Trends in Biosciences 5 (3): 163-165, 2012

Mechanized Harvesting of Cereal Crops - An Overview of the Problems and Factors Affecting

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ABSTRACT

Harvesting is one of the most labor intensive operations in the production of crops. Development of mechanical harvesters / reapers operated by self mounted engines, power tillers, tractors and combined harvesters for harvesting crops like paddy, wheat and other cereal crops are gaining the popularity. The efficiency of harvesting operation depends on the shear stress and the modulus of elasticity of the crop. The factors affecting the shearing principles are the moisture content, height and the diameters of cutting stem. The shearing stress of wheat stalk given the direct relation to wheat stems size and the moisture content, but has inverse relation with the cutting height of stalk because of a reduction in stalk diameter. The bending stress and modulus of elasticity has got inverse relation with moisture content (Esehaghbeygi et al., 2009). However the findings with the cotton crop contradicting with the shearing principle of wheat. The shearing stress and moisture content of cotton stalks leads to increasing the cutting efficiency, which means decreasing the shear stress (Metwalli et al. 1995). Also the reapers developed for harvesting crops like wheat and paddy could not become popular for harvesting finger millet and other rain fed crops because of varied crop materials. Several commercial reapers developed has got vide range of field capacities for wheat and paddy crops.

Key words *Harvesting, reapers, shear stress, modulus of elasticity, efficiency, field capacity*

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Harvesting is one of the most labor intensive operations in the production of crops. Traditionally crops are harvested manually using locally made sickle which is time and labor consuming operation and both are scares during peak harvesting season. The harvesting period is very short and delay in harvesting reduces both quality and quantity of grain. Further, due to the rapid industrialization and large scale migration to urban areas, labor is becoming increasingly scarce and also proving costly. This labor shortage during harvesting resulted in delayed harvest and consequent field grain losses. Labor requirement for harvesting of cereal crops with traditional manual harvesting varies greatly depending on the crops, crop conditions, type of tools and the quality of man power used. Mechanization of harvesting is an alternative solution will also result in lesser cost of operation. Where farmers have adopted combines for harvesting, alternative straw handling and disposal technology may have to be developed and promoted, as burning of straw is creating environmental pollution and farmers are losing valuable animal feed material (Gyanendra Singh, 2002). The efforts of the research work in various research organizations in India and abroad resulted in developing the mechanical harvesters / reapers operated by self mounted engines, power tillers, tractors and combined harvesters for harvesting crops like paddy, wheat and other cereal crops (Pndey and Devanani,1987 and Mohammad Raza Alizadeh et al., 2007). Based on the power operated paddy reaper designed by IRRI, Philippines, power tiller operated reapers were developed and evaluated for harvesting wheat (Garg et al. 1984). However the reapers developed for harvesting crops like wheat and paddy could not become popular for harvesting finger millet and other rain fed crops because of various reasons. One of the main reasons attributed to the blade design and metallurgy. Cutting blades used for harvesting soft and non fibrous stem portion of the crops like wheat and paddy were not very effective in harvesting crops like finger millet, since the stem portion of the finger millet crop is hard and fibrous. Further the height, ear-head size and the size of the stem portion of wheat and paddy crop were small as compared to the height, ear-head size and the size of stem portion of finger millet. The

cutting blades fitted in the existing reapers used for harvesting wheat and paddy becomes wear and tear and requires very frequent replacement when they are used for harvesting crop like finger millet, jawar, bajra etc. due to hard and fibrous stem and needs frequent replacement. This necessitates the design and development of suitable blades material which can effectively used for harvesting hard stem cereal crops.

HARVESTING

Harvesting of crops is an important field operation and it is one of the most labor intensive operations in the production of crops. Mechanized harvesting is done under varied situation by several commercial reapers and their capacity varies greatly. The studies on cutting of the crop stalk with traditional sickles revealed that it requires 64-128 man-h / ha (Fleurdeliz et al.1989). Nadeem (1983) has reported that the paddy harvesting by manual method require about 25 % of the total labor requirement of the crop. Depending upon the crop yield it demands 120 to 250 man-hr/ha for cutting, bundling and on-field stacking of rice field by using traditional sickle. Feasibility study conducted by Manjunath et al.,(2009) during the period 2002 to 2005 showed the reduced cost of cultivation in paddy through mechanized harvesting at the Agricultural Research Station, as well in the farmer's field of Gangavathi in the state of Karnataka. The studies revealed that the vertical conveyor power reaper (KAMCO Model KR 120) was having the field capacity of 0.3 ha/hr with the field efficiency of 73 % at an average operating speed of 3.2 kilometer per hour. Gajendra Singh et al. (1988) reported that the locally manufactured and commercially available tractor front mounted reapers can harvest 0.284 ha / h and saves 129 man-h/ha compared to traditional manual harvesting with sickle for wheat crop. It was also observed that the average field capacity of 0.4 ha/h with 4 per cent grain loss while harvesting by using reapers. Garg et al. (1984) reported the labour input for mechanical reaping was about 5 man-h / ha compared to 84 man-h / ha in manual harvesting of wheat crop. Devani and Pandey (1985) obtained the wheat crop field capacity of 0.269 ha/h with 1.6 m wide reaper, while for 2.08 m wide unit it was observed to be 0.337 ha/h. Also they observed the total harvesting losses in the range of 4 to 6 % of grain yield when grain moisture content was 7 to 11 %. The studies on cutting of the crop stalk with traditional sickles revealed that it requires 64-128 man-h / ha (Fleurdeliz et al.1989). Kumar et al. (2006) reported the harvesting of finger millet with sickles requiring about 150-200 man-h / ha.

APPLICATION OF SHEAR PRINCIPLE

Shearing stress of wheat stalk was measured for four moisture content levels (15, 25, 35 and 45 %(w.b), three cutting heights (100, 200 and 300 mm), two types of cutting knives (smooth and serrated edge) with three blades oblique angle (0, 15 and 30 deg.). The results showed that the shearing stress of wheat stems decreased as the moisture content decreased. The shearing force of stems decreased as the cutting height of stalk increased because of a reduction in stalk diameter. Reduced in shearing stress was observed by using smooth edge knife because of less friction than serrated one. The blade oblique angle of 30 degree showed the least shearing stress. The average of shearing stress varied between 3.25 and 3.86 Mpa. It was reported that the increased bending stress and modulus of elasticity with the decreased moisture content and an increased cutting height of stem. The average of bending stress observed to be between 17.74 - 26.77 Mpa and modulus of elasticity varied between 3.13 - 3.75 Gpa (Esehaghbeygi et al., 2009).

FACTORS AFFECTING

According to 1nce et.al.(2005) the value of shearing stress at low moisture content was approximately 19 % lower than at high moisture contents. This result was also reported for wheat straw, sunflower stalk and alfalfa stem (Dogherty et al. 1995, Crook and Ennos, 1994). The average shearing stresses were found to be 3.25, 3.57, 3.69 and 3.86 MPa for moisture contents 15%, 25%, 35% and 45% respectively. The moisture content had a significant effect on the shearing stress at 1% probability level. The studies of Nazari, et al.,(2008) are in line with the findings of 1nce et.al.(2005). They observed the decreased in shearing stress with increase in cutting height from ground level. Increasing the cutting height from 100 to 300 mm, resulted in reduced shearing stress by 13%. Also they observed an increasing the stem height, resulted in decreased stem diameter in the range of 5.1 to 7.5 mm.

The moisture content had a significant effect on bending stress (Annoussamy et al. [2000]). Bending stress decreased with increasing moisture content. Also it was reported that the moisture content and height had significant effects on bending stress and the value of bending stress at low moisture content was approximately 1.5 times higher than at high moisture content. However, the reports on moisture content and cutting efficiency for cotton crop are contradicting the findings of wheat (Metwalli et al., 1995). Increasing moisture content of cotton stalks leads to increasing the cutting efficiency, which means decreasing the power requirement.

Hoseinzadeh et al.(2009), conducted experiment on three varieties of wheat and knife bevel angles, four levels of moisture content and three shearing speeds of pendulum to determine their effects on the shearing energy of wheat straw. Results showed that the effects of variety, knife bevel angle, moisture content and shearing speed on shearing energy were significant at 1%. Shearing energy decreased with decreasing moisture content and bevel angle and with increasing shearing speed. Minimum shearing energy was obtained at knife bevel angles of 25° and 30°, while its mean value of 35° showed a significant difference at 5%.

Hadidi (1984) stated that, the height of crop stubbles increasing as stalk moisture content increased and decreased

with increasing of knife velocity. He added that the percentage of wheat and rice grin losses increasing as the machine forward speed increased. Increasing cutter bar speed leads to decrease in percentage of grain loss. Also, increasing forward speed leads to increase in number of uncut stalks.

Habib, *et al.*, 2002 reported the parameters affecting cutting process are related to the cutting tool, machine specifications and plant material properties. Further, they have observed the cutting energy consumed in harvesting process is much lower than the energy consumed in crushing process due to the effect of moisture content. Further, Habib, *et al.,* 2001 reported that increasing plant diameter needs higher knife velocity for performing the free cutting operation. Whereas, increasing mass of plant stalks need low critical speed. Further, they have found that the critical knife velocity affected by both height of knife from ground and the plant overall length. Also, moisture content of plants materials affecting on the critical knife velocity throwing by the cutting force, where cutting force variation with the moisture content.

Labor is becoming increasingly scarce and also proving costly and the mechanized harvesting is the need of the hour. The efficiency of harvesting operation mainly depends on the shear resistance offered by the crop for harvesting. For the application of shear principles for harvesting the crop, the factors influencing are, moisture content, cutting heights, cutting knives and the blades oblique angle. The observation of shearing stress on wheat crop revealed the decreased in shear stress with the decrease in moisture content. The reduction of shearing force was observed due to increased in cutting height of stalk because of a reduced stalk diameter. Also the reduced in shearing stress was observed by using smooth edge knife, because of less friction than serrated one. The blade oblique angle of 30 degree showed the least shearing stress. Bending stress and modulus of elasticity increased as the moisture content decreased with increased in cutting height of the stem. However, the findings are not true for the entire range of field crops. An increasing moisture content of cotton stalks leads to increasing the cutting efficiency, which means decreasing the power requirement. Similarly, use of reapers for mechanized harvesting of rain fed crop like Finger millet reported with frequent break down and repairs due to the hardy fibrous stem nature. There are no reports available for mechanized harvesting of crop like Jowar, Bajra etc. Hence there is need to improve the metallurgy of blade materials used for harvesting different crops.

LITERARURE CITED

1nce, A., urluay, S. U., Güzel, E. and Özcan, M.T. 2005. Bending and shearing characteristics of sunflower stalk residue. *Biosyst. Eng.,* **92**(2): 175-181.

Annoussamy, M., Richard, G., Recous, S. and Guerif, J. 2000. Change in mechanical properties of wheat straw due to decomposition and moisture. *Appl. Eng. Agric.,* **16**(6): 657-664.

Anonymous, 2000. Survey of Indian Agriculture, *Hindu publication*.

Crook, M. J. and Ennos, A. R. 1994. Stem and root characteristics associated with lodging resistance in poor winter wheat cultivars. *J. Agric. Sci.,* **126**: 167-174.

Devani R.S. and Pandey M. M. 1985. Design, development and evaluation of vertical conveyor reaper windower. *AMA*, **15**(a):41-52.

Esehaghbeygi, A., Hoseinzadeh, B., Khazaei, M. and Masoumi. A. 2009. Bending and Shearing Properties of Wheat Stem of Alvand Variety. *World Applied Sciences Journal,* **6**(8):1028-1032.

Fleurdeliz, S., Luarez, Bart Duff, Amande Te and Robert E. Stickney, 1989. Socio economic and technical performance of mechanical reapers in the Philippines. *Agril. Mechanization in ASIA, AFRICA and LATIN ANERICA,* **20**(1):49-54.

Gajendra, Singh, Amjad, P., Chaudhary and David Gee- Clough, 1988. Performance evaluation of mechanical reapers in Pakistan. *Agril. Mechanization in ASIA, AFRICA and LATIN ANERICA,* **19**(3):47-52.

Garg, I. K., Sharma, V. K. and Santokh Sing, 1984. *Agril. Mechanization in ASIA, AFRICA and LATIN ANERICA,* **15**(3):40-44.

Gyanendra Singh, 2002. Equipment to ensure timeliness. *The Hindu Survey of Indianagriculture,* 195-198.

Habib, R. A., Azzam, B.S., Nasr, G. M. and Khattab, A.A., 2001. A theorreticall analysis of the free cutting force of plant materials. *1st International Conference for Manufacturing Agricultural Equipment and Machinery-9th Conference of Misr Society of Agric. Engg. 9-11 Sept.*

Habib, R.A., Azzam, B.S., Nasr, G.M. and Khattab, A.A., 2002. The parameters affecting the cutting process performance of agricultural plants. *Misr J. of Agric. Engg.,* **19**(2):361-372.

Hadidi Y.M., 1984. A study on mechanical moving. *M.Sc. Thesis Agril. Engg., Mansoura University, Egypt.*

Hoseinzadeh, B., Esehaghbeygi, A. and Raghami, N. 2009. Effect of Moisture Content, Bevel Angle and Cutting Speed on Shearing Energy of Three Wheat Varieties. *World Applied Sciences Jounral,* **7**(9):1120-1123.

Kumar, K.G., Chowdegowda, M. and Jayamala, G. B. 2006. Comparative performance of mechanical reapers for harvesting rainfed and irrigated Fingermillet. *Mysore J.agric.Science.,* **40**(3): 351-355.

Kumar, K.G., Chowdegowda, M. and Jayamala, G.B. 2006. Comparative performance of mechanical reapers for harvesting rainfed and irrigated Fingermillet. *Mysore J. Agric. Science,* **40**(3): 351-355.

Manjunath, M. V., Mastan Reddy, B. G., Shashidhar, S. D. and Joshi, R. 2009. Field performance evaluation of vertical conveyor paddy reaper. *Karnataka J. Agric. Sci.,* **22**(1):140-142.

Metwalli, M. M., Helmy, M. A., Gomaa, S. M. and Khateeb, H. A. 1995. Evaluation of different mechanical methods of cutting and chopping cotton stalks, *Misr J. of Agric. Engg.,* **12**(1):205-217.

Mohammad Raza Alizadeh, Iraj Bagheri and Mir Hussein Payman 2007. Evaluation of a rice reaper used for rapeseed harvesting. *American-Eurasian J. Agric. & Environ. Sci.,* **2**(4):388-394.

Nadeem Amjad 1983. Field performance evaluation of rice reaper. *In*: *Agricultural mechanization in Asia, Africa and Latin America*, **14**:35-40.

Nazari, Galedar, M., Jafari, A., Mohtasebi, S. S., Tabatabaeefar, A., Sharifi, A., O'Dogherty, M. J., Rafiee, S. and Richard, G. 2008. Effects of moisture content and level in the crop on the engineering properties of alfalfa stems. *Biosyst. Eng.,* **101**:199-208.

O'Dogherty, M.J., Hubert, J. A., Dyson, J. and Marshall, C. J., 1995. A study of the physical and mechanical properties of wheat straw. *J. Agric. Eng. Res.,* **62**:133-142.

Pndey, M. M. and Devanani, R.S. 1987. Analytical determination of an optimum mechanical harvesting pattern for high field efficiency and low cost of operation. *J. Agric*, **36**:261-274.

Recieved on 09-07-2012 *Accepted on 08-08-2012*