing, harrowing stubble are formed to ensure standard working in plowing and planting; Dispensed fertilizering technics is adopted, and chemical weeding and seed drug disposing technics are applied to ensure harvest timely and decreasing loss. Because of adoption of above-mentioned productive and technical standard, mechanical working quality of this farm is always the first in reclaimed area. Wheat (planting area is about 50%) is high and stable yield in 13 years in a row. Average output per unit is 3150 kg/hm^2. It was over 4500 kg/hm^2 in 1990.

(3) The Yi'an big ridge double row film mulching corn model (the third temperature accumulated zone), mechanical cultivate technics of big ridge, two row corn filming was taken up , it created the precedent of that high yield corn strain was planted stepping area, increation of yield was 50% to 80%, which preceded the corn production of normal accumulated temperature area, average production per unit of big area was 12000 kg/hm^2, some land preceded 15000 kg/hm^2, and it was formed dry land crop cultivate, equiped technical assembly model of corn and soybean of wheat intercropping, corn, soybean and wheat rotate cropping.

(4) The Yongchang high yield mechanized soybean model. (The second temperature accumulated zone) The characteristic of this model is insisting on "six unify", that was mechanical preparation, planting in time, mechanical planting, rational fertilizering, selecting good seed and rational changing stubble, these six productive techniques were assembled and applied unified and reasonably, one village planted soybean 67 hm^2, the unit production was over 3000 kg/hm^2 in 1988, that was model record of large area high yield.

(5) The Shuangcheng 3－depth precision sowing corn model. (The first temperature accumulated zone) Since this model was put through, the city corn unit production was over ten thousand kg/hm^2, it opened up the new way for corn and soybean mechanical high yield cultivate in the first and second temperature accumulated zones.

3.3 Agricultural machinery systems to insure the fulfillment of technical assembly model

In the course of the combinations of farm machinery and agronomy and the formation of comprehensive high yield technical assembly model, the Heilongjiang Provincial Academy of Agricultural Machinery Engineering and other organizations had worked out many farm machinery of various models for ridge farming, to meet the need of the mechanized high yield crop production. They first worked out the serial machines of diffrent sizes, such as, cutivate precision sowing machine attachments, 7 bottom plow(model Ⅲ), machine to return stubble back to soil and machine for protective cultivation. Then they worked out the combined machines with many high yield promoting devices, such as, the precision planter with ridge cultivation and fertilizer application parts, the combined plants with ridging, rotortilling, subsoiling, watering and film mulching devices. They had further worked out a combined machine which can accomplish the following functions in one operation: stubble harrowing, ridge body subsoiling, fertilizer deep application by layers, precision sowing and rolling, insecticide spraying etc. An agricultural machinery system to assure the fulfillment of the technical assemblies had thus been built up.

The main technical assembly models and the corresponding machinery systems which have been extended for the production of wheat, soybean and corn are listed in table 2. Obviousely, they are given as examples. For the different crop in different regions, the technical assemblies applied are more or less different in detail.

4 Conclusion remarks

(1) The transit of agricultural technology from the mutual adoption of farm

machinery and agronomy to the comprehensive technical assembly, and then to the formation of technical assembly model and the corresponding farm machinery systems is a big jump of crop production. It is also the technical basis of the transformation from extensive to intensive production, and also the key point of changing the agricultural province to the strong agricultural province, and to climb a new step of grain production.

(2) In order to promote the agricultural production to a new stage and to realize the transformation from the traditional agriculture to the modernized agriculture, we should take "high yield, high quality, high efficiency, sustainability and earning foreign currency" as the general target of the formation and application of comprehensive technical assembly, we should take into consideration of the benefit of nowadays as well as in the future.

(3) To apply the technical assembly and to fulfil the modelized production, we have to realize the following policies and measures: to build up stable and modelized tillage systems, to promote the cooperate systems and to enlarge the scale of management for the benefits of the operation of big farm machinery and the comprehensive development of agriculture. To develop the service systems of farm machinery, to develop the farm machinery industry according to the demand of provincial agriculture, to raise the technical quality of agricultural workers, to improve and to perfect the rules and regulations of agricultural operation systems, especially the input systems to stimulate the initiative of the farmer masses.

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Table 1. The Technic Assemblies Adopted in Heilongjiang Province

Name of The Technics	Technic Elements & The Standard	Functions Realized	Yield Increase
Minimum tillage and plowing by turns	Subsoiling: 27 – 40 cm Turning: 18 – 25 cm Harrowing stubble land: 10 – 15 cm Plowing once every 3 years	Crop rotation, plowing by turns, minimum tillage, power saving; loose & compact soil over turned, regulatingthe equilibrium of water, fertilizer, gas & heat in the soil; resisting erosion, drought & waterlogging	10% – 12%
Precision sowing with 3 depth	Seed bed deep subsoiling: 18 – 25 cm Furrow deep subsoiling: 20 – 25 cm Fertilizer deep application: 10 – 15 cm Precision seeding	Alternate subsoiling, change seed bed & furrow alternatively, deep application to raise the fertilizer effect, crop seedlings plants even and strong	Soybean: 16 – 37% Corn: 20%
Fertilizer deep application	1st layer: 4 – 6 cm under the seed 2nd layer: 9 – 12 cm under the seed Apply once the total amount for whole year	Put fertilizer by layers to be absorbed at diffrent time, root system deeply taken to ensure fertilizer total amount applyed to raise the effect	·11%
Film mulching	Film mulching by machine big ridge space: 97.5 – 105 cm small ridge space: 65 – 70 cm	Increasing temperature, water conserving, weed restraining, raising fertilizer effect	Corn: 25%
Herbicide application	Mechanized spray: uniform, accurate amount of herbicide used	High efficient, low cost, weed control, reduce cultivation, increase yield	4 – 5%
Cut and return straw and stubble back land	Length of the straw cut less than 10 cm, amount of the stubble treated more than 80%	Improve soil texture, raise soil fertility, control soil erosion, increase the capacity of conserving water	Corn: 7.7% Soybean: 8.1%

Table 2. The Comprehensive Technical Assembly Model and the Corresponding Agricultural Machinery System for Intercropping and Rotation of Corn, Wheat and Soybean

Name of the technical assembly set	Elemental technics	Coresponding agricultural machinery system
Minimum tillage technics on dry land	Subsoiling, plowing, harrowing Crop rotation, plowing once every 3 years	1SQ−250 Subsoiler 1LX−435 Mounted moldboad plow 1BJ−4.4 Dis harrow
Alternate plowing on big and small ridge	Corn big ridge 97.5−105cm(4row) Soybean small ridge 67−70 cm (6 row)	1GL−4.2 Big & small ridge tillage machine 1LZ−770B Ridge farming 7 bottom plow III
Deep application of total amount fertilizer	Total amount multiple fertilizer once application by layers	
Corn big ridge watering precision sowing & film mulching	Seed selection and wrapping Seed bed watering, double row precision sowing, row dis. 30 cm Film mulching	5BA−1.0 Seed wrapping machine 2BSM Big ridge precision seeder PM−1 Mulching machine
Precision sowing with 3 depth (soybean)	Seed bed deep subsoiling Fertilizer deep applied by layers Precision seeding on ridge Furrow deep subsoiling	1LFBJ−6 Precision seeder with fertilizer for ridge farming GBL−4 Combined tillage machine
Wheat sowing with side & deep fertilizer applying	Side & deep fertilizer applying Precision sowing	2BLX−3.6 General propose seeder
Herbicide application	Spraying herbicide, insecticide, regulator or controllers	3WQ−200/400/650 Sprayer
Mechanical harvesting & return straw, stubble back to land	Combining harvesting & returning straw back to soil Stubble cutting & back to soil	4Y−2A Corn combined harvester Wheat & soybean combine 1FCH−4 Returning stubble to back soil machine