CHAPTER II

REVIEW OF LITERATURE

This chapter deals with the review of research works reported mainly on threshing aspects of soybean threshing especially for seed purpose. Although there is long list of literature reviewed pertaining to the subject of study such as, traditional practices adopted by the farmers and their constraints, experimental studies on various factors affecting thresher performance, studies on physical, mechanical properties of pod and seed. Recent developments and present status of threshers developed. Seed quality and norms for quality soybean seed as per BIS, USDA and International seed norms. At all India level several efforts were made to develop a soybean thresher, but the designs could not be taken up to the level of commercial production. In this chapter, an attempt has been made to present the research and development works done on different aspects of threshing for seed purpose under the following headings.

2.1 Development of soybean thresher in India

2.2 Experimental studies on various factors affecting threshing performance;

2.1. Development of soybean thresher in India

2.1.1. Pantnagar soybean thresher

In India soybean thresher development work for soybean threshing was started at Pantnagar. Two units of soybean threshers were developed at GB Pant University of Agriculture and Technology, Pantnagar (1974-75). Both the threshers consisted of rasp bar type cylinder, concave, straw walker and blower fan. The performance of small thresher (7.5 hp) at 8 x 10 mm cylinder concave clearance and 620 m/min peripheral cylinder speed for variety Bragg at 10.00-12.00 per cent grain moisture content was studied by Chhabra and Singh (1976). They reported that the free grain loss increased rapidly with increase in feed rate. The damage percentage was high at lower feed rate and lower concave clearances. The minimum breakage was 5.14 per cent at 846 Kg feed rate at a moisture content of 10.00-12.00 per cent. The maximum power requirement at higher feed rates was about 6 hp. The larger thresher (15 hp) was tested on two varieties of soybean, Ankur and Bragg. It was reported that grain damage increased and percentage of unthreshed grain decreased as the cylinder speed was increased.
The effect of grain moisture on damage was high in lower moisture range even at lower cylinder speed for both the varieties. Bragg was more susceptible to damage and had better thresh ability than Ankur. They have also recommended the operation of the threshers at cylinder speed of about 800 m/min for 14.00-15.00 per cent and 500 to 600 m/min for 10.00-13.00 per cent of grain moisture for minimum damage and unthreshed grain. The output capacity of the threshers was 800 to 900 Kg/h at a cylinder speed of 800 m/min with 4.40 per cent grain damage at 14.00-15.00 per cent grain moisture content.

Singh and Singh (1981) compared the results of manual threshing, tractor treading, threshing with soybean thresher and stationary combine on the basis of labor, fuel power requirement, capacity, damaged and unthreshed grain, germination percentage and cost of operation. Threshing soybean with rasp bar type thresher with a capacity of 421 Kg/h which resulted in 8.5 per cent unthreshed grain, 3.40 per cent grain damage and 92.00 per cent germination. The latter was superior to other systems.

2.1.2. Soybean thresher developed at Udaipur

Nag and Devnani (1970) reported that the damage in the threshing of beans occurred mostly due to impact. The peripheral speed of the threshing cylinder was found to be the most critical factor to be considered to minimize seed and grain damage of soybean and other beans.

A small (2 hp) soybean thresher was developed at the Mohanlal Sukhadia University, Udaipur (1971). The thresher consisted of a feeding tray, rasp bar cylinder, open concave and blower. On testing, the threshing efficiency was found to be 90.00 per cent with 0.20 per cent seed damage at 10 mm concave clearance. The output capacity of this threshing was 85 Kg/h at a cylinder speed of 6.89 m/s while the power consumption was 1.15 KW (Sharma and Devnani (1980)). They have also recommended the cylinder tip speed and concave clearance for soybean and cowpea threshing of 6.89 m/s at 12 mm and 4.8 m/s at 8 mm clearance for seed purpose, respectively.

2.1.3. Development of multi crop thresher at Jabalpur

A multi crop thresher for cereals and pulses was developed at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur during 1974. The unit was a modified version of Akshat paddy thresher to suit different crops. The additional feature was a modified concave and additional screen which improved the threshing and cleaning efficiencies. It was fitted with spike tooth type threshing cylinder with 2 hp electric motor. The capacity of this thresher on soybean was 300 Kg/h (Shanmugham, 1981).
2.1.4. Development of multi crop and soybean threshers at Bhopal

The work on threshers started at the Central Institute of Agricultural Engineering, Bhopal, in the year 1979. Initially, four different types of commercial threshers were evaluated on major cereals, pulses and oilseed crops during 1979-80. Majumdar (1981) reported that only one thresher having independent drive to cylinder and blower could thresh major crops except paddy with minor modifications. This thresher consisted of spike tooth cylinder, different size of concaves and sieves, two separate blowers, conveying auger and grain elevator. During initial trials, the machine could not work on soybean at manufacturer recommended speed of 780 m/min due to excessive grain damage of 25.00 to 50.00 per cent at conveying auger outlet and 8.00 to 25.00 per cent at lower sieve when the feed rate was reduced from 100.00 to 50.00 per cent. The above problem was overcome by reducing radial gap of concave bars from 12 to 8 mm, disconnecting auger and reducing cylinder speed to 390 m/min.

Attempts were made by different research organizations in the country to develop multi crop threshers during last 10 to 15 years. Major work was done under ICAR Co-ordinated Scheme on Farm Implements and Machinery located at different agro-climatic regions in the country. The centre located at Punjab Agricultural University, Ludhiana reported the development of paddy-wheat-maize, paddy-wheat, paddy-sunflower and groundnut threshers. GB Pant University of paddy-wheat and paddy-soybean thresher. Mohanlal Sukhadia University, Udaipur reported the development of sunflower-mustard and soybean-cowpea thresher. The Central Institute of Agricultural Engineering, Bhopal reported the development of a multi crop thresher for wheat, gram, maize, sorghum, soybean, paddy and a groundnut thresher. Though the performance of these threshers were superior over to conventional spike tooth thresher, but these were not adopted by the manufacturers for commercial production because of change in production technology, high cost involved and problems of selling existing conventional threshers.

Majumdar (1982) evaluated the thresher on JS 7244 variety of soybean indicated that the percentage of damaged beans was only 0.7 at a cylinder speed of 390 m/min and grain moisture of 9.30 per cent. The grain damage was more at higher cylinder speed and at low feed rate. The separation loss was about 1.00 per cent on above speed. The output capacity of this thresher was 143 Kg/h with a 3 hp electric motor. The thresher was provided with round spikes and could not produce very fine, bruised wheat straw of
desired quality and was therefore not popular among the farmers in spite of its best features for threshing variety of crop.

On the basis of above studies the work on development of a multi crop thresher (5 hp) was taken up in the year 1982. The above studies also revealed that spike tooth type threshing cylinder could thresh major crops effectively but the cylinder speed was to be adjusted according to the crop conditions. For threshing paddy, axial flow principle of threshing was found to be more effective. Therefore, the development of cylinder included the incorporation of axial flow threshing mechanism and conventional spike tooth cylinder design in one unit. The thresher consisted of spike tooth cylinder (500 mm dia.) different concaves and sieves, aspirator blower and two covers, one for paddy and another for crops other than paddy. Paddy top cover was provided with louvers to more the threshed material axially. The blower was mounted on a separate shaft for better control over cylinder speed.

The improved thresher was tested by Majumdar (1985) at different feed rates and speeds. The grain damage was found high at higher speeds and low feed rates. The optimum peripheral cylinder speed for satisfactory performance was found to be 440 m/min for JS 7244 variety of soybean at grain moisture of 8.00 to 9.00 per cent. The feed rates had a very little effect on threshing efficiencies for almost all crops tested. The grain output capacities of the thresher were 276, 348, 1635, 200, 540 and 392 Kg/h at cylinder speed of 1100, 630, 480, 440, 600 and 780 m/min for wheat, gram, maize, soybean, sorghum and paddy respectively. The grain damage range from 0.35 to 2.20 per cent and un threshed loss was 1.00 per cent or less for threshing above crops. The cylinder was provided with 10 mm thick flat spikes and could produce fine straw of wheat, gram, soybean and sorghum.

Singh and Majumdar (1986) modified a commercial wheat thresher for different varieties of soybean. It consisted of a conventional spike tooth threshing cylinder, blower, concave and sieves. The aspirator blower was provided on the cylinder shaft. The recommended speed for threshing wheat was 1200 m/min which had to be lowered for soybean but the cleaning system did not work below 540 rpm. So the speed was kept at 540 rpm (700 m/min) and the number of spikes in each row was reduced to one instead of seven. Different varieties of soybean were threshed at grain moisture range of 6.00 to 15.00 per cent. It was observed that the grain damage was less than 2.00 per cent. When grain moisture was more than 12.00 per cent, the output capacity of the thresher was
244, 270 and 254 Kg/h for Punjab-1, JS 7244 and JS 2 respectively with a 7.5 hp electric motor. The straw quality was poor.

Saxena and Ojha (1988) reported that percentage of un threshed grain decreased with an increase in cylinder speed and decrease in pod moisture content. The per cent of damage grain increased with an increase in cylinder speed while it decreased with the increase in grain moisture content. However, it was noticed that cylinder speed had more pronounced effect on un threshed and damage grain than moisture content of pod or grain. Similarly, the energy requirement increased with the increase in pod moisture content as well as cylinder speed.

Yadav (1990-91) evaluated Nursery Master Elite plot combine for soybean harvesting at 7.3-10.9 m/s peripheral speed of the cylinder keeping concave clearance 20-10 mm front and rear respectively. The threshing efficiency, cleaning efficiency, broken grain, shattering and combining loss were recorded as 98.70 per cent, 95.00 to 96.00 per cent, 0.87 to 5.30 per cent, 0.15 to 0.45 per cent and 1.40 to 5.40 per cent respectively. Varietals seed mixing was observed to be negligible.

Yadav (2004) conducted comparative test of three different type of threshers namely spike tooth round bar type cylinder, spike tooth flat beater type and rasp bar type threshing cylinder on soybean variety JS 335. He reported the performance of round bar type thresher was superior as compared to other designs in terms of seed damage and germination of seed. Scope of design refinement of machine components was suggested in the paper.

Yadav (2007), conducted study on design refinement of thresher for soybean seed purpose. Refinements incorporated in the spike tooth type thresher design have been highlighted in the report for soybean seed purpose.

Yadav, Singh and Udhayakumar (2008) reported the findings of the study on thresher development for soybean seed purpose. The findings of the study included the thresher test, and design data for soybean variety JS 335 during threshing at low moisture regime between 5.00-13.00 per cent moisture. They optimized the design parameters for soybean threshing and reported peripheral speed, concave clearance, rib spacing, crop feeding height, crop feeding angle and moisture content and their effect on seed damage, seed germination, threshing, cleaning efficiency, thresher output capacity and economics of thresher developed.
2.2. Experimental studies on various factors affecting threshing performance

The factors which affect the quality and efficiency of threshing are broadly classified in three groups such as:

A. Crop factors
   a. Variety of crop
   b. Temperature of grains
   c. Moisture of crop material.

B. Machine factors
   a. Feeding chute angle
   b. Cylinder type
   c. Cylinder speed
   d. Cylinder diameter
   e. Concave size, shape, numbers
   f. Concave size, shape and clearance

Number of researchers studied these factors critically and their findings are as follows:

2.2.1. Effect of crop factors

Bainer and Winters (1938) reported that the seed of dicotyledonous plants (such as beans) were extremely susceptible to impact.

Silver (1942), Singh and Linvill (1977) and Singh (1981) reported that the variety of grain had much influence on grain loss during threshing.

Burrough and Harbage (1953) reported that the percentage of kernels damaged by the shelling unit was almost directly proportional to the moisture content of the kernel.

Lamp et al., (1961) observed that increased threshing effort required for high moisture harvesting resulted in a reduction in germination.

Arnold and Jones (1963) observed that the damage present in wheat samples was more than barley under similar machine settings.

Arnold (1964) reported that the damage incurred by cereal grains during combine harvesting was controlled by their moisture content at the threshing.

Henderson (1965) found that high moisture soybean was more susceptible to bruise damage than low moisture soybean and concluded that soybean with a moisture between 10.00 and 15.00 per cent was the most resistant to mechanical damage.

Hoki and Pickett (1973) reported that moisture content of beans was a major factor in controlling the damage. A decrease in moisture appeared to greatly increase in
the brittleness of the beans. Beans with low moisture content were very much susceptible to splitting during impact from the side.

Pickett (1973) observed that the threshing loss was dependent on both the bean moisture and pod moisture. Excellent condition for harvest would be to have been moisture between 17.00 and 20.00 per cent and pod moisture as low as possible, preferably below 12.00 per cent. When bean moisture was low, harvesting could proceed only when the pods were especially dry so that low cylinder speed could be used without excessive threshing loss.

Using laboratory impact tester Paulsen (1978) found that a greater percentage of large beans were damaged than small beans at same impact velocity and orientation. Amount of damage increased rapidly as temperature was decreased below 50° F.

Singh and Singh (1981) concluded that the unthreshed grain increased with increase in pod moisture content whereas the grain damage decreased with an increase in grain moisture content.

2.1.2. Effect of machine factors

Arnold (1959) studied the effect of harvest damage on the germination of barley at different cylinder speeds and concave clearance. The results revealed that there was little difference in germination between the grains harvested at the two moisture levels but that both high cylinder speed and a small concave clearance caused damage and that the effect was cumulative.

King and Riddolls (1960) studied the effect of different combination of cylinder speed and concave clearance on damage to wheat and pea seeds at fairly low moisture content. The studies revealed that high cylinder speed was the chief factor in increasing visible damage.

Extensive field work in soybean combine was conducted by Lamp et al, (1961). Tests were done over a period of five years in mostly high moisture crops. Threshing loss and bean damage were reported as function of threshing speed and crop moisture level. It was determined that increasing the cylinder speed for high moisture soybean harvesting resulted in reduced germination and increased splits and cracked seed coats.

Mark et al, (1962); Henry (1942); Bunnelle et al, (1954); reported that the damage in the threshing of beans occurred mostly due to impact. The peripheral speed of the threshing cylinder was found to be the most critical factor to be considered to minimize seed and grain damage of soybean and other beans.
Bainer et al., (1963) reported that with increase in cylinder peripheral speed the seed damage increased while threshing losses were reduced. Tests carried out at California Agricultural Experimental Station indicated that the unthreshed seed loss increased with the increase in total feed rate.

The experiment conducted by Arnold (1964) at National Institute of Agricultural Engineering showed that reduction of damage and its possible elimination depended mainly on the use of lower cylinder speeds. Most of the threshing is done by impact of the beaters on the crop and this caused most of the damage. Hence, any means of reducing the magnitude of number of impacts required could reduce the chances of damage to the grain. It was further noted that cylinder speed was one of the most important factors effecting cylinder losses which progressively decreased with the increasing speeds.

Threshing percentage (13.62 %) increased with the increases in cylinder peripheral speed and decreased with the increase in moisture content (Arnold et al, 1958; Bainer and Bothwich, 1934; Peter, 1964).

Kemp et al, (1967) reported that lower cylinder speed caused lower seed damage and observed 0.75 per cent seed damage at a peripheral speed of 1570 fpm (478 m/min).

Shoji and Sano (1968) studied the process of threshing by means of high speed cinematography. It was reported that the time requited for threshing in earhead was found to be about 1/100 to 1/50 second. In threshing process, there were two kinds of actions. Firstly, the teeth directly struck against an ear while touching and secondly, the grains were shaken off on the occasion of swinging ears. The ears were found to be oscillated by advancing the teeth.

Harrington (1970) developed a multi crop thresher with spike tooth cylinder and a fixed cylinder-concave clearance. This thresher resulted in wheat straw split of 25.00 to 30.00 per cent of original length.

Mittal and Arya (1970) reported that the effect of the speed of the threshing cylinder on the output of the threshed grain varied with variety. Total grain losses increased with increased in threshing cylinder speed.

Pathak (1970) reported that hammer mill type threshers bruised the straw very fine but the specific energy requirement was highest among all types of threshers.

Kaul and Kumar (1975) reported that spike tooth cylinder type of machine are more popular in India due to their compact design, less energy requirement and less grain damage. However, the performance of these threshers varies considerably in terms of energy consumption, grain out and grain loss.
Studies have shown that fast cylinder speed is the main cause of threshing damage. In a single impact test, Cain and Holmes (1977) observed that both the percentage of splits and the percentage of beans with cracked seed coats increased as impact velocity increased and as bean moisture content decreased.

The effect of concave length when threshing wheat and barley was studied by Cooper (1978). It was reported that a 25.00 per cent increase of arc from 84° to 105° increased grain separation by 17.00 per cent; but a similar increase are from 105° to 135° gave a smaller increase in grain separation (5.00 %); however, the importance of increasing concave separation efficiency was emphasized when a 5.00 per cent difference of concave separation nearly halved the level of straw walker loss.

IRRI-PAK axial flow thresher, which had a provision of threshing and wheat straw bruising, was evaluated by Ahuja et al. (1980) on paddy and wheat. It was reported that the major problems encountered while threshing wheat were poor quality of straw and straw was thrown at small distances. The machine performance on paddy was satisfactory.

Newbery et al. (1980) evaluated the damage to soybean caused by rotary and rasp bar threshing mechanisms of combines and observed that the percentage of splits were significantly higher for rasp bar cylinder than for the rotary threshing mechanism at similar threshing cylinder speeds. In either the above systems increase in cylinder or rotor speed resulted in an increase in percentage of split grain and decrease in threshing and separating losses. Increasing the concave clearance generally decreased the percentage of splits, but the effect was less than caused by changes in cylinder or rotor speed.

Thyagraj and Shrivastava (1980) carried out studies on safety feeding chute and recommended the minimum bottom length as 90 cm and top cover length as 45 cm. They also suggested a tilt angle up to 6° with horizontal for proper feeding of crop materials.

Verma et al. (1980) estimated that every year there was about 1000 thresher accidents in India resulting in either loss of life or disability to the workers. Survey in Punjab revealed that about 73.00 per cent of accidents was due to human factors like carelessness, over work, physical incapability and unskillful ness. About 13.00 per cent of accidents were due to machine factors like improper feeding system. About 5.00 per cent of accidents took place due to crop factors like short crops and about 5.00 per cent due to environmental factors as insufficient light, and hot weather conditions.

Majumdar (1981) conducted threshing studies on different crops with different types of commercial threshers. The types of cylinders were spike tooth having cylinder
and blower on separate shafts, hammer mill and axial flow. The studies revealed that the
spike tooth type thresher having independent drive to cylinder and blower could thresh
major crops effectively but the cylinder speed was to be adjusted according to the crop
conditions. For threshing paddy axial flow principle of threshing was found to be more
effective.

Rawal and Verma (1982) studied the effect of base and cover angles and the
covered length of the feeding chute in relation to the feed rate, physical effort, muscular
and mental fatigue. It was suggested the feeding chute with base length of 90 cm, cover
length of 45 cm base and cover angles of 5° to be optimum for maximum feed rate
against minimum physical effort for spike tooth thresher.

Multi crop threshers based on conventional rasp bar design were available in the
country. These could thresh most of the crops except groundnut. However, these
machines had no provision to bruise the wheat straw which was invariably sought by the
farmers as cattle feed (Sharma et al, 1983). The concept of a wheat straw bruising
attachment to threshers which could deliver long straw was technically feasible.
However, it was a very costly and relatively complex system which had very low chances
of adoption by the farmers (Sharma et al, 1986).

Banga et al, (1984) studied the spikes tooth threshing system for wheat crop. The
studies revealed that:

i. Increased cross-sectional area of spikes increased grain crackage and power
consumption and produced fine straw;

ii. Longer spikes reduced grain crack age;

iii. Less number of spikes in rows consumed more power due to more retention time and
caused less grain damage and poor quality straw and

iv. More number of spikes consumed more power due to higher impact forces.

It was also reported that the performance of flat spikes were better over round and
square shaped spikes. It was due to fine quality of straw with minimum specific power
requirement.

Hundal et al., (1984) suggested that the capacity of the thresher can be increased
considerably on wheat by increasing concave bar spacing but reported poor straw quality.

Kamble and Panwar (1984) reported that spike tooth cylinder caused least grain
damage over rasp bar and round bar for threshing green gram. They recommended
peripheral speed of 7 m/s and 5 to 10 mm concave clearance for threshing crop,
Studies conducted by Kamble and Panwar (1984) with an experimental thresher having provision for mounting rasp bar, round bar or spike bars on green gram indicated that threshing efficiency and grain damage increased with the increase in peripheral speed. For the round and rasp bar cylinder, the damage to grain was excessively high beyond the cylinder speed of 540 m/min. Threshing efficiency and grain damage varied inversely with the concave clearance. The influence of clearance, on grain damage was appreciably high at the higher speeds. Threshing efficiency and grain damage were inversely related to the grain moisture content.

Madan et al. (1985) reported that axial flow threshing system can handle high moisture crop while existing threshing system can handle dry crops only.

Norris and wall (1986) studied cylinder-concave performance in corn with fine concave with different axial bar spacing, radial rod spacing and bar height, using constant cylinder-concave clearance. It was reported that increased concave open area resulted in increased concave separation efficiency and decreased kernel damage.