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Research Article

Evaluations of Head Feed Combine in Paddy Variety HKR – 47

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ABSTRACT

Ahead feed combine was evaluated for optimization of combining parameters viz., cylinder speed (14.42, 15.53 and 16.64 m s^{-1}), forward speed (3.5, 4.0 and 4.5 km h^{-1}) and crop parameter viz., grain moisture content (18.2, 20.3, 22.4 %) in relation to threshing efficiency, cleaning efficiency and total grain losses for paddy variety HKR - 47. The optimal threshing efficiency (99.62 %), cleaning efficiency (98.95 %) and total grain losses (1.45 %) was observed in moisture content of 18.2 %, cylinder speed of 16.64 m s^{-1} and forward speed of 4.5 km h^{-1}. Therefore, moisture content of 18.2 %, cylinder speed of 16.64 m s^{-1} and forward speed of 4.5 km h^{-1} was recommended for harvesting of paddy variety HKR - 47.

Keywords: *Cleaning efficiency, Cylinder speed, Forward speed, Moisture content, Threshing efficiency*

INTRODUCTION

Rice-wheat is the major cropping system of Haryana. Presently, more than 75 % area of both the crops combine harvested and is increasing every year due to shortage of farm labor in the State. The majority of leftover paddy straw is burnt in the field which results in a huge loss of plant nutrients, organic matter and degradation of soil properties due to the wastage of residue (Walia et al., 2019, Kumar et al., 2020). Straw burning results in loss of more than 90 % carbon, 80 % nitrogen and sulphur and 20 - 25 % phosphorous and potassium (Choudhary, 2018) and gaseous emission of CO_2, CO, CH_4 and N_2O (Neemisha & Sharma, 2019). In addition to these, burning causes severe air pollution, which badly affects the human and animal health. The inhaling of fine particulate matter also causes chronic bronchitis, aggravating asthma, lung disease, decreasing lung function (Thakur et al., 2018). Burning of paddy straw also reduces visibility to a great extent, leading to accidents on roads (Thakur et al., 2018). The total loss of nutrients due to burning of paddy straw resulted in loss of Rs. 3300 per hectare (Singh et al., 2017).

Combine harvester mostly has rasp-bar type threshing cylinder which works on the principle of impact and resulted in more broken grains due to higher moisture content of paddy.

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To overcome this problem axial flow combines were introduced in which the crop advances parallel to the axis of rotor resulting in less grain damage. This problem of residue burning can be solved by using head feed combine which cuts the crop from very near to the ground and drop the straw in windrow or in bundles, which can be easily collected by manual labor or by using balers and can be used as animal fodder (Ingole et al., 2019). The threshing effectiveness and losses of combine harvester are greatly influenced by machine parameters *viz.* Cylinder speed and forward speed of operation. Crop parameters *viz.* moisture content of grain and straw, grain-straw ratio and environmental factors viz. Temperature, humidity, etc. also influence the performance of combines. Thus, there was a need to evaluate and optimize the combine parameters for efficient harvesting of crops.

MATERIALS AND METHODS

The head feed combine whose specifications are presented in Table 1, was evaluated for optimization of combining parameters *viz*., cylinder speed (14.42, 15.53 and 16.64 m s^{-1}), forward speed (3.5, 4 and 4.5 kh h^{-1}) and crop parameter *viz*., grain moisture content (22.4, 20.1 and 18.2 %) in relation to threshing efficiency, cleaning efficiency and total grain losses in paddy variety HKR - 47. The moisture content of soil varied from 14.6 – 15.4 % (w.b.) and bulk density was 1.50 g cm^{-3}. The moisture content of grain and straw varied from 18.2 – 22.4 and 52.4 – 56.7 %. The average plant height was 92 cm and the straw, grain ratio was 1.22. The data was quantified according to standards laid down and tabulated to draw meaningful inferences. ANOVA was calculated and the influence of each variable and their interaction were tested at 5 % level of significance in an OPSTAT program of CCS HAU, Hisar.

Table 1: Technical specification of Head feed combine

Dimension, mm	L x W x H	4445 x 1910 x 2635
	Total displacement (CC)	2955
Engine Crawler	Width x ground contact (mm)	450 x1580
Driving system	Transmission type	HST servo control
Reaping Unit	Width of reaping cutting blade (mm)	1450
	Type of reaping cutting blade	Two blades sliding cutting
Threshing Unit	Threshing type	Half feeding, single drum
	Threshing cylinder	Loop type
	Threshing cylinder, Dia. x width (mm)	424 x 900
Grain discharging system	Tank capacity (kg)	1400

RESULTS AND DISCUSSION

Effect of independent variables on threshing performance

The prediction equation for paddy variety HKR - 47 using multiple regression technique was:

$$T_E = 101.869 - 0.289\, M_C - 0.228\, F_S + 0.222\, C_S \quad (R^2 = 0.83) \ldots\ldots\ldots\ldots (1)$$

$$C_E = 100.97 - 0.270\, M_C - 0.124\, F_S + 0.190\, C_S \quad (R^2 = 0.81) \ldots\ldots\ldots\ldots (2)$$

$$G_L = 0.590 + 0.234\, M_C + 0.129\, F_S - 0.219\, C_S \quad (R^2 = 0.78) \ldots\ldots\ldots\ldots (3)$$

T_E= Threshing efficiency (%)

C_E = Cleaning efficiency (%)

G_L= Total grain losses (%)

R^2 = Multiple coefficient of determination (Significant at p = 0.05)

Effect of forward speed, moisture content and cylinder speed with threshing efficiency

The regression coefficients of moisture content and forward speed were negative in equation (1), which indicated that an increase of these variables resulted in a decrease in threshing efficiency. The positive value of cylinder speed indicated that threshing efficiency, increased with increase in cylinder speed. The coefficient of determination indicated that these variables contributed 83 % to total variation to threshing efficiency. The effect of forward speed, moisture content with cylinder speed and their individual interactions were significant, however, overall interaction were nonsignificant. The effect of grain moisture, cylinder speed and forward speed with threshing efficiency were presented in Fig. 1 - 3. The threshing efficiency was minimum at higher moisture content, forward speed and lower cylinder speed. It increases as the moisture content decreases and cylinder speed increases. The threshing efficiency was minimized (97.66 %) at a moisture content of 22.% with forward speed of 4.5 km h^{-1} and cylinder speed of 14.42 m s^{-1}. It increased from 97.66 to 99.62 % as the moisture content decreased from 22.4 to 18.2 % and cylinder speed increased from 14.42 to 16.64 m s^{-1} at a forward speed of 4.5 km h^{-1}. The average threshing efficiency, increased significantly from 98.09 to 99.34 % as the moisture content decreased from 22.4 to 18.2 %. The average threshing efficiency, increased significantly from 98.318 to 98.812 % as the cylinder speed increased from the 14.42 to 16.64 m s^{-1}. The average threshing efficiency decreased significantly from 98.779 to 98.567 % as the forward speed decreased from 4.5 km h^{-1} to 3.5 km h^{-1}. The minimum threshing efficiency at higher moisture content may be due to the fact that at higher moisture content the grains became slightly elastic and more impact force is required for the grain to get detached from the panicle. The results are in conformity with those reported by Ingole et al. (2019) in head feed combine.

Effect of moisture content, forward speed and cylinder speed on cleaning efficiency

The regression coefficients of moisture content and forward speed were negative in equation (2), which indicated that an increase of these variables resulted in a decrease in cleaning efficiency. The positive value of the regression coefficient of cylinder speed indicated that the cleaning efficiency, increased with the increase in cylinder speed. The coefficient of determination indicated that these variables contributed 81 % of total variation in cleaning efficiency. The effect of forward speed, cylinder speed, moisture content and their individual interactions were significant, however, overall interaction were nonsignificant. The effect of moisture content, cylinder speed and forward speed on cleaning efficiency are presented in Fig. 4 - 6. The cleaning efficiency was minimum at higher moisture content, forward speed and lower cylinder speed. It increased as the grain moisture content decreased from 22.4 to 18.2 %. The cleaning efficiency, increased as cylinder speed increased from 14.42 to 16.64 m s^{-1} at 18.2 % moisture content. The results are in conformity with Ingole et al. (2019) and Sangwijit and Chinsuwan (2010), who revealed that higher moisture content caused difficulties in the proper screening because of the poor flow of threshed material on sieve. The cleaning efficiency was minimized (97.13 %) at a moisture content of 22.4 %, forward speed of 4.5 km h^{-1} and cylinder speed 14.42 ms^{-1} and maximum (98.95 %) at a moisture content of 18.2 %, forward speed of 4.5 km h^{-1} and cylinder speed 16.64 ms^{-1}. The average cleaning efficiency, increased from 97.51 to 98.67 % as the moisture content decreased from 22.4 to 18.2 %. The average cleaning efficiency significantly increased from 97.73 to 98.14 % as the cylinder speed increased from 14.42 to 16.64 m s^{-1}. The average cleaning efficiency decreased significantly from 98.02 to 97.89 % as forward speed increased from 3.5 km h^{-1} to 4.5 km h^{-1}.

Effect of moisture content, forward speed and cylinder speed on total grain losses

The regression coefficient of cylinder speed was negative in equation (3), which indicated that an increase in cylinder speed resulted in a decrease in total grain losses. The positive value of the regression coefficients of moisture content and forward speed indicated that total grain losses increased with the increase in moisture content and forward speed. The coefficient of determination indicated that these variables contributed 78 % to total variation to total grain losses. The effect of forward speed, cylinder speed, moisture content and their interactions were significant. The effects of moisture content, cylinder speed and forward speed on total grain losses are presented in Fig. 7 - 9. The total grain losses were maximum at higher moisture content, forward speed and lower cylinder speed. It decreased as the grain moisture content decreased from 22.4 to 18.2 %. It may be due to the reason that at higher grain moisture content, un-threshed losses increases as more force is required to detach the grain from the panicle. However, at lower grain moisture content, the less energy is required to detach the grain from the panicle. The results are in conformity with those reported by Ingole et al. (2019), Alizadeh and Khoda bakhshipour (2010) and Sangwijit and Chinsuwan (2010). The total grain losses decreased as cylinder speed increased from 14.42 to 16.64 m s^{-1} and forward speed increased from 3.5 to 4.5 km h^{-1} at 18.2 % moisture content. . It might be due to the fact that at lower moisture content un-threshed grains become less, but the damage incurred to grain becomes more which resulted in more total grain losses. These results are in conformity with Ingole et al. (2019), Manes et al. (2015) and Lashgiri et al. (2008). The total grain losses were maximum (3.245 %) at a moisture content of 22.4 %, forward speed of 4.5 km h^{-1} and cylinder speed of 14.42 m s^{-1} and minimum (1.45 %) at a moisture content of 18.2 % with forward speed of 4.5 km h^{-1} and cylinder speed of 16.64 m s^{-1}. The average total grain losses decreased significantly from 2.81 to 1.79 % as moisture content decreased from 22.4 to 18.2 %. The average total grain losses decreased significantly from 2.69 to 2.21 % as cylinder speed increased from the 14.42 to 16.64 m s^{-1}. The average total grain losses increased significantly from the 2.37 to 2.50 % as forward speed increased from 3.5 to 4.5 km h^{-1}.

Selection of optimum variables for Head feed combine:

The minimum total grain losses (1.45 %) were observed in moisture content of 18.2 %, cylinder speed of 16.64 m s^{-1} and forward speed of 4.5 km h^{-1}. The maximum threshing efficiency (99.62 %) was observed in moisture content of 18.2 %, cylinder speed of 16.64 m s^{-1} and forward speed of 4.5 km h^{-1}.The maximum cleaning efficiency (98.95 %) was observed in moisture content of 18.2 %, cylinder speed of 16.64 m s^{-1} and forward speed of 4.5 km h^{-1}. The three response parameters (Total grain losses, threshing efficiency and cleaning efficiency) showed optimized values at same combination of parameters moisture content of 18.2 %, forward speed of 4.5 km h^{-1} and cylinder speed of 16.64 m s^{-1}, therefore, considered as optimum variables.

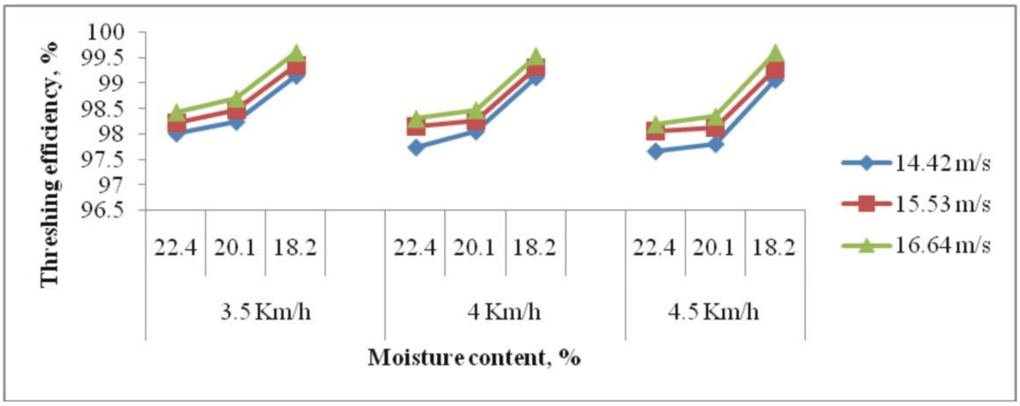

Fig. 1: Effect of moisture content on threshing efficiency (%) at different cylinder speed and forward speed

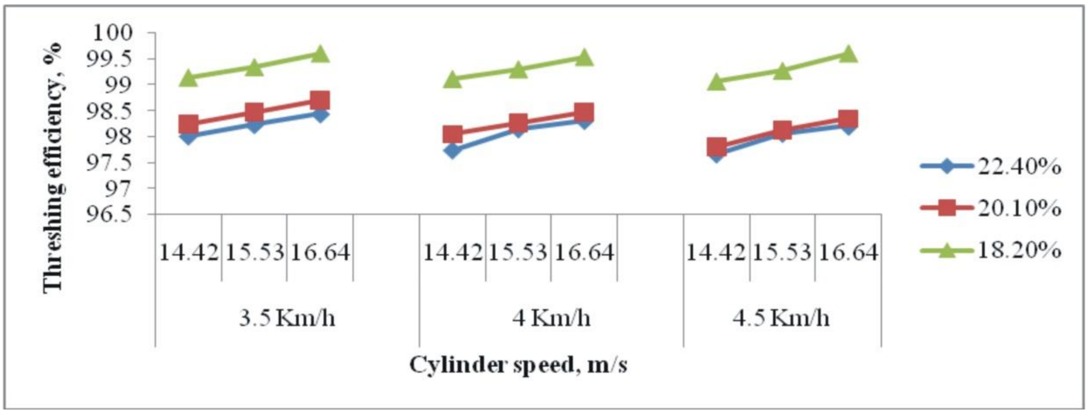

Fig. 2: Effect of cylinder speed on threshing efficiency (%) at different moisture content and forward speed

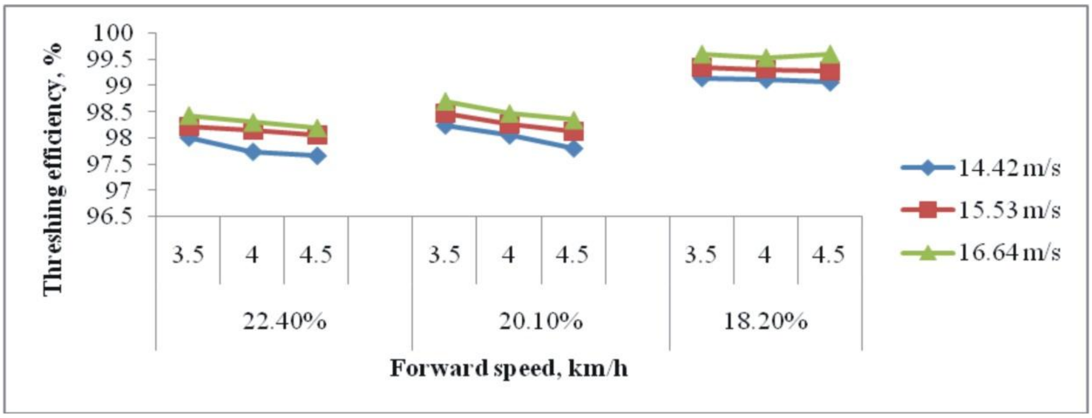

Fig. 3: Effect of forward speed on threshing efficiency (%) at different moisture content and cylinder speed

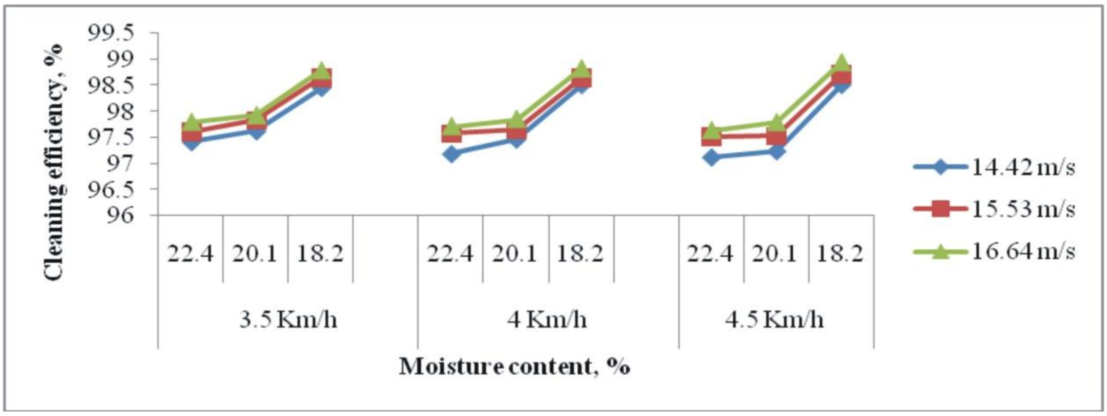

Fig. 4: Effect of moisture content on cleaning efficiency (%) at different cylinder speed and forward speed

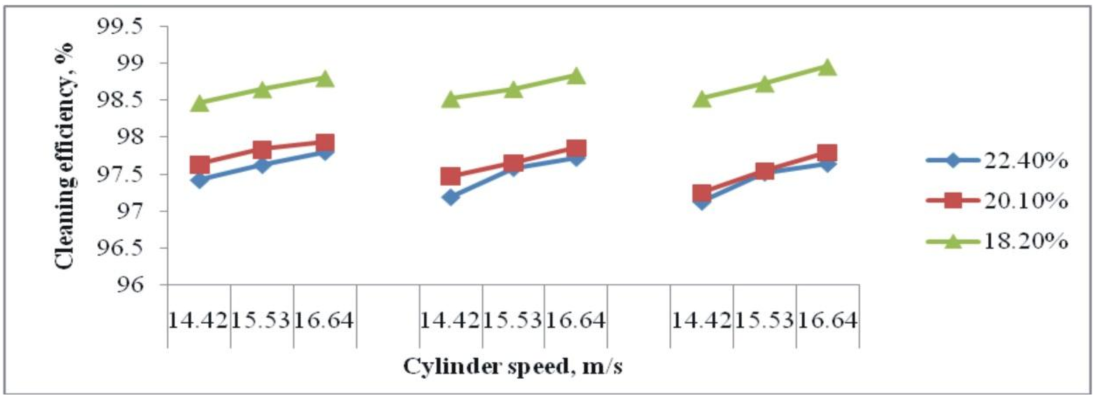

Fig. 5: Effect of cylinder speed on cleaning efficiency (%) at different moisture content and forward speed

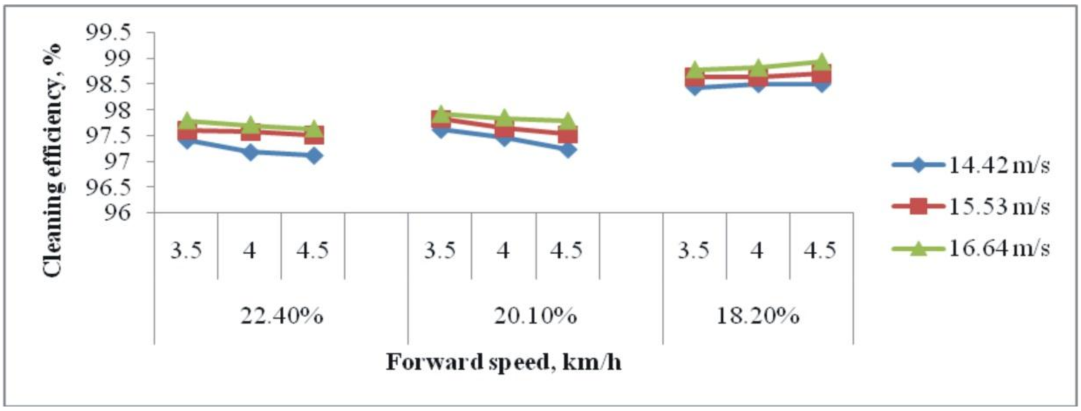

Fig. 6: Effect of forward speed on cleaning efficiency (%) at different moisture content and cylinder speed

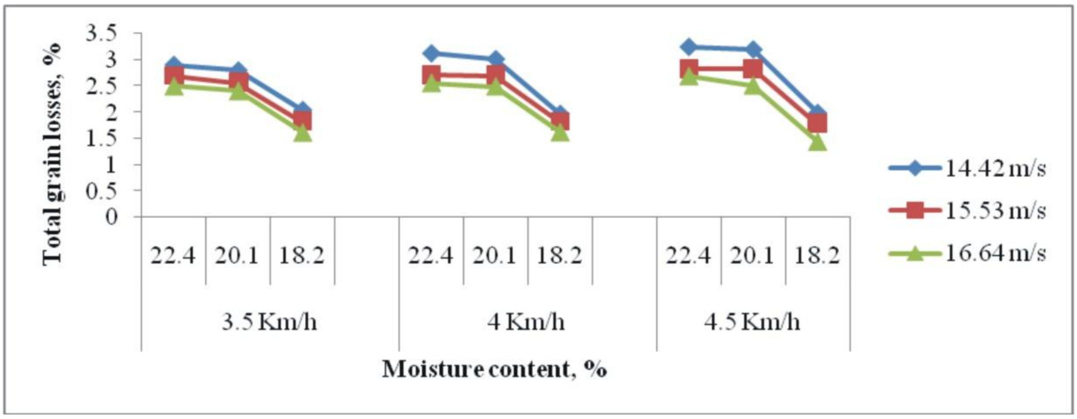

Fig. 7: Effect of moisture content on total grain losses (%) at different cylinder speed and forward speed

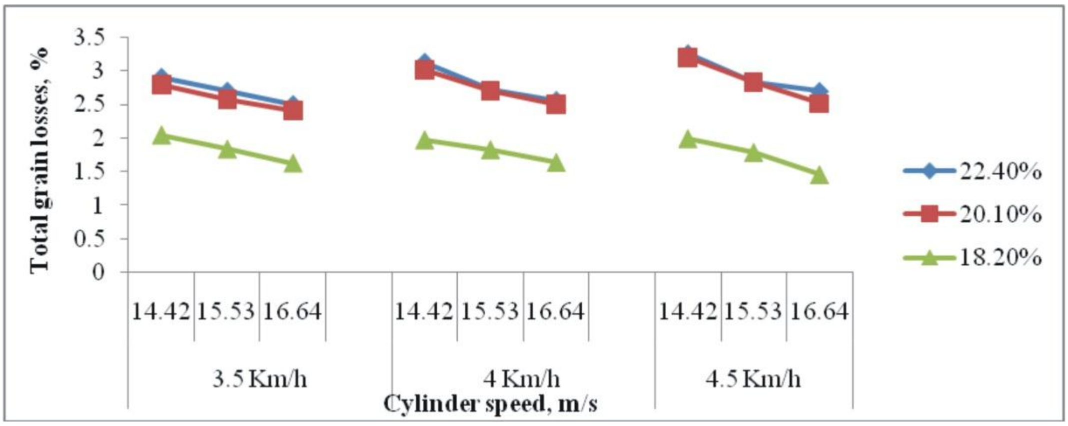

Fig. 8: Effect of cylinder speed on total grain losses (%) at different moisture content and forward speed

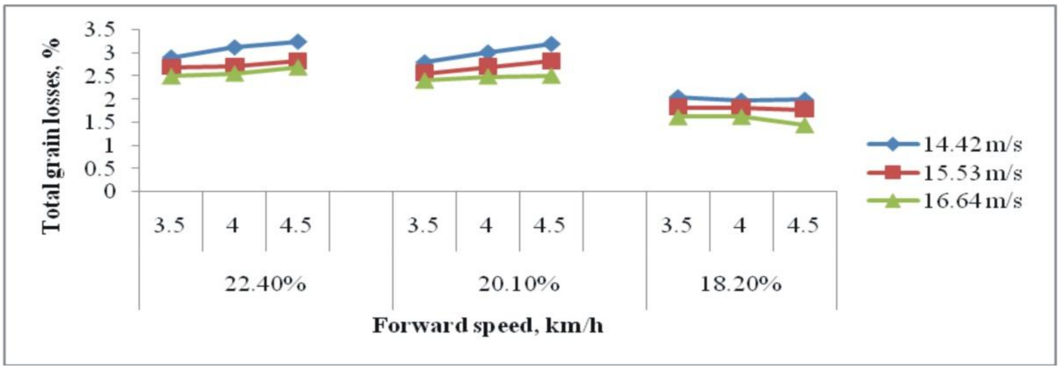

Fig. 9: Effect of forward speed on total grain losses (%) at different moisture content and cylinder speed

CONCLUSIONS

The total grain losses were maximum at higher moisture content, lower cylinder speed and higher forward speed and decreased with a decrease in moisture content, forward speed and increased cylinder speed. The threshing efficiency was minimum at higher moisture content, higher forward speed and lower cylinder speed and increased with decrease in moisture content, forward speed and increased cylinder speed. The cleaning efficiency was minimum at higher moisture content, lower forward speed and lower cylinder speed and increased with decrease in grain moisture content, increased forward speed and increased cylinder speed. The optimal total grain losses (1.45 %), threshing efficiency (99.62 %) and cleaning efficiency (98.95 %) were observed in moisture content of 18.2 %, cylinder speed of 16.64 m s^{-1} and forward speed of 4.5 km h^{-1}. The moisture content of 18.2 %, cylinder speed of 16.64 m s^{-1} and forward speed of 4.5 km h^{-1} is recommended for the effective working of head feed combine in paddy variety HKR - 47.

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