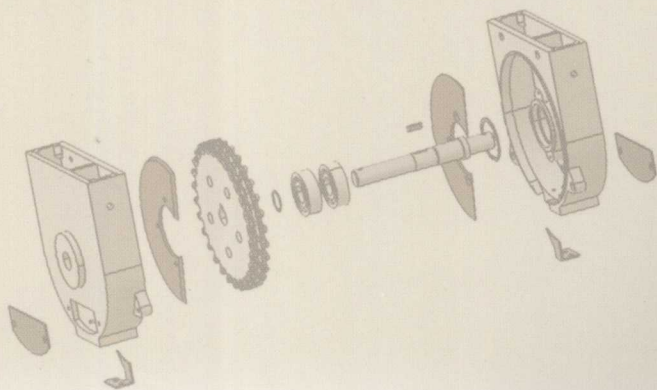


大豆密植平播机

关键部件研究 及整机设计

STUDY ON KEY PARTS AND HOLISTIC DEVICE
OF THE SOYBEAN DENSE AND FLAT SOWING MACHINE

刘宏新◎著 王福林◎审



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序

作为重要的经济作物，大豆生产在我国农业生产中一直占有重要地位，相应的良种繁育、种植模式、配套机具等方面均受到广泛的重视，技术不断推陈出新。密植平作法是我国上世纪 90 年代从美国引进的大豆高产农艺栽培技术，即平整地、平播、平管、一平到底的窄行密植栽培，简称“窄平密”。其核心思想是增加作物绿色面积，充分利用光、水、土、肥等资源，达到有效提高产量的目的。生产实践证明，这种栽培技术较传统方法可稳定增产 15% 以上，增收节支每公顷千余元，被认为是继水稻旱育稀植，玉米覆膜栽培和大豆垄三栽培之后的又一项突破性农艺技术，具有巨大的发展潜力，对我国粮食安全战略将产生不可估量的深远影响。

但作为一项具有突破性预期的项目，大豆密植平作法自引进以来的推广进展相对缓慢，较设想有较大差距，无法迅速转化为生产力。造成这种局面的一个重要原因是缺乏适宜的配套机具，全程机械化生产体系无法建立，与其他传统栽培方法相比，机械化劣势明显，而这种劣势又主

要集中在播种及田间管理上。目前,国内所用机具基本上属临时及过渡性质,缺乏专门的设计环节与实践检验,深入的研究与系统的理论支持更显不足,使得密植平作的农艺优势无法充分发挥。

由于农业装备的工作对象特点决定了其除技术因素外还受制于经济因素、农业生产组织形式及差异较大的各自土壤条件。因此,全面引进发达国家该项农艺技术的配套机具装备,有悖于农机作业机具较动力机械相比具有极强的地域性与适应性的属性,且高昂的配套费用也是我国农业现阶段薄弱的经济基础所无法承受的。引进消化、改进研发是发展中国家所普遍采用的形式,这种形式无论从装备成本、使用费用以及适应性上讲都是早期农业现代化发展较为现实可行的选择,我国农业装备制造和使用的历史进程及现实状况能很好地佐证这一点。基于上述原因,国家科技攻关重大项目“粮食主产区主要经济作物增效技术研究”及黑龙江省政府重大科技推广项目“大豆优质高效生产技术与示范”中,均把大豆密植平作及配套机具的研制列为重要内容之一。

本书针对最能充分发挥密植平作优势的方型理论均匀行距种植规范,在总结多年配套机具研发经验的基础上,定位于从部件到整机的创新设计,紧密结合农艺技术要求,充分借鉴国内外现有同类机具的技术特点,有针对性

地对开沟、排种、施肥、覆土、镇压等播种机具关键零部件进行深入的理论分析及研究，设计、选型、改进、试制、试验、优化创新型及改进型零部件。在建立全面系统相关理论以及实用数学模型的同时，设计紧凑、可靠、适用、实用的高性能复式播种作业单元，并以播种单元为基本元素构建机具框架、设置种肥箱、确定传动路线等辅助机构，最终提供整机及系列机型的工程解决方案，从理论及实践两方面为大豆密植平作的机械化播种提供技术保障。

限于时间及作者水平，加之现代技术日新月异的发展速度，虽努力谨慎，但疏漏之处在所难免，恳请专家学者不吝指教。

摘 要

本书选题基于国家科技攻关重大项目“粮食主产区主要经济作物增效技术研究”及黑龙江省政府重大科技推广项目“大豆优质高效生产技术与示范”，旨在为其中重要研究内容之一的大豆密植平作高产栽培新技术的推广提供装备支持。

遵循理论分析与创新设计相结合、实验室试验与实践检验相结合的原则以及全面系统的研究路线，作者就大豆密植平作配套播种机的关键部件及系列整机进行了深入系统的研究。

(1) 明确配套机具的技术要点及解决途径

从广泛查阅相关技术资料、充分征求专家意见、透彻理解大豆密植平作耕作制度下的农艺规范入手，全面总结配套机具研发的经验教训，借鉴国内外现有同类机具的技术特点并结合现代机械化作业的新要求，明确了机具技术要点在于整体结构优化、复式作业项目合理搭配、完善配套机械化作业环节、新型专用零部件研发及相关理论建立等方面。同时，本书全面总结归纳了影响播种作业性能，涵盖作业规程、结构参数、调整数据等诸方面的共性因素，并充分分析每一因素对作业性能的作用方式及影响程度，给出了相关因素之间的转换关系，为部件和整机试验研究过程中根据不同对象、不同目的、不同手段进行因素选择、水平域确定，以及通过试验研究获取具有实用价值的规律及经验总结提供了相应依据和便利。

(2) 新型高性能排种器设计

在继承和发展传统立式圆盘排种器结构简单，传动方便以及作者前期设计的侧充重力清种排种器不伤种、工作阻力小等优点

的基础上,研究开发了一种新型双体立式复合圆盘重力清种结构形式的机械式精密排种器。该型排种器创新性地采用双体及复合种盘的结构,在有效改善种子充填条件、保证排种质量的同时,成倍提高了机械式精密排种器的极限作业速度及可靠性。结合深入的理论分析及试验测试,完成了排种盘型孔参数优化,具有良好工艺性及工作性能型孔防堵塞机构、种层高度控制机构等细节设计。新型排种器实现了制造工艺简单、配合精度适宜、适于高速作业、工作可靠、便于调整维护的设计目标,全面完成了传统机械立式圆盘排种器的升级换代。突出的性价比是其重要特征。

(3) 排种器工作机理、性能特点研究及回归模型建立

为配合深入的试验研究及理论分析,探讨改进提高排种器工作性能的正确途径,设计了具有全面体现原型排种器重要特征、适应因素多水平调整、工作过程可视化、与试验台机械接口良好等特点的排种器试验装置。利用该装置于国内先进水平的 JPS-12 计算机视觉技术排种器检测实验台上进行试验研究,试验通过专业软件 Reda (Northeast Agriculture University)、Design Expert 6 (Copyright 2000 by Stat-Ease, Inc) 等进行设计及数据处理。同时,使用具有国际领先水平的 Phantom V5.1-4G (Vision Research, Inc. USA, Max-1200 帧/s) 高速摄影系统摄取排种器工作过程各环节的高速影片。

通过全面的试验研究及高速影像信息技术,明确了排种器的工作机理,以及播种(排种)作业、基础结构等诸因素对排种器工作性能的影响规律并建立相应多因素回归模型。研究手段及结论具有双重创新性,研究成果除可直接用于该型排种器的优化设计及产品定型外,对同类型排种器研究亦具有较大的基础理论指导价值。

(4) 关键作业部件研究

创新设计了差径同轴等角双圆盘分层施肥开沟器、等角螺旋线前刃及限深翼板种沟开沟器等关键零部件。差径同轴等角双圆

盘分层施肥开沟器用于侧位分层施肥,具有通过性好、阻力小、适应能力强等特点;等角螺旋线前刃及限深翼板种沟开沟器则有地形起伏敏感度高,反馈量适宜,开沟深度稳定,种沟沟型及土层结构合理等优势。

(5) 复式播种单元设计

经充分论证而选择的由侧位分层施肥、开沟、精量点播、覆土、镇压等环节组成的复式作业组合,具有项目搭配合理、易于实现、符合作物生长规律及便于作业组织等特点。在全面考虑单元功能、部件构成、联接顺序、挂接形式、仿形方案等技术环节的基础上,由差径同轴等角双圆盘分层施肥开沟器、外槽轮排肥器、等角螺旋线前刃及限深翼板种沟开沟器、双体立式复合圆盘排种器、刮板式覆土器、橡胶轮镇压器组成的高性能复式播种作业单元紧凑、可靠、适用、实用。

(6) 整机设计及机型系列化方案

整机以通用梁架为基础平台,围绕播种单元设置种肥箱,确定传动路线,兼顾功能的专用性与多用性。播种单元之间横向距离的改变可适应不同行距要求,整机限深装置的升降配合部分工作部件更换或调整亦可用于垄、台作,排种盘的更换及传动速比的调整可兼顾不同作物品种。

系列机型由大、中、小单机悬挂式及大型水平伸缩、水平折叠、多机组合牵引等6种具体形式构成。系列化由不同宽度及结构的梁架、标准播种单元数量及配置方式的变化实现,各机型零部件通用性强、联接标准化、使用灵活。

研究基于全面分析、系统设计及多种先进手段相结合,力求定位准确、思路清晰、论证充分、试验全面、数据翔实、程序标准、结论可信、理论深入、设计适用。

关键词: 大豆;密植平作;配套机具;播种机;排种器;关键部件;试验研究;高速影像

ABSTRACT

The topic selection of this book is based on the National Science and Technology Key Problem Item "Study on Technology Increasing Efficiency of the Main Economic Crop in the Main Grain Production Region" and Key Science and Technology Extension Project of Heilongjiang Provincial Government "Study and Demonstration of High Quality and Efficiency Production Technology of Soybean". The objective of this paper is to offer equipment support for the high yield agricultural technology of soybean dense and flat sowing which is one of the main research content of these two projects.

This book made thorough systemic researches on the key parts and the series holistic device of the soybean dense and flat sowing matching seeding machine according to the principle of the combination of theoretic analysis and innovating design, the combination of lab experiment and practical test and the all-around and systemic research route.

(1) Clear the technology keys of matching machine and solving approach

Based on the wide reference of related technological materials, comprehensive consultant of specialists' opinions, thorough understanding of agricultural specification of soybean dense and flat sowing cultivation system, this paper thoroughly summed up the lessons from the research and development of the former

matching machine, referred to the technological characteristics of the present same machines both at home and abroad and combined the new requires of modern mechanized operation, and further cleared the technology keys of the machine which lied in the whole structure optimization, reasonable arrangement of the multinomial seeding operation items, improvement of matching mechanized operation links, research and development of new type exclusive parts, and establishing of related theory, etc.

At the same time, the book generalized the common factors that affected seeding performance, and included operation procedures, structure parameters, adjustment data, and so on, analyzed the acted manner and affected degree of every factor, and made the converted relation of related factors to offer basis and convenience for factor selection and determination of level field according to different objects, objectives, and methods in the research of parts and whole-machine, and obtaining practical valuable rules and lessons generalization through experimental research.

(2) Design of new type and high performance seed-metering device

A mechanical type precision seeding-metering device with characteristics of twin vertical composite plate and clearing ex-crescent seeds by its gravitation was developed, which inherited and developed the simple construction, convenience transmission of traditional vertical plate, and took advantages of the low hurting seed rate and low working resistance of the one invented by the author. The device effectively improved seed filling condition, ensured the seeding qualities and also doubly increased the limiting operation speed and reliability by twin vertical composite

plate. Some detailed designs were done with the combination of theoretic analysis and experimental test, such as the cell parameter optimization of seed plate, seed hole preventing blockage structure with favorable technics and working performance, and seed layer control mechanism. The new type seed-metering device realized the objectives of simple manufacturing process, feasible cooperative precision, fitting for high speed operation, reliable work, and convenience to adjustment and maintenance, and roundly improved the traditional vertical plate seed-metering device with the outstanding characteristics of high performance and low price.

(3) Working principle, performance character research and regression model construction of the seed-metering device

In order to cooperate with comprehensive experimental research and theoretic analysis, discuss the right approach to improve and increase the performance of seed-metering device, a test device that could thoroughly reflect major characters of the original seed-metering device, adapt to factors of multiple-level adjustment, visualize the working process, and joint well with test bed was designed. The device was studied on JPS-12 cyber-vision Seed-metering device test-bed which is in the lead at the domestic. Experiment was designed and data was processed with professional software Reda (Northeast Agriculture University), Design Expert 6 (Copyright 2000 by Stat-Ease, Inc). And the working process of seed-metering device were took photos by using international advanced level high-speed image system Phantom V5.1-4G (Vision Research, Inc. USA, Max-1 200 frame/s).

The working principle of seed-metering device, and the af-

fecting regulation of other factors such as seeding operation and fundamental structure on seed-metering device performance were cleared and the multiple-factor regression model was built through comprehensive experimental research and high-speed image analysis. The research method and conclusion have double innovations, and the research findings have major fundamental theoretical and instructive value for the research of the same type seed-metering device except for the optimized design and product approval of this kind of device.

(4) Research on the key operation parts

The key parts of repugnant diameter double-disk equal angle separated layer fertilization opener and equal angle helix slide depth stop seed fossa coulter were designed. Repugnant diameter double-disk opener was apply to lateral position separated layer fertilization with the characters of well throughput capacity, low resistance, and strong adaptability; arc-edge seed fossa coulter had the advantages of high sensitiveness of topographic inequality, feasible feedback quantity, stable depth of furrowing, reasonable seed furrow mold and soil layer structure.

(5) Working unit design of multinomial seeding

The combination of multinomial operation that was thoroughly demonstrated and comprised of lateral position separated layer fertilization, furrowing seed fossa, exact amount of spot seeding, covering soil, and compacting of soil, etc. had the characteristics of reasonable item arrangement, easy realization, meeting with growth regulation of crop and convenience to operation and organization of producing. The high performance multinomial seeding unit comprised of repugnant diameter double-disk equal angle separated layer opener, outside fluted roller fer-

tilization distributor, arc-edge seed fossa coulter, twin vertical composite plate seed-metering device, scraper covering device, and rubber wheel compactor is dense, reliable, suitable and practical.

(6) Whole-machine design and scheme of series machine

Whole-machine set seed and fertilizer box around the seeding unit, confirmed transmission route, and gave attention to the exclusivity and versatility with the general beam mounting as the fundamental platform. The cross range changes among seeding unit could adapt to different requires of distances between rows, the lifting and dropping of whole-machine depth stop device cooperated with the replacing or adjusting of parts can also fit with ridge and dado, the replacing of seeding plate and the adjusting of speed ratio could be used to different crop species.

Series machine comprised of large, medium, and small scale single machine carried types and large-scale multiple machine combination pull type, single machine model was realized with the width of beam mounting and the increasing or reducing of seeding unit, large-scale multiple machine combination pull type model was assembled with standard single machines with exclusive combined draw frame which had standard hanging interfaces. The parts of family machines have characters of well throughput capacity, standardization jointing, and flexible uses.

This research has exact orientation, clear thoughts, thorough demonstration and experiment, full and accurate data, standard procedure, reliable conclusion, and so on with thorough analyses, systemic design and the combinations of many advanced means.

Key Words: soybean; dense and flat sowing; matching machine; seeding machine; seed-metering device; key parts; experimental research; high-speed image

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