Univerzitet u Beogradu
Poljoprivredni fakultet
Institut za poljoprivrednu tehniku
Naučni časopis
**POLJOPRIVREDNA TEHNIKA**
Godina XL
Broj 3, 2015.
Strane: 13 – 22

University of Belgrade
Faculty of Agriculture
Institute of Agricultural Engineering
Scientific Journal
**AGRICULTURAL ENGINEERING**
Year XL
No. 3, 2015.
pp: 13 – 22

*UDK: 615.1.*

*Originalni naučni rad*
*Original scientific paper*

# EFFECT OF FEED RATE, CONCAVE CLEARANCE AND PERIPHERAL SPEED ON THE PERFORMANCE EVALUATION OF PRE THRESHER FOR ONION UMBELS (*Allium cepa* var. *aggregatum* L.)

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***Abstract:*** Freshly harvested, sun dried onion umbels consists of florets attached to the hard umbel heads. Conventional threshing method involves tractor treading, rubbing umbels using rubber slippers on hard surface and beating with sticks. This method resulted in seed damage and affected the germination and vigor index. High quality seeds can be produced through effective threshing and separation process. Threshing of onion umbels was carried out in a lab model thresher resulted in chocking of umbel heads in the threshing chamber and reduced the threshing efficiency of the thresher. Pre threshing is an important unit operation carried out before threshing of onion umbels. The main aim of the study was to develop a pre threshing unit to separate the florets from hard umbel heads. Hence, a pre thresher with peg tooth type threshing cylinder was designed and developed for separating the florets from onion umbels further florets are conveyed to the thresher for separation of seeds from the florets. The performance of the unit was evaluated in terms of florets threshing efficiency, floret separation efficiency, percentage floret loss and seed damage at different feed rate, concave clearance and peripheral speed. The peg tooth type pre thresher's performance was good at 100 $kg \cdot h^{-1}$ feed rate 6 mm concave clearance and 7 $m \cdot s^{-1}$ peripheral speed.

***Key words****: pre thresher, umbels, seed damage, concave clearance, feed rate, peripheral speed, tractor treading, peg tooth, vigor index, floret loss*

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## INTRODUCTION

Onion (*Allium cepa* var. *aggregatum* L.) is an important commercial horticultural crop grown all over the world. India ranks second in the world next to China followed by U.S.A, Turkey, Pakistan, Russia, Indonesia, Vietnam, Korea and Myanmar. India occupies 24.47% of area and 20.2% production [1] in the world. USA recorded the highest productivity of onion (54.6 $Mt\cdot ha^{-1}$), followed Netherlands (49.7 $Mt\cdot ha^{-1}$), and Egypt (33.7 $Mt\cdot ha^{-1}$). India the second major onion producing (16.81 mT) country in the world has a productivity of 16.0 $Mt\cdot ha^{-1}$ [1]. Lower productivity is due non availability of quality planting material. It is reported that in India, the area and production of onion are in increasing trend. It is expected to increase its production in coming years to meet the growing demand for onion of the state. Due to non availability of suitable machinery for post harvest operations, farmers are following the traditional methods. Traditionally, the farmers use tractor treading methods, rubbing the umbels using rubber slippers on hard concrete surface and beating with sticks. This results in more seed damage which affects the seed germination and vigor index. Moreover this method is labor intensive, tedious and costlier. Keeping this in mind a lab model thresher with rasp bar threshing cylinder was developed to thresh the onion umbels. During field experiments, it was found that the lab model thresher did not perform well and stopped the thresher due to choking of umbel heads. To overcome this problem, it was decided to fabricate a pre thresher to free or detach all florets from umbel heads, move all umbel heads outside the pre thresher after separation of florets from them and passing only florets below to a radial flow, rasp bar type thresher for easy threshing and separation of seeds from florets. This paper deals with the performance of the pre thresher under different feed rate, peripheral speed and concave clearance. The machine was evaluated in terms of floret threshing efficiency, floret separation efficiency, floret loss and seed damage.

## MATERIAL AND METHODS

Pre thresher works based on the principal of impact force in detaching the florets from umbel head. Threshing chamber of pre thresher consisted of a threshing cylinder and a concave. The concave was made into two halves namely top and bottom portions. The top and bottom halves are made up of 18 gauge thick, mild steel sheet. Bottom half was provided with perforations of 10 mm diameter at a center to center distance of 20 mm. Threshing cylinder of pre thresher was made up of centre wooden drum of 300 mm diameter, 1300 mm length. This wooden cylinder was attached to, two shaft at onion umbels feed end and umbel head discharge end, respectively. The shafts were welded to two thick plates and screwed to both ends of the wooden roller, for firm fixing of the shaft in to it. Front end of the roller was made in the form of screw auger to feed the onion umbels positively in to the threshing chamber. Similarly at the discharge end four vanes baffles were fabricated and fixed such that these blades discharged the umbel heads from the threshing chamber of pre thresher. Two ball bearings were fixed for friction free rotation. One ‘B’ type two groove pulley was attached from the front end of the pre thresher threshing cylinder shaft to transmit power from prime mover to the threshing cylinder. Pegs were driven in four rows in a staggered manner over the remaining portion of the wooden drum such that during operation these pegs will not only perform beating action but also acts as a screw conveyor and convey the material from feeding end to discharge end.

A semi circular plate was cut and fixed on the discharge end of the wooden drum over the bottom concave portion of the threshing chamber to arrest the free movement of florets following a trajectory motion. This plate intercepts free flowing threshed materials and helped for agitation of the threshed materials near the discharge end for complete separation of detached florets from the umbel head. A discharge chute is fixed below the concave of the threshing chamber to release florets from pre thresher to thresher and the other after the thresher to discharge the threshed seeds and trashes through concave to the threshing unit. A clearance of 7.0 mm was maintained between the concave and the tip of pegs in pre thresher. This helped to make gentle impact action on the umbels and then rubbing the florets over the concave, which in turn helped to separate the florets from umbels from pre thresher. Normally, concave clearance influences threshing efficiency and seed damage. It is well known that increase in clearance would result in low threshing efficiency whereas, reduced clearance would cause more seed damage. Therefore, optimum concave clearance required was determined by varying clearance. By screwing the rod in to the wooden body of threshing cylinder in the pre thresher, clearance was varied and experiments were conducted.

In this study, performance of the developed pre thresher was carried by changing the feed rate, peripheral speed and concave clearance of the pre thresher and the readings were recorded and statistically analyzed using AGRESS and the results are discussed below.

## RESULTS AND DISCUSSION

Performance of the pre thresher was carried out at different feed rate, peripheral speed and concave clearance and evaluated based on the floret threshing efficiency, floret separation efficiency, seed damage and floret loss. Each parameter was studied at three different levels and the results are represented in Tab.1.

### Effects of feed rate, peripheral speed and concave clearance on florets threshing efficiency of pre thresher

Pre thresher for onion umbel was operated with feed rates of 100±5, 125±5 and 150±5 $kg{\cdot}h^{-1}$. During the experiments, peripheral speed and concave clearance were changed to 7, 8.5 and 10 $m{\cdot}s^{-1}$ and 6, 7 and 8 mm, respectively. Samples were collected, analyzed and the results are presented in the Fig.1. From figure, it is seen that for the same feed rate, increase in peripheral speed in general decreased the florets threshing efficiency. This may be due to less residential time of onion umbels within the pre thresher (threshing chamber) due to higher forward speed.

In case of 100±5 $kg{\cdot}h^{-1}$ umbel feed rate, pre thresher recorded the highest floret threshing efficiency of 99.93% at 7 $m{\cdot}s^{-1}$ peripheral speed with 6 mm concave clearance. Increase in peripheral speed from 7 to 8.5 $m{\cdot}s^{-1}$, decreased the floret threshing efficiency from 99.93 to 99.91% at 6 mm clearance and 99.28% at 8 mm clearance. Further increase in peripheral speed from 8.5 to 10 $m{\cdot}s^{-1}$, lowered floret threshing efficiency from 99.91 to 99.23% at 6 mm clearance. For the same feed rate of 100±5 kg·h$^{-1}$, 10 m·s$^{-1}$ peripheral speed and increase in clearance from 6 to 8 mm lowered the floret threshing efficiency from 99.23 to 99.18%. From the figure it is clearly seen that changes in peripheral speed from 7 to 10 m·s$^{-1}$ and clearance from 6 to 8 mm recorded only 0.75% decrease in floret threshing efficiency. This clearly indicates that the above mentioned changes in peripheral speed and concave clearance did not influence much on floret threshing efficiency.

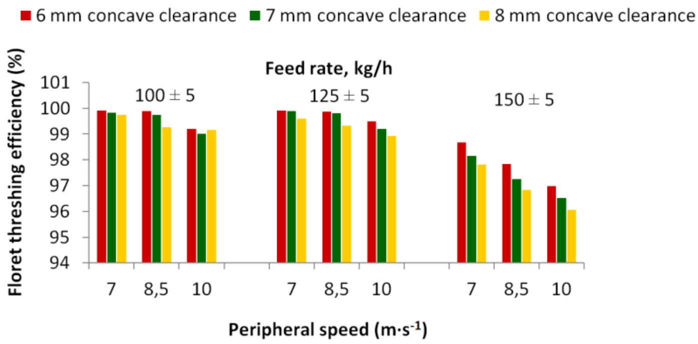


*Figure 1. Effects of feed rate, peripheral speed and concave clearance on florets threshing efficiency of onion umbels in the pre thresher*

Feed rate of 125±5 kg·h$^{-1}$, 7 m·s$^{-1}$ peripheral speed and 6 mm clearance recorded 99.94% floret threshing efficiency. Increase in clearance from 6 to 7 and 7 to 8 mm, resulted in floret threshing efficiency of 99.91 and 99.62%, respectively. When the peripheral speed was increased from 7 to 8.5 m·s$^{-1}$ lowered the floret threshing efficiency from 99.94 to 99.89% at 6 mm, 99.91 to 99.82% at 7 mm clearance and 99.62 to 99.34% at 8 mm clearance. As the peripheral speed was increased the floret threshing efficiency reduced. From this, it is seen that for this feed rate (125±5 kg·h$^{-1}$) change in peripheral speed from 7 to 10 m·s$^{-1}$ and increase in concave clearance from 6 to 8 mm recorded 1.00% change in the floret threshing efficiency. As compared to 100±5 kg·h$^{-1}$feed rate, 125±5 kg·h$^{-1}$feed rate recorded a higher reduction in the floret threshing efficiency.

From the figure it is further seen that increase in feed rate from 125±5 to 150±5 kg·h$^{-1}$ recorded lesser floret threshing efficiency for the above said conditions. It was noted that for 150±5 kg·h$^{-1}$ feed rate and 7 m·s$^{-1}$ peripheral speed, change in concave clearance from6 to 8 mm lowered floret threshing efficiency by 0.86%. From this, it is clear that at 150±5 kg·h$^{-1}$ feed rate, change in peripheral speed from 7 to 10 m·s$^{-1}$ and change in concave clearance from 6 to 8 mm lowered the floret threshing efficiency by 1.82%.

From this it is clear that, an increase in feed rate from 100±5 to 150±5 kg·h$^{-1}$, decreased the floret threshing efficiency from 0.75 to 1.82%, which indicates that increase in feed rate lowered the floret threshing efficiency.

Similar results were reported for threshing of chickpea seeds [2] and for cow pea thresher by [3]. [2]reported that increase in feed rate from 150 kg·h$^{-1}$to 200 kg·h$^{-1}$ at 8.94 m·s$^{-1}$ peripheral speed decreased the threshing efficiency from 99.99 to 98.67% in cow pea. [3] reported that increase in feed rate from 101.19 kg·h$^{-1}$ to 110.86 kg·h$^{-1}$ at 500 rpm beater speed, decreased the threshing efficiency from 98.26 to 96.29%. These findings are similar to the results recorded in the present study and supports the results of present study.

### Effects of feed rate, peripheral speed and concave clearance on florets separation efficiency of pre thresher

The pre thresher for onion umbel was operated at 100±5, 125±5 and 150±5 kg·h$^{-1}$ feed rates, 7, 8.5 and 10 m·s$^{-1}$ peripheral speeds and 6, 7 and 8 mm concave clearances. Samples were collected, analyzed and floret separation efficiency was recorded and presented in Tab. 1 and shown in Fig. 2.

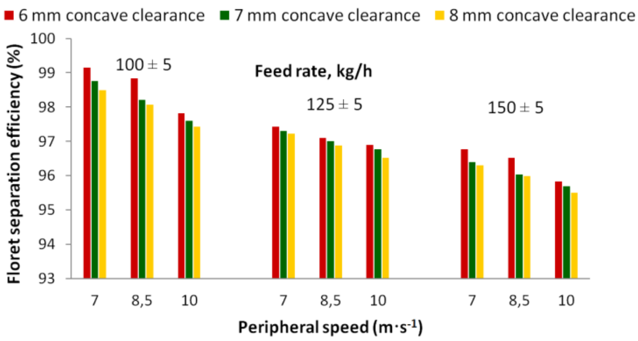


*Figure 2. Effects of feed rate, peripheral speed and concave clearance on florets separation efficiency of onion umbels in the pre thresher*

From figure, it is seen that among three clearances studied, 6 mm concave clearance recorded the highest floret separation efficiency of 99.17% for the feed rate of 100±5 kg·h$^{-1}$ and 7 m·s$^{-1}$ peripheral speed. For the same operating condition, 7 and 8 mm concave clearances, recorded a floret separation efficiency of 98.77 and 98.50%, respectively. Increase in peripheral speed from 7 to 8.5 m·s$^{-1}$ recorded a maximum floret separation efficiency of 98.85% at 6 mm clearance and minimum floret separation efficiency of 98.09% and intermediate concave clearance of 7 mm recorded a floret separation efficiency of 98.23%. Further increase in peripheral speed from 8.5 to 10 m·s$^{-1}$ recorded 97.84, 97.62 and 97.44% floret separation efficiency with 6, 7 and 8 mm concave clearances, respectively. From this, it is seen that at 100±5 kg·h$^{-1}$ umbel feed rate, increase in peripheral speed from 7 to 10 m·s$^{-1}$ and increase in concave clearance from 6 to 8 mm recorded a reduction in floret separation efficiency by 2.29%.

In case of 125±5 kg·h$^{-1}$ feed rate at 7 m·s$^{-1}$ peripheral speed with 6 mm concave clearance recorded a maximum floret separation efficiency of 97.45% and a minimum value of 96.53% for 10 m·s$^{-1}$ peripheral speed with 8 mm concave clearance. For the same feed rate changes in peripheral speed (7 to 10 m·s$^{-1}$) and concave clearance (6 to 8 mm) recorded a reduction in the floret separation efficiency by 0.95%. At this feed rate and peripheral speed of 7 m·s$^{-1}$, increase in concave clearance from 7 and 8 mm recorded a floret separation efficiency of 97.32 and 97.24%, respectively. Increase in peripheral speed further 7 to 8.5 m·s$^{-1}$) recorded 97.12, 97.02 and 96.89% as floret separation efficiency with concave clearance of 6, 7 and 8 mm, respectively. At a peripheral speed of 10 m·s$^{-1}$ and 6 mm concave clearance, the floret separation efficiency was 96.91%. Further increase in clearance to 7 and 8 mm, recorded 96.78 and 96.53% floret separation efficiency, respectively. From the figure, in general it is seen that irrespective of increase in peripheral speeds and concave clearances, increase in feed rate recorded decrease in floret separation efficiency. However, changes are much less (97.45 to 96.53%).

When the feed rate was increased to 150±5 kg·h$^{-1}$, the maximum and minimum floret separation efficiency recorded was 96.78 and 95.52% at 7 and 10 m·s$^{-1}$ peripheral speeds and 6 and 8 mm concave clearances, respectively. For this feed rate, at 7 m·s$^{-1}$ peripheral speed increase in concave clearance (6 to 7 mm) recorded a floret separation efficiency of 96.41% and further increase in clearance from 7 to 8 mm recorded 96.32% as floret separation efficiency. As the peripheral speed was increased to 8.5 and 10 m·s$^{-1}$ with the concave clearance of 6, 7 and 8 mm the floret separation efficiency recorded a value of 96.54, 96.05 and 96.01 and 95.84, 95.70 and 95.52%, respectively. For this feed rate, increase in peripheral speed from 7 to 10 m·s$^{-1}$ and 6 to 8 mm concave clearance recorded a change in floret separation efficiency by 1.32%.

Feed rates 125±5 and 150±5 kg·h$^{-1}$ recorded a decrease in floret separation efficiency with increase in peripheral speed and concave clearances. This may be due to the reason that at higher peripheral speed, the residential time of umbels in the pre threshing chamber got reduced and hence chance for separation of florets got decreased. Similarly increase in concave clearance resulted in lesser mixing effect in the layer of materials present in between tip of pegs of pre thresher and concave surface and hence resulted in lower floret separation efficiency.

**Effects of feed rate, peripheral speed and concave clearance on% floret loss of pre thresher**

Floret loss in onion umbels fed in to the pre thresher occurred due to reduction in floret separation efficiency. To determine the% floret loss, studies were conducted at different feed rates (100±5, 125±5 and 150±5 kg·h$^{-1}$), various peripheral speeds (7, 8.5 and 10 m·s$^{-1}$) and concave clearances (6, 7 and 8 mm). Samples were collected, analyzed and the results are presented in Tab. 1 and shown in the Fig. 3.

From figure, it is evident that 100±5 kg·h$^{-1}$ feed rate at 10 m·s$^{-1}$ peripheral speed with a concave clearance of 8 mm resulted in maximum floret loss percentage of 2.56 and minimum value of 0.83% at 7 m·s$^{-1}$ peripheral speed with a concave clearance of 6 mm. That is, in this case, there is an increase in floret loss by 156.00%. When the feed rate was increased to 125±5 kg·h$^{-1}$, the pre thresher performance recorded further increased results in floret loss. The maximum and minimum values of floret loss were 3.47 and 2.55%, respectively. This was recorded at a peripheral speed of 10 m·s$^{-1}$ with a concave clearance of 8 mm and 7 m·s$^{-1}$ peripheral speed with a concave clearance of 6 mm, respectively. In this case, the floret loss was increased by 36.08%. This value is lesser than the value recorded at 100±5 kg·h$^{-1}$ feed rate. Further increase in feed rate to 150±5 kg·h$^{-1}$ resulted in increased floret loss than the values observed in 100±5 and 125±5 kg·h$^{-1}$ feed rates. The maximum floret loss was 4.48% and minimum was 3.22%, the increase in floret loss was increased by 39.13%.

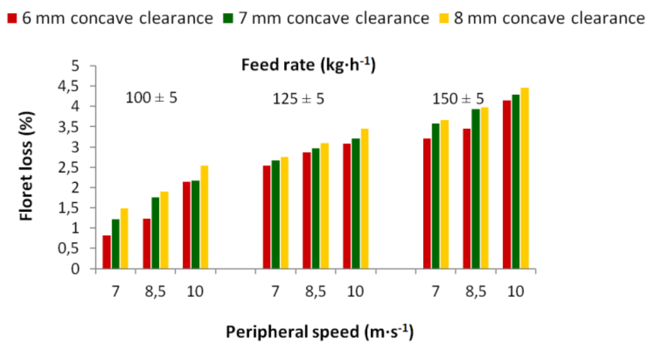


*Figure 3. Effects of feed rate, peripheral speed and concave clearance on % floret loss of onion umbels in the pre thresher*

From figure, it is clearly seen that maximum floret loss was 4.48% and minimum was 0.83%. Irrespective of feed rates, adopted increase in peripheral speed and concave clearance resulted in increased floret loss. This may be due to the following reasons. In case of onion umbel pre thresher, there is a screw auger in the feeding end which positively pushed the umbels in to the pre threshing chamber and at the discharge end there is a opening for the discharge of umbel head. When the peripheral speed was increased, the residential time inside the pre threshing chamber got reduced and this resulted in reduction in the floret separation efficiency, which in turn increased the floret loss along with umbel head at umbel head out let. As the concave clearance increases, the thickness of undisturbed layer of florets below the tip of pegs in the threshing cylinder got increased, which resulted in poor mixing and poor separation and higher loss of florets (along with umbel head at umbel head out let).

**Effects of feed rate, peripheral speed and concave clearance on% seed damage in pre thresher**

It was observed from the experiment that the impact force of the pegs not only detached the florets from umbel heads but also resulted in seed damage and discharged through umbel head outlet. Seed damage results collected during different operating conditions are also depicted in Fig. 4. From figure, it is seen that irrespective of feed rates and peripheral speeds adopted increase in concave clearances recorded reduction in seed damage. This may be due the fact that at higher clearance, the seeds moved along different directions during impact action caused by pegs and hence recorded lower seed damage. It is also seen that for the same feed rate, increase in peripheral speed recorded increase in seed damage. This may be due to higher impact force created by the pegs during higher peripheral speed, which caused higher seed damage. At constant clearance, as the feed rate increased the quantum of florets available for separation also got increased. If it exceeded the handling capacity of pre threshing chamber, accumulation of florets may take place, which may result in seed damage.

At 100±5 kg·h$^{-1}$ umbel feed rate, 7 m·s$^{-1}$ peripheral speed with 6 mm concave clearance, recorded a seed damage of 0.25%. For the same operating condition, increase in concave clearance to 7 and 8 mm recorded a seed damage of 0.24 and 0.20%, respectively. For the same feed rate, at 8.5 m·s$^{-1}$ peripheral speed with 6 mm clearance, seed damage was 0.26%, 0.23% seed damage at 7 mm clearance and 0.21% seed damage at 8 mm clearance. In the case of 10 m·s$^{-1}$ peripheral speed, 6, 7 and 8 mm concave clearances recorded a seed damage of 0.27, 0.25 and 0.23%, respectively. At this feed rate, a maximum seed damage of 0.27% was recorded at 10 m·s$^{-1}$ with 6 mm concave clearance. The minimum seed damage of 0.20% was recorded at a peripheral speed of 7 m·s$^{-1}$ with a concave clearance of 8 mm. That is, it recorded a reduction in the seed damage by 25.93%.

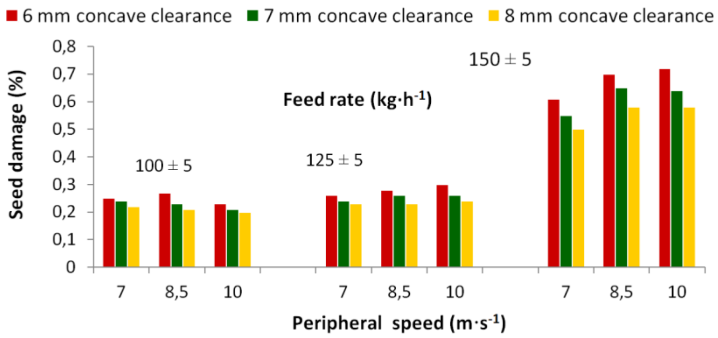


*Figure 4. Effects of feed rate, peripheral speed and concave clearance on% seed damage of onion umbels in the pre thresher*

For the feed rate of 125±5 kg·h$^{-1}$ and 7, 8.5 and 10 m·s$^{-1}$ peripheral speed recorded a seed damage of 0.26, 0.28 and 0.30% at 6 mm concave clearance and minimum seed damage of 0.23, 0.23 and 0.24% at 8 mm clearance and with 7 mm concave clearance recorded 0.24, 0.26 and 0.26% seed damage, respectively. In the case of 125±5 kg·h$^{-1}$ umbel feed rate, a minimum seed damage of 0.23% and a maximum of 0.30% was recorded at 7 m·s$^{-1}$ peripheral speed with 8 mm concave clearance and 10 m·s$^{-1}$ peripheral speed with 6 mm concave clearance, respectively. That is, the above said operating conditions recorded a reduction in seed damage by 23.33%.

In the case of 150±5 kg·h$^{-1}$ umbel feed rate, 7 m·s$^{-1}$ peripheral speed recorded a minimum seed damage of 0.50% at 8 mm concave clearance and a maximum seed damage of 0.61% at 6 mm concave clearance and 0.55% at 7 mm concave clearance. When the peripheral speed was increased from 7 to 8.5 m·s$^{-1}$, higher seed damage was recorded at all clearances. It is seen from the figure that a minimum seed damage of 0.58% at 8 mm concave clearance, followed by 0.65% at 7 mm concave clearance and a maximum seed damage of 0.70% at 6 mm concave clearance was recorded at a peripheral speed of 8.5 m·s$^{-1}$. Similarly, in the case of 10 m·s$^{-1}$ peripheral speed (threshing cylinder), 6 mm concave clearance recorded a minimum seed damage of 0.58%. The intermediate clearance of 7 mm recorded a seed damage of 0.64%.

From the study, it is seen that when the feed rate was increased from 100±5 to 150±5 kg·h$^{-1}$, peripheral speed from 7 to 10 m·s$^{-1}$ and concave clearance from 6 to 8 mm recorded a minimum seed damage 0.2% (100±5 kg·h$^{-1}$ feed rate, 7 m·s$^{-1}$ peripheral speed with 8 mm concave clearance) and a maximum seed damage of 0.72% (150±5 kg·h$^{-1}$, 10 m·s$^{-1}$ peripheral speed with 6 mm concave clearance). This clearly indicates that changes in the feed rate, peripheral speed and concave clearance did not affect the seed damage very much *(i.e)* the seed damage was less than 1% only in all cases.

Similar results were reported in soy seed thresher [3], and in chick pea thresher by [2]. [4] studied the machine-crop parameters of an axial flow thresher for threshing of soybean. They reported that increase in threshing drum speed from 600 to 700 rpm at 540 kg (plant)/h feed rate at 14.34% (wb) seed moisture content increased the seed damage from 0.72 to 0.96% and [2]reported that increase in peripheral speed from 8.94 to 10.62 $m \cdot s^{-1}$ at 200 kg (chick pea)/h increased the seed damage from 3.37 to 4.18%. This confirmed the findings reported in the present study.

## CONCLUSIONS

It was observed from the pre thresher performance evaluation studies, it is seen that changes in the feed rate from 100±5 $kg \cdot h^{-1}$, 125±5 $kg \cdot h^{-1}$ and 150±5 $kg \cdot h^{-1}$, peripheral speed 7, 8 and 10 $m \cdot s^{-1}$ and concave clearance 6, 7 and 8 mm changed the floret threshing efficiency from 99.93 to 96.07%, floret separation efficiency from 99.17 to 95.52%, floret loss% from 0.83 to 4.48 and seed damage from 0.22 to 0.72%. For best performance the pre thresher has to be operated at feed rate of 100 $kg \cdot h^{-1}$, with a concave clearance of 6 mm and peripheral speed of 7 $m \cdot s^{-1}$. Under this operating condition pre thresher recorded floret threshing efficiency, floret separation efficiency, floret loss and seed damage of 99.93, 99.17, 0.83 and 0.25%, respectively.

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# UTICAJ NORME PUNJENJA, ZAZORA PODBUBNJA I PERIFERIJSKE BRZINE NA PERFORMANSE PRED VRŠALICE CVASTI CRNOG LUKA (*Allium cepa* var. *aggregatum* L.)

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***Sažetak:*** Sveže požnjevene cvasti crnog luka, osušene na suncu, sastoje se od cvetova usađenih u glave cvasti. Konvencionalna vršidba uključuje gaženje traktorom, trenje cvasti gumenim papučama po tvrdoj podlozi i udaranje štapovima. Ovaj postupak dovodi do oštećenja semena i smanjenja klijavosti i indeksa vigora. Visoko kvalitetno seme se može proizvesti efikasnom vršidbom i odvajanjem semena. Vršidba semena iz cvasti crnog luka izvođena je laboratorijskim modelom vršalice, što je dovelo do zagušenja glava cvasti u vršidbenoj komori i smanjilo efikasnost vršidbe. Pred vršidba je važna operacija koja je izvedena pre vršidbe cvasti crnog luka. Glavni cilj ovog istraživanja bio je da razvije pred vršidbeni uređaj za odvajanje cvetova od tvrdih glava cvasti. Zato je konstruisana i razvijena pred vršalica sa vršidbenim cilindrom sa klinastim zubima za odvajanje cvetova iz cvasti luka i dalje odvođenje cvetova do vršalice za odvajanje semena iz cvetova. Karakteristike uređaja su ocenjivane prema efikasnosti izvršaja cvetova, efikasnosti odvajanja cvetova, procenta gubitka cvetova i oštećenja semena pri različitim normama punjenja, zazorima podbubnja i periferijskim brzinama. Pred vršalica sa klinastim zubima imala je najbolje rezultate pri normi punjenja od 100 $kg \cdot h^{-1}$, zazoru podbubnja od 6 mm i periferijskoj brzini od 7 $m \cdot s^{-1}$.

***Ključne reči****: pred vršalica, cvasti, oštećenje semena, zazor podbubnja, norma punjenja, periferijska brzina, gaženje traktorom, klinasti zub, indeks vigora, gubitak cveta*

| | |
|---|---|
| Prijavljen: *Submitted*: | 31.01.2015. |
| Ispravljen: *Revised*: | |
| Prihvaćen: *Accepted*: | 12.08.2015. |