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Influence of Combine Harvester Forward and Reel Speeds on Wheat Harvesting Losses in Gezira Scheme (Sudan)

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ABSTRACT

The present study was conducted at the demonstration farm of Massaed Technology Transfer Center, Gezira State, during 2016/2017, to evaluate the effect of combine harvester forward and reel speed on wheat harvesting losses (total header, processing and total machine losses). Three combine harvester forward speeds (4, 5 and 6 km/h), and three reel speeds (25, 35 and 45 rpm) were used in the experiment, which was arranged in a split plot design with three replications. The results showed that forward speed 4 km/h with reel speed 25 rpm recorded the lowest total header losses (31.8 kg/ha) while the highest losses (90.1 kg/ha) was recorded by the forward speed 6 km/h and reel seed 25 rpm. The lowest processing losses was obtained from the forward speed 6 km/h with reel speed 25 rpm (13.2 kg/ha) while the highest was recorded by the forward speed 4 km/h with the reel speed 45 rpm (38.2 kg/ha). Forward speed 4 km/h with reel speed 25 rpm recorded the lowest total machine losses (56.7 kg/ha) which represents 9.5% of the total yield as compared to 118.0 kg/ha which represents 19.67% of the total yield recorded by the same speed with 45 rpm reel speed. It was concluded that the forward speed 4 km/h with reel speed 25 rpm was appropriate for reducing combined wheat harvesting losses under Gezira Scheme conditions.

Keywords: combine; losses; forward; reel; speed

INTRODUCTION

Agricultural production is the cornerstone to Sudan's economy. The country is blessed with a wealth of about 125– 170 million ha of fertile land and abundant sources of water (rains and ground water). The agricultural sector employs over 80% of the work force and accounts for nearly 40% of the Gross Domestic Product. Irrigated area in Sudan is estimated at some 1.7 million ha of which federal schemes (Gezira, El Rahad, Souki, New Halfa) represent an area of 1.3 million ha [1]. Sudan grows a variety of crops that include cereals (wheat, sorghum, millet, corn, and rice), oil-seeds (sesame, cotton, groundnut, and sunflower), beans, chickpea, and lentil. Others crops include vegetables and fodder crops. Due to the expansion in cultivated area, mechanization of cultural practices will be the appropriate option in securing high crops yield in both irrigated and rain-fed agriculture in Sudan. The role of full mechanization of crops production is now receiving attention all over Sudan (tillage, seeding, fertilizers and pesticides application, harvesting). The objective of mechanizing crops harvesting and threshing is to recover the seed, free from plant residue with minimum of seed losses, minimum of external and internal damage. Combine harvester are widely used in Sudan for harvesting of most of cereal crops (especially sorghum, wheat and millet) in both rain-fed and irrigated schemes. They are now available in different makes and sizes and are imported from different countries (mainly Germany, Turkey and China).

The use of combine harvesters in Sudan is faced by many problems among which are the high grain losses before and during the harvesting operation. Proper adjustments and operation, regular repair and maintenance, optimum seed moisture content at harvesting time, adapted varieties and time of harvesting can help in increasing harvester efficiency and reducing harvesting losses. Using suitable combinations of combine harvester forward and reel speeds can reduce harvesting losses to an acceptable level [2]. Other combine harvester adjustments (header height, cylinder – concave clearance, fan speed) can also be managed to increase the combine efficiency, capacity and reduce grain losses. According to a most conservative estimate, about 10% of the cereals harvested in developing countries are lost annually [3]. [4] found considerable grain losses of wheat during the threshing activity. They concluded that threshing losses were mainly in the form of broken grains. They observed 2.35 kg/quintal post-harvest losses at farm level and concluded that the harvesting losses have added up to about 40.85%. One of the primary indicators of combine performance is the amount of grain loss during harvesting operation [5]. [6] studied wheat harvesting losses in Fars province (Iran) utilizing combine "New Holland TC56. They found that the best forward speed and reel speed to reduce wheat harvesting losses were 3 km/hand 25 rpm, respectively; they concluded that proper setting of these two factors will result in minimum wheat harvesting losses.

Main effects of ground speed and reel rotational speed were highly significant for total loss. [7] reported that the greatest combine harvest loss related to maximum mean ground speed. The general objective of the present study was to investigate the effect of forward and reel speeds on combined wheat harvesting losses. The specific objectives of this research were to measure the header, processing and total machine losses as affected by forward and reel speeds.

MATERIALS AND METHODS

The experiment was conducted during the season 2016/2017; at the demonstration farm of Massaed Technology Transfer Centerin the Gezira State altitude (25° 32" and 18° 34") east and (15°29" – 13°36") north. The soil of the experimental area was generally heavy clay soil. Temperature increases up to 47°C with relatively high moisture content (June to October) with seasonal variation. The wheat variety grown in the experiment was Boheen with a seed rate of 70 kg/ha. Nitrogen fertilizer of 100kg/ha and tri mono phosphate fertilizer at a rate of 50 kg/ha were used in the experiment. 2-4D herbicide was used to control the weeds. The crop was irrigated on 10/12/2016. The crop was harvested on 12/4/2017.

The primary tillage of the land was accomplished by a chisel plow while the secondary tillage was carried out by a heavy disc harrow. The land was seeded by a mounted seed drill. The land was divided into tangents and gadwalls (local names for irrigation structures) for the irrigation practice. The experiment was planned in a split plot design with three forward speeds (4, 5, and 6 km/h) in the main plots and three reel speeds (25, 35 and 45 rpm) in the sub plots. The experiment was replicated three timesand the total area of the experiment was 8400 m^2 (2 fed). The combine harvester used for harvesting wheat was Class Crop Tiger 30. One square meter iron frame was used to measure potential yield and crop density, uncut heads, and pre harvest losses, shattered heads and seeds and processing losses. A processer tachometer was used to measure the reel rpm. Some simple regression analysis was carried out for the measured parameters with the factors used.

RESULTS AND DISCUSSION

The results of the effects of forward and reel speeds on all measured combine harvester losses, are shown in Table 1. It was observed that as the forward speed increased, all typed of losses were not generally affected (FIGURE 1). As the reel speed was increased, all types of combine harvest losses were observed decreased (FIGURE 2).

TABLE 1: Effect of forward and reel speed on wheat harvesting losses

Forward Speed (km/h)	Reel Speed (rpm)	Shattering (Kg/ha)	Uncut (Kg/ha)	Total Header (Kg/ha)	Processing (Kg/ha)	Total Machine (Kg/ha)
	25	24.41	17.35	41.75	24.99	56.74
4	35	40.91	12.18	53.09	29.69	82.78
	45	65.31	14.20	79.51	38.51	118.02
Mean		**43.54**	**14.58**	**54.78**	**31.06**	**85.85**
	25	33.85	21.34	55.19	29.19	84.38
5	35	42.50	14.78	57.29	19.16	66.44
	45	29.44	29.95	59.39	17.89	77.28
Mean		**35.26**	**22.02**	**57.29**	**22.08**	**76.03**
	25	64.34	25.75	90.09	13.15	103.25
6	35	33.10	30.83	63.93	26.63	90.56
	45	31.21	16.13	47.34	26.63	73.97
Mean		**42.88**	**24.24**	**67.12**	**22.13**	**89.26**

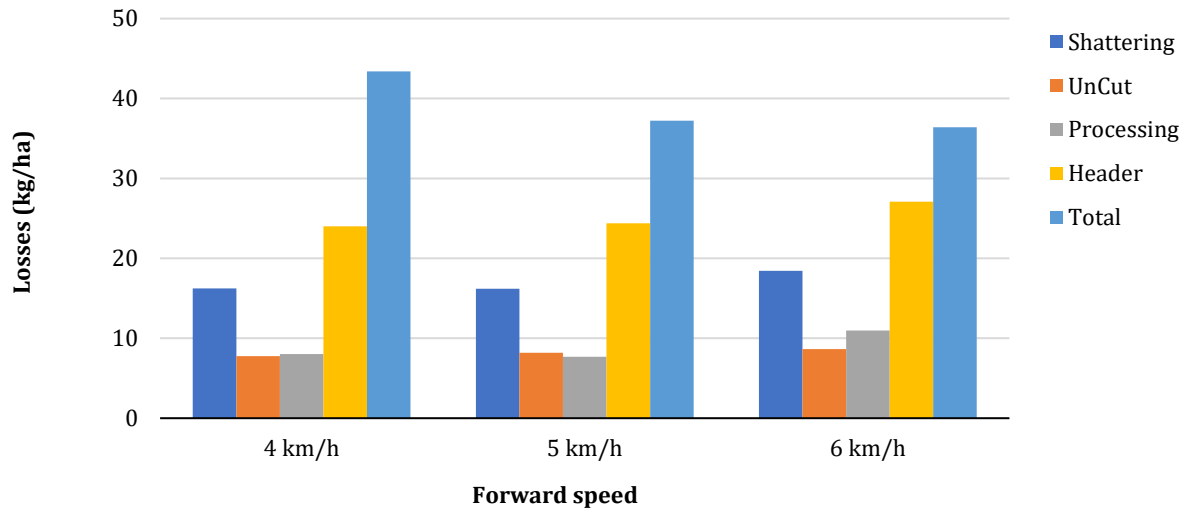

FIGURE 1: Effect of forward speed on different combine harvest losses

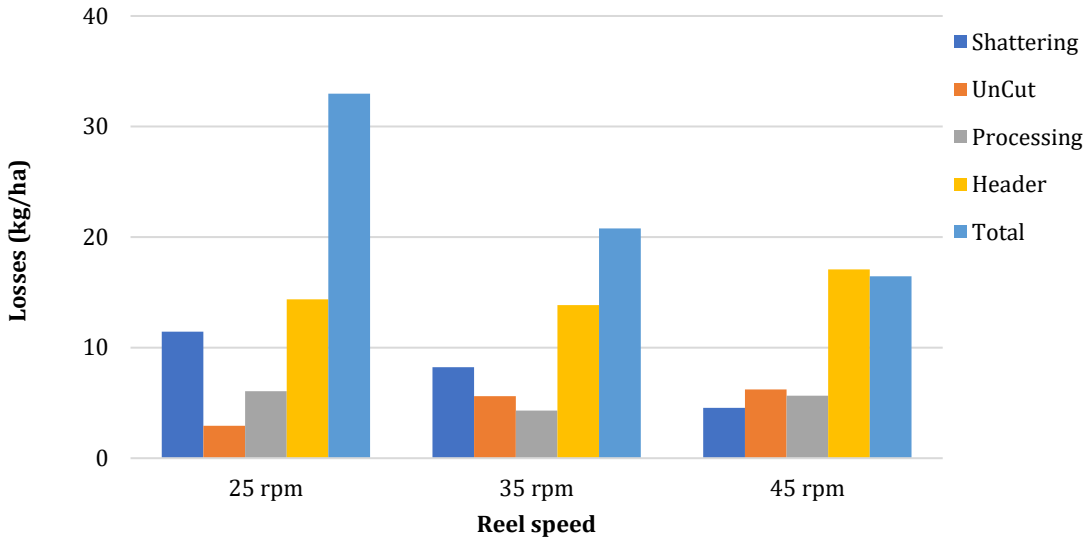

FIGURE 2: Effect of reel speed on different combine harvest losses

The interaction effects of speeds on different types of losses are given in tables 3, 4, 5, 6, 7. The lowest shattered losses (24.41kg/ha) was recorded for the forward speed of 4 km/h with reel speed of 25 rpm while the highest shattering losses (65.31 kg/ha) was recorded for the forward speed of 4km/h with the reel speed of 45 rpm (FIGURE 3). Shattering losses increased with increase in reel speeds.

This may be attributed to high vibration in the header and fast reel rotation. This result agrees with the findings of [8] who attributed the large amount of shattering losses to the great vibration of the header due to its fast speed. [9] found that more vibration in the header unit at increasing forward speed of the combine harvester and the mismatch between the speed of the reel and the forward speed of the combine harvester have also led to increased shattering of grain from the panicle

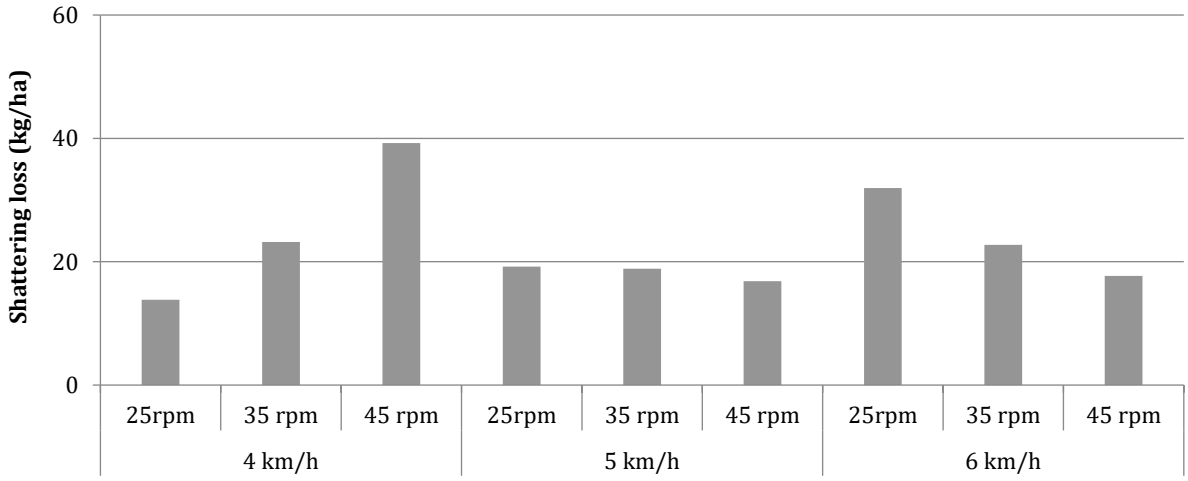

FIGURE 3: Effect of speeds Interaction on shattering losses

[10] stated that forward speed had highly significant effect on header losses. He found that increasing forward speed from 2.4 to 4.28km/h increased header losses. He added, it is evident that more vibration occurred with increasing forward speed, furthermore, the mismatch between the speed of the reel and the led to in-creased scattering of grain from the spikes.

The lowest rate of loss was related to minimum ground speed but there was no significant difference between two treatments of ground speed [7]. The statistical analysis (TABLE 2) indicated that there was no significant difference between the values of shattering losses ($P>0.05$).

TABLE 2: Summary of statistical analysis for the measured parameters (ANOVA)

Source	DF	Shattering	Uncut	Processing	Header	Total
Block	2	17.13^{ns}	0.70^{ns}	18.29^{ns}	19.57^{ns}	36.25*
Tractor speed	2	22.80^{ns}	24.06^{ns}	6.65^{ns}	23.50^{ns}	575.40*
Real speed	2	4.66^{ns}	0.55^{ns}	9.17^{ns}	7.98^{ns}	41.13*
Interaction	4	55.56^{ns}	10.70^{ns}	24.63^{ns}	85.28*	30.05*
Error	16	20.32	13.32	23.71	18.31	1.78
Total	26					
SE±		2.25	1.82	2.43	2.14	0.67

FIGURE 4. shows the effect of forward speed and reel speed on uncut heads losses. The lowest uncut head losses (7.35kg/ha) resulted at the forward speed of 4km/h and reel speed of 25 rpm, while the highest uncut losses (30.83kg/ha) has resulted from 6 km/h forward speed and the 35 rpm reel speed.

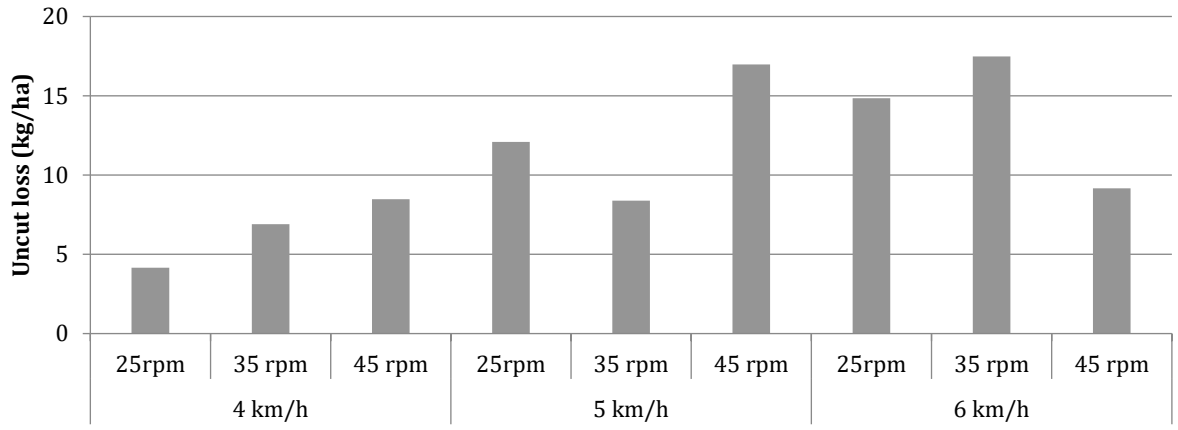

FIGURE 4: Effect of speeds interaction on uncut harvest losses

The statistical analysis of the uncut head losses (TABLE 2) indicated that was no significant difference between the losses values (P>0.05). FIGURE 5 shows the effect of forward speed and reel speed on total header losses. The results showed that the lowest total header losses (31.75kg/ha) recorded from 4 km/h forward speed and 25 rpm reel speed while the highest total header losses (90.09 kg/ha) was recorded for 6km/h forward speed and the 25 rpm reel speed. The result agrees with the findings of [11]; [12] and [13]. The statistical analysis shown in Table2 indicated that there was no significant difference between the values of the total header losses (P > 0.05).

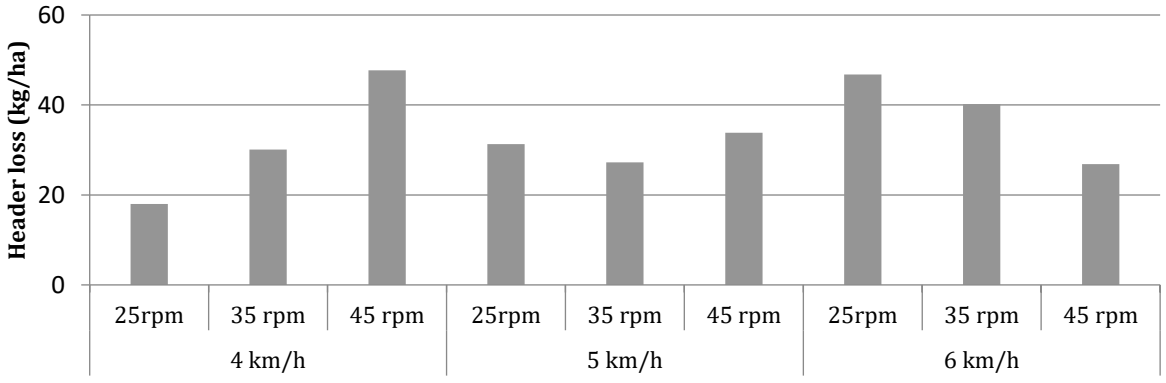

FIGURE 5: Interaction effect of speeds on header losses

The result of forward speed and reel speed effect on processing losses is shown FIGURE 6. The lowest processing losses (9.19kg/ha) was recorded for the forward speed of 5 km/h with 35 rpm reel speed while the highest (38.51 kg/ha) was recorded when the forward speed was 4 km/h and the reel speed was 45rpm. This may be attributed to the too low ground speed and insufficient loading of the crop into the machine.

The finding agrees with [14] but it disagrees with [15] who reported that, the cylinder speed and concave clearance are considered to be the major sources of threshing losses and not the combine forward speed. The statistical analysis of the processing losses shown in Table2 indicated that there was no significant difference between the obtained (P < 0.05).

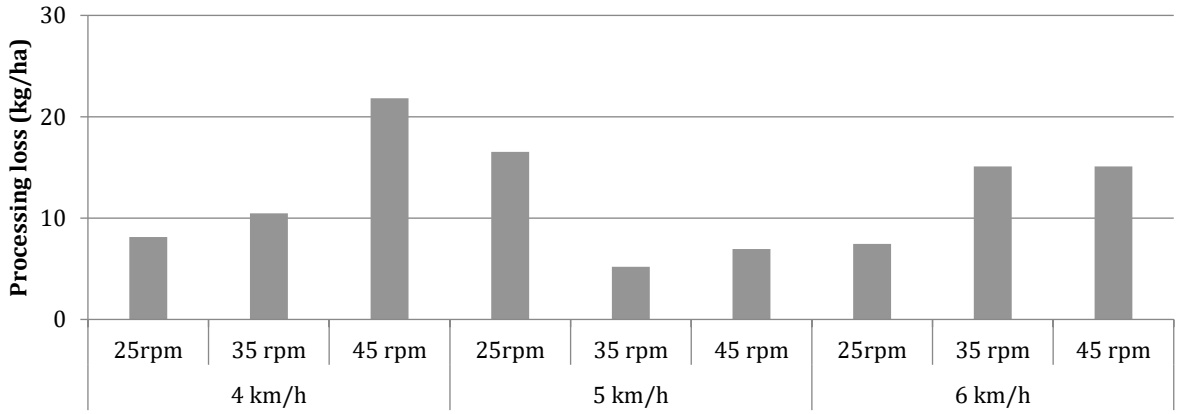

FIGURE 6: Interaction effect of speeds on processing losses

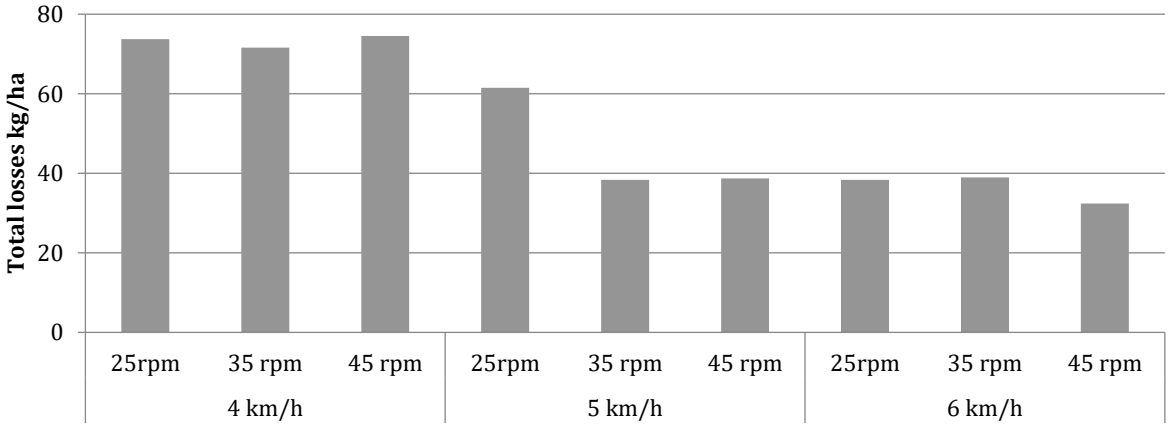

FIGURE 7: Effec of speeds interaction on total harvest losses

FIGURE 7. shows the effect of forward speed and reel speed on total machine losses. It is evident that the lowest total machine losses (56.74kg/ha) was recorded for the forward speed of 4 km/hand 25 rpm reel speed while the highest (118.02 kg/ha) was obtained when the forward and reel speeds was4 km/h and the reel speed was 45 rpm. The result agrees with the findings of [16]. Simple correlation regression analysis of either forward or reel speed on header, processing and total machine losses showed, forward speed accounted 95%, 70% and 25% of variability in total header, processing and machine losses respectively, whereas reel speed accounted 74%, 82% and 78% of variability in the above-mentioned parameters in sequence (Table 3). It can be generally concluded that lower combine harvest losses may be obtained by 4 km/h combine forward speed and 25 rpm reel speed in Gezira scheme.

TABLE 3: Simple regression analysis of Reel and Forward speeds with measured parameters

Parameter	Regression Equation	R	R^2
	Reel Speed		
Total Header	0.15x1 + 54.36	0.74	0.55
Processing	0.26x1 + 14.82	0.82	0.67
Total machine	0.41x1 + 69.19	0.78	0.61
	Forward		
Total Header	6.17x + 28.89	0.95	0.90
Processing	-4.46x + 46.30	0.70	0.49
Total machine	1.71x + 75.18	0.25	0.06

CONCLUSION

From the results of this study the following conclusions can be drawn:

Combine harvester losses can be due to improper operation and machine adjustments, therefore, selecting proper combination of forward and reel speeds can help in reducing wheat combine harvesting losses.

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