Zero Tillage Plus Residue Management and K Fertilization Effect on Cotton Yield and K Use Efficiency in Wheat-Cotton System

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Abstract
Zero tillage straw retained with optimum K is an important strategy to increase cotton (Gossypium hirsutum L.) yield and K efficiency in wheat (Triticum aestivum L.)-cotton system. A 2 years field experiment was conducted during 2018, and 2019 to study the impact of [zero tillage straw as such on soil surface (ZT\textsubscript{SAS}) and zero tillage straw burnt (ZT\textsubscript{SB})] and five K rates were 0, 20, 40, 60 and 80 kg ha\textsuperscript{-1} on cotton yield and K use efficiency. Results indicated that bolls/plant \textsuperscript{-1}, weight per boll, seed cotton yields, ginning out turn and K agronomic efficiency were highest with 60-80 kg K ha\textsuperscript{-1}. Interactions revealed that ZT\textsubscript{SAS} with 60-80 kg K ha\textsuperscript{-1} had higher bolls/plant, bolls weight, seed cotton yields and ginning out turn compared to ZT\textsubscript{SB}. K agronomic efficiency indices decreased with increasing K rate. ZT\textsubscript{SAS} with 20 kg K ha\textsuperscript{-1} gave greater K agronomic efficiency than other combinations. ZT\textsubscript{SAS} with 60-80 kg potassium per hectare may be a sustainable and environmentally safe strategy to enhance cotton yield and soil fertility.

Keywords: Zero tillage, residue management, potassium, cotton yield, K agronomic efficiency

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INTRODUCTION
Zero tillage plus straw retained as such on surface (ZT\textsubscript{SAS}) is a suitable tillage method that increased soil fertility and cotton production as compared to zero tillage straw burnt, ZT\textsubscript{SB} (Ishaq et al., 200; Hulugalle et al., 2004). Zero tillage (ZT) impacted soil, water and environment. ZT with wheat residues is feasible and economical in wheat, cotton rotation (Wang, 2006). Zero tillage plus residues is the possible alternative to builds up organic matter in the surface of soil, increase moisture absorption capability, improve soil prosperities and increased cotton yield (Boquetet al., 2004). ZT plus residues enhanced SOM and potassium in the soil (Doganel et al., 2009). Cotton scientists said that ZT with residue mulch gave higher size of aggregates, stability and total organic carbon in soil aggregates than ZT straw burnt (Mert et al., 2006). Higher accumulation of organic matter in the soil, greater fertilizer use efficiency and optimum moisture accessibility increased cotton yield under zero tillage straw retained (Nyakatawa and Reddy, 2000; Blaise, 2011).

Crop residues retained on soil surface recommended for moisture conservation in cotton sown after wheat (Kumar and Goh, 2000; Pabin et al., 2004). Straw as mulch enhanced K agronomic efficiency and crop yield (Kumar et al., 2000; Endale et al., 2002; Jan et al., 2012). In long term mulched catch crops approach also increased microbial biomass (Goyal et al., 2005; Chan, et al., 2001; Usman et al., 2013; Beri et al., 2003).

Potassium is a major macro fertilizer that needed in large quantity and significantly affect cotton production and K agronomic efficiency (Kumar and Goh 2000; Torbertet al., 2002; Xuet al., 2009; Usman et al., 2014). Cotton crop requires optimum potassium for maximum production. Higher and lower K rates greatly influenced cotton yield and efficiency (Kumar et al., 2000; Singh et al., 2006; Jan et al., 2012; Wang et al., 2007). Potassium deficiency resulted in number of bolls per plant and boll weight that reduced cotton yield. (Sijtsma et al., 1998, Schwab et al., 2002, Tewolde et al., 2008)and Reddy et al., 2012). Potassium uptake could be improved through zero tillage and nutrients availability (Su et al. 2008; Sharma et al. 2002; Beri et al., 2003; Hu, W et al., 2015; Endale et al., 2002; Unay et al., 2005; Singh et al., 2005, Xu et al., 2009). K use efficiency depends on fertilizer application rate and soil tillage methods (Pettigrew et al., 2001; Nyakatawa et al., 2001; Norsworthy et al., 2010; Potter et al., 2011; Cassman et al., 200; et al., 2001; Minton et al., 1991, Pettigrew et al., 2008). K use in conational cotton sown after is decidedly un-productive (Kienzler, 2010; Dong et al., 2012), having less N recovery efficiency (Reddy et al., (2009) and Reddy et al., (2001)). Research findings showed that the zero tillage straw retained with proper nitrogen use has shown to be a possible alternative for sustainable cotton crop production in irrigated wheat-cotton systems (Zhang, et al., 2007; Wang, et al., 2012; Yang, et al., 2014). The experiment was carried out with the aim of zero tillage with residues management and K levels on cotton yield and K agronomic efficiency in arid environment of Dera Ismail Khan.
MATERIALS AND METHODS

EXPERIMENTAL SITE

Field experiments were carried out during 2018 and 2019 at Cotton Research Station, PCCC, Dera Ismail Khan, Pakistan. Dera Ismail Khan district is situated in the south of Khyber Pakhtunkhwa with low rainfall (<200 mm per year), hot and dry are main features of the area. Soil characteristics were shown in Table 2. The weather data were collected from the meteorological centre near the Station, Dera Ismail Khan (Table 1).

TREATMENT AND COTTON MANAGEMENT

Research trials were carried out in randomized complete block design in split plot having 3 replications. Zero tillage straw as such on soil surface (ZT<sub>SAS</sub>) and zero tillage straw burnt (ZT<sub>SB</sub>) were assigned to main plots while five K rates such as 0, 20, 40, 60 and 80 kg ha<sup>-1</sup> were given to subplots. Wheat was sown in November and was well-fertilized every year so as to reduce the remaining effect of K rates in the succeeding year. The wheat was harvested on 20th April, leaving all wheat straw in the field. After the harvest of wheat, cotton seed was direct seeded into standing wheat residues with dibbling method in ZT<sub>SAS</sub> plots (making holes with wooden stick) without seed bed preparation during both the study years. While in zero tillage straw burnt (ZT<sub>SB</sub>) plots, wheat straw was burnt and cotton seed was sown by dibbling method. Cotton genotype (CIM-622) was sown on 7th May-2018, 10th May-2019, respectively. 75 cm row to row and 30 cm plant to plant was maintained. A net plot size was 10m×3m. NP was given as 150:60 kg ha<sup>-1</sup>. All P and K were applied during sowing and N was given in three splits namely thinning, at flowering and boll formation. All other cultural and protective methods were normally adopted. Seed cotton was picked on November 20, 2018 and November 24, 2019.

DATA COLLECTION

Data on plant height, boll count per plant, weight per boll in gms, seed cotton yield, kg per hectare, ginning bout turn were recorded using standard procedures.

G.O.T (%) = weight of lint in sample/weight of seed cotton in sample x100.

Potassium agronomic efficiency (NAE, kg kg<sup>-1</sup>),

i.e., the yield (kg ha-1) increase for each kg K applied, was calculated by formula;

Potassium agronomic efficiency = \frac{\text{Lint yield K- Lint yield K}_0}{\text{Amount of K applied}}

STATISTICAL ANALYSIS

Statistical analyses of the data were performed as per ANOVA techniques (Steel et al., 1980) and significant results were subjected to LSD test for mean comparison using MSTATC software (MSTATC, 1991).

RESULTS

Plant height (cm)

ANOVA indicated that plant height showed significant response to zero tillage plus residue management, potassium (K) however, it did not respond to ZT plus straw management (ZT<sub>SAS</sub> × K) interaction during b2018-19 (Table 3). ZT<sub>SAS</sub> had the highest plant height compared to zero tillage straw burnt (ZT<sub>SB</sub>). Mean values for potassium revealed that application of K at the rate of 80 kg ha<sup>-1</sup> produced taller plants amongst all the other potassium rates (Table 4). The results indicate that ZT<sub>SAS</sub> can have productive plant height besides conservation of resources and low cost of cultivation.

Bolls plant<sup>-1</sup>

Boll per plant had significant response to ZT plus straw management and K whereas interaction was not significant during 2018 and 2019 (Table 3). Means showed that ZT<sub>SAS</sub> had the highest number of bolls (Table 5). K at 60-80 kg ha<sup>-1</sup> produced more boll per plant. Application of K at 60-80 kg ha<sup>-1</sup> gave higher boll number in ZT<sub>SAS</sub> plots compared to ZT<sub>SB</sub>.

Bolls weight-gms

Bolls weight was affected significantly by ZT plus straw management, potassium, ZT × K interaction during Y1 while in Y2 interaction was not significant (Table- 3). Higher boll weight was recorded with 80 kg K ha<sup>-1</sup> as compared to all other combinations (Table 6). Interactions indicated that ZT<sub>SAS</sub> at 80 kg K ha<sup>-1</sup> gave heavier boll weight than other treatments.

Seed cotton yield

Seed cotton yield had significant response to ZT, K and ZT × K interactions during 2019 and in Y1 the interaction was non significant (Table-3). ZT<sub>SAS</sub> had significantly greater yield than ZT<sub>SB</sub> in Y1 and Y2 (Table 7). Potassium means revealed highest seed cotton yield was obtained from 60-80 kg K ha<sup>-1</sup> during two study years. ZT × K interactions showed that ZT<sub>SAS</sub> at 80 kg K ha<sup>-1</sup> produced highest seed cotton yield.
Ginning out turn (%)
Lint percent was affected significantly by ZT, potassium and interactions were not significant (Table- 3). ZTSAS produced greater ginning out turn %age than ZTBS. Maximum GOT was obtained from 80 kg K ha\(^{-1}\) (Table 8). Interactions indicated that optimum lint percentage could be recorded with 80 kg K ha\(^{-1}\) under ZTSAS.

Potassium Agronomic Efficiency (KAE)
Potassium agronomic efficiency as the yield (kg ha\(^{-1}\)) increase for each kg K applied (kg ha\(^{-1}\)) is the most important K use efficiency to producers. KAE was significantly affected by ZT and K and ZT \(\times\) K interactions (Table 3). ZTSAS resulted in higher KAE than ZTBS. Potassium application at 20 kg ha\(^{-1}\) had the greatest agronomic efficiencies, while 80 kg K ha\(^{-1}\) had the lowest KAE (Table 9). Mean values for ZT \(\times\) K interactions revealed that ZTSAS in combination with 20 kg K ha\(^{-1}\) gave an optimum NAE.

DISCUSSION
Zero tillage cotton sown into standing residues of wheat is done on experimental basis in Pakistan. Though, cotton growers take eager attention in ZT cotton establishment after wheat harvest due to lower cost of production and profitable cotton yield (Su et al. 2008; Sharma et al., 2002). Research data revealed that higher bolls per plant observed in ZTsas. Because the plants on the ZTsas plots had more numbers of fruiting sites were greater than those observed in the ZTBS (SB-straw burnt). Consequently, ZTsas had greater boll number and weight per boll than ZTBS. Thus, higher seed cotton was recorded under ZTsas than under ZTBS. Enhanced boll retention and weight per boll in ZTsas could be due to other factors such as improved soil K and soil organic matter, differences in nutrient supply and/or conserved soil moisture. Greater boll numbers and boll weight under ZTsas contributed to yield improvements compared to the ZTBS (Pettigrew et al., 2001; Nyakatawa et al., 2001; Norsworthy et al., 2010; Potter et al., 2011; Cassman et al., 200; et al., 2001; Minton et al., 1991; Pettigrew et al., 2008; Kienzler, 2010; Dong et al., 2012). Highest plant height were under ZTsas with optimum K level (Ber et al., 2003; Hu, W et al., 2015). In long-term study on conservation tillage, significant yield differences were observed in upland cotton (Gormus,&Yucel , 2002) The study offers great yield variations in cotton genotype under conservation tillage. In addition, improved soil moisture content due straw mulch and better soil physical conditions might have contributed to more number of bolls and yield improvements in ZTsas than ZTBS (Singh et al., 2005; Xu, et al., 2009). Readet al.,(2006) and Oosterhuis(2010) obtained greater yield due to better soil hydrothermal regime under zero tillage and K at 80 kg ha\(^{-1}\). In this research work, Seed cotton yields was significantly encouraged by ZTsas plots compared to plots ZT straw burnt. Seed cotton yield of the residue burnt plots was lowered significantly compared with the straw retained treatments due to the distinctive decrease of bolls, weight per boll and GOT % age (Kumar et al., 2000; Singh et al., 2006; Jan et al., 2012; Wang et al., 2007; Read et al., 2006; Oosterhuis, 2010).

Our results revealed that lower cotton yield in residue burnt treatments, probably due to loss of mainly organic carbon (C) and huge losses of nitrogen (up to 70%), Phosphorus (26%) and mainly Potassium (20 %) and the death of useful soil flora and micro-organisms (Kumar and Goh 2000; Torbertet al., 2002; Xuet al., 2009). While greater seed cotton-yields in residues retained plots maybe due to improved nutrient accessibility in crop residues and right fertilizer management in soil through the adjustment of abundant micro-organisms after returning of wheat residues to the cotton fields (Sijitsma et al., 1998; Schwab et al., 2002; Tewolde et al.,2008; Reddy et al., 2012; Reddy et al., 2009; Reddy et al., 2001). In the first cotton growing year, the micro-organisms might have feed on more nutrients such as potassium and Carbon to meet their own growth need, thus, lesser bolls, weight boll and last decreased seed cotton yield have reported. However, in the 2nd cotton sowing season, optimum use of soil resources by ZTsas sown cotton and decomposed residues that released fertilizer resulting in higher seed cotton (Zhang, et al., 2007; Wang, et al., 2012; Yang, et al., 2014). Optimum K management in cotton sown in ZTsas with wheat residues retained have increased seed cotton yield due to higher enzymatic activities in boll formation (Pettigrew et al., 2001; Nyakatawa et al., 2001; Norsworthy et al., 2010; Potter et al., 2011). Our results showed K at 60-80 kg ha\(^{-1}\) produced number bolls per plant and heavier boll weight as compared other K treatments (Kaddah, 1997; Kushwaha et al., 2001; Nehra et al., 2005). Enhanced yields in ZTsas with 60-80 kg K ha\(^{-1}\) were probably due to increased K supply, improved decomposition of wheat straw that enhances biological activity, better cotton root growth because of improved soil structure and enhanced soil moisture content by way of better infiltration rates (Cassman et al., 200; et al., 2001; Minton et al., 1991; Pettigrew et al., 2008; Davis-Carter et al., 1992). Results also showed that ZTsas with wheat residues retention in combination with 80 kg K ha\(^{-1}\) had comparatively higher Potassium agronomic efficiency than ZTBS. This result was probably due to more efficient K delivery, and lower losses of K from the system as against ZTBS (Prasad and Power 1991; Unger et al., 1997; Schwab et al., 2002; Tursionov. 2009; Pettigrew and Jones 2001; Ishaq et al., 200; Javed et al., 2009; Huang et al., 2001). An optimum yield response could be achieved from combined input of ZT with straw retained and k fertilizer application at 60 kg K ha\(^{-1}\). This shows that retention of crop residues has led to the increase in the K contents of soil and microbial activity which is clear indication of an improvement in soil health (Pankhurst et al. 2002; Nie et al. 2007). In the present study, we tried to optimize K management under zero tillage methods in order to improve cotton yield in wheat-cotton system.
CONCLUSION
Our data indicate that ZTSAS with 60–80 kg K ha\(^{-1}\) had highest plant height, bolls per plant; bolls weight (g), seed cotton yield and ginning out turn as compared to compared to other treatments. K agronomic efficiency indices decreased with increasing K rate under straw retained than tillage plots with straw burnt. Cotton production with ZTSAS may be maintained at minimum cost of cultivation with no environmental hitch. The results of this study indicate that ZTSAS with 60 kg K ha\(^{-1}\) can improve cotton yield through conservation of resources.

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Table 1: Monthly seasonal precipitation, temperature and relative humidity (%) at Cotton Research Station, Dera Ismail Khan during 2015 and 2016 growing seasons

| Month       | 2018 | 2019 | 2018 | 2019 |
|-------------|------|------|------|------|
|              | Temp (°C) | Relative humidity (%) | Rainfall (mm) | Temp (°C) | Relative humidity (%) | Rainfall (mm) |
| April       | Max | Min | Mean | Max | Min | Max | Min | Mean | Max | Min | Max | Min | Max | Min | Mean | Max | Min | Max | Min | Mean | Max | Min | Mean | Max | Min |
| May         | Max | Min | Mean | Max | Min | Max | Min | Mean | Max | Min | Max | Min | Max | Min | Mean | Max | Min | Max | Min | Mean | Max | Min | Mean | Max | Min |
| June        | Max | Min | Mean | Max | Min | Max | Min | Mean | Max | Min | Max | Min | Max | Min | Mean | Max | Min | Max | Min | Mean | Max | Min | Mean | Max | Min |
| July        | Max | Min | Mean | Max | Min | Max | Min | Mean | Max | Min | Max | Min | Max | Min | Mean | Max | Min | Max | Min | Mean | Max | Min | Mean | Max | Min |
| August      | Max | Min | Mean | Max | Min | Max | Min | Mean | Max | Min | Max | Min | Max | Min | Mean | Max | Min | Max | Min | Mean | Max | Min | Mean | Max | Min |
| September   | Max | Min | Mean | Max | Min | Max | Min | Mean | Max | Min | Max | Min | Max | Min | Mean | Max | Min | Max | Min | Mean | Max | Min | Mean | Max | Min |
| October     | Max | Min | Mean | Max | Min | Max | Min | Mean | Max | Min | Max | Min | Max | Min | Mean | Max | Min | Max | Min | Mean | Max | Min | Mean | Max | Min |
| November    | Max | Min | Mean | Max | Min | Max | Min | Mean | Max | Min | Max | Min | Max | Min | Mean | Max | Min | Max | Min | Mean | Max | Min | Mean | Max | Min |
| Total rainfall | 223.5 | 271.0 |

Source: Arid Zone Research Council (AZRC), D.I.Khan, Pakistan.
### Table 2: Physico-chemical characteristics of the soils used for the experiments at Cotton Research Station, D.I.Khan.

| Characteristic   | Units       | Values |
|-----------------|-------------|--------|
| Sand            | g kg\(^{-1}\) | 140    |
| Silt            | -           | 330    |
| Clay            | -           | 410    |
| Texture Classes | -           | clay loam |
| PH (1:5)        | -           | 7.8    |
| Organic matter  | %           | 0.81   |
| Total N         | %           | 0.03   |
| Available P     | mg/Kg       | 5.6    |
| Available K     | mg/Kg       | 219    |
| EC              | dS/m        | 0.2    |
| CEC             | m.e/100g    | 18.2   |
| HCO\(_3^-\)     | mol/L       | 1.7    |
| CL              | -           | 3.4    |
| Ca\(^{+}\)Mg\(^{+}\) | -       | 2.5    |

Source: ARRI, Dera Ismail Khan, Pakistan.

### Table 3: Analysis of variance (mean squares) of Plant height , bolls plant\(^{-1}\), boll weight (g), seed cotton yield (kg ha\(^{-1}\)), ginning out turn (GOT %) and potassium agronomic efficiency (KAE; kg kg\(^{-1}\)) as influenced by zero tillage plus residue management and potassium rates during 2018 and 2019

| Source          | D.F. | Plant height | Bolls plant\(^{-1}\) | Boll weight | Seed cotton yield | GOT (%) | KAE |
|-----------------|------|--------------|----------------------|-------------|-------------------|---------|-----|
|                  |      |              |                      |             |                   |         |     |
| Replication Y1  | 2    | 0.469        | 0.433                | 0.00434     | 123528            | 0.0448  | 0.00057 |
| Zero tillage (ZT)| 1    | 133.141**    | 120.000**            | 0.36300**   | 356648**          | 14.8544**| 3.96033** |
| Error a         | 2    | 0.474        | 4.900                | 0.00183     | 805               | 0.6356  | 0.00089 |
| Potassium (K)   | 4    | 699.975**    | 206.283**            | 0.18313**   | 1070671**         | 8.3749**| 9.97835** |
| ZT × K          | 4    | 1.726**      | 3.917**              | 0.01506**   | 4898**            | 0.6576**| 0.32633** |
| Error b         | 16   | 1.049        | 4.375                | 0.00033     | 24428             | 1.3883  | 0.00031 |
| Replication Y2  | 2    | 1.233        | 2.396                | 0.00196     | 7920              | 3.1545  | 0.05239 |
| Zero tillage (ZT)| 1    | 168.03**     | 274.216**            | 0.05292*    | 347979*           | 46.3266*| 5.35096** |
| Error a         | 2    | 0.033        | 1.776                | 0.00229     | 9673              | 1.0195  | 0.03172 |
| Potassium (K)   | 4    | 390.42**     | 120.701**            | 0.25895**   | 1592513**         | 24.3931**| 9.53100** |
| ZT × K          | 4    | 2.12**       | 1.612**              | 0.00435**   | 56806*            | 0.6125* | 0.43516** |
| Error b         | 16   | 4.967        | 2.444                | 0.00256     | 12398             | 0.7329  | 0.16029 |

*, **, Significant at 5% and 1% level of probability, respectively. ns, No-significant difference at 5%.
### Table 4 Impact of zero tillage plus residue management and potassium rate on plant height (cm)

| Year (Year) | Potassium rate (kg ha\(^{-1}\)) | Zero tillage plus residue management | Mean |
|-------------|---------------------------------|-------------------------------------|------|
|             |                                 | ZT\(_{SB}\)                      | ZT\(_{SAS}\) |     |
| Y1 (2018)   | 0                               | 89.00                              | 95.00  | 92.00 e |
|             | 20                              | 95.00                              | 99.33  | 97.17 d |
|             | 40                              | 99.00                              | 104.67 | 101.83 c |
|             | 60                              | 106.00                             | 109.00 | 107.50 b |
|             | 80                              | 110.00                             | 114.67 | 112.33 a |
| Mean        |                                 | 99.80 b                           | 104.53 a |

LSD\(_{0.05}\) for ZT\(_{SB}\) = 0.2868, K\(_{SB}\) = 2.7276

Means of similar alphabets are non significant (LSD 5%).

ZT\(_{SB}\) = zero tillage straw burnt
ZT\(_{SAS}\) = zero tillage straw as such on soil surface

### Table 5 Impact of zero tillage plus residue management and potassium rate on bolls plant\(^{-1}\)

| Year (Year) | Potassium rate (kg ha\(^{-1}\)) | Zero tillage plus residue management | Mean |
|-------------|---------------------------------|-------------------------------------|------|
|             |                                 | ZT\(_{SB}\)                      | ZT\(_{SAS}\) |     |
| Y1 (2018)   | 0                               | 15.80                              | 22.03  | 18.92 d |
|             | 20                              | 21.10                              | 25.83  | 23.47 c |
|             | 40                              | 22.53                              | 28.50  | 25.52 b |
|             | 60                              | 25.87                              | 31.57  | 28.72 a |
|             | 80                              | 26.47                              | 34.07  | 30.27 a |
| Mean        |                                 | 22.35 b                           | 28.40 a |

LSD\(_{0.05}\) for ZT\(_{SB}\) = 2.0940, K\(_{SB}\) = 1.9133

Means of similar alphabets are non significant (LSD 5%).

ZT\(_{SB}\) = zero tillage straw burnt
ZT\(_{SAS}\) = zero tillage straw as such on soil surface
Table 6 Impact of zero tillage plus residue management and potassium rate on boll weight (g)

| Year  | Potassium rate (kg ha⁻¹) | Zero tillage plus residue management | Mean  |
|-------|--------------------------|-------------------------------------|-------|
|       |                          | ZT_SB | ZT_SAS   |       |
| Y1 (2018) | 0 | 2.27 | 2.38 | 2.32 d |
|         | 20 | 2.60 | 2.67 | 2.63 c |
|         | 40 | 2.71 | 2.77 | 2.74 b |
|         | 60 | 2.76 | 2.78 | 2.77 b |
|         | 80 | 2.78 | 2.94 | 2.86 a |
| Mean   |     | 2.62 b | 2.71 a |       |

LSD_{0.05} for ZT= 0.0752, K= 0.0619

| Year  | Potassium rate (kg ha⁻¹) | Zero tillage plus residue management | Mean  |
|-------|--------------------------|-------------------------------------|-------|
| Y2 (2019) | 0 | 2.41 h | 2.56 g | 2.48 e |
|         | 20 | 2.65 f | 2.85 c | 2.75 d |
|         | 40 | 2.71 e | 2.91 b | 2.81 c |
|         | 60 | 2.78 c | 2.94 b | 2.86 b |
|         | 80 | 2.75 d | 3.14 a | 2.94 a |
| Mean   |     | 2.66b | 2.88 a |       |

LSD_{0.05} for ZT= 0.0672, K= 0.0222, ZT × K= 0.0314

Means of similar alphabets are non significant (LSD 5%).
ZT_SB = zero tillage straw burnt
ZT_SAS = zero tillage straw as such on soil surface

Table 7 Impact of zero tillage plus residue management and potassium rate on seed cotton yield (kg ha⁻¹)

| Year  | Potassium rate (kg ha⁻¹) | Zero tillage plus residue management | Mean  |
|-------|--------------------------|-------------------------------------|-------|
|       |                          | ZT_SB | ZT_SAS   |       |
| Y1 (2018) | 0 | 1145.0 | 1373.0 | 1259.0 d |
|         | 20 | 1437.3 | 1655.3 | 1546.3 c |
|         | 40 | 1782.0 | 1964.3 | 1873.2 b |
|         | 60 | 2089.3 | 2245.0 | 2167.2 a |
|         | 80 | 2115.0 | 2421.3 | 2268.2 a |
| Mean   |     | 1713.7 b | 1931.8 a |       |

LSD_{0.05} for ZT= 44.588, K= 191.29

| Year  | Potassium rate (kg ha⁻¹) | Zero tillage plus residue management | Mean  |
|-------|--------------------------|-------------------------------------|-------|
| Y2 (2019) | 0 | 1053.3 h | 1579.3 g | 1316.3 e |
|         | 20 | 1791.7 fg | 1932.0 ef | 1861.8 d |
|         | 40 | 2111.3 de | 2160.0 cd | 2135.7 c |
|         | 60 | 2357.0 bc | 2440.0 b | 2398.5 b |
|         | 80 | 2512.0 b | 2791.0 a | 2651.5 a |
| Mean   |     | 1965.1 b | 2180.5 a |       |

LSD_{0.05} for ZT= 154.52, K= 136.28, ZT × K= 192.73

Means of similar alphabets are non significant (LSD 5%).ZT_SB = zero tillage straw burnt
ZT_SAS = zero tillage straw as such on soil surface
### Table 8: Impact of zero tillage plus residue management and potassium rate on ginning out turn (%)

| Year  | Potassium rate (kg ha\(^{-1}\)) | Zero tillage plus residue management | Mean |
|-------|---------------------------------|-------------------------------------|------|
|       |                                 | ZT\(_{SB}\) | ZT\(_{SAS}\) |      |
| Y1 (2018) | 0                              | 35.41 | 37.32 | 36.36 c |
|         | 20                              | 36.20 | 38.37 | 37.28bc |
|         | 40                              | 37.32 | 38.73 | 38.02ab |
|         | 60                              | 38.18 | 39.19 | 38.68ab |
|         | 80                              | 39.12 | 39.66 | 39.39 a  |
| Mean   |                                 | 37.25 b | 38.65 a |      |
|        | LSD\(_{0.05}\) for ZT= 1.2526, K= 1.4421 |      |      |      |
| Y2 (2019) | 0                              | 34.15 | 37.15 | 35.65 d |
|         | 20                              | 35.08 | 38.08 | 36.58 d |
|         | 40                              | 37.06 | 39.04 | 38.05 c |
|         | 60                              | 38.45 | 40.08 | 39.26 b |
|         | 80                              | 39.26 | 42.08 | 40.67 a  |
| Mean   |                                 | 36.80 b | 39.28 a |      |
|        | LSD\(_{0.05}\) for ZT= 1.5864, K= 1.0478 |      |      |      |

Means of similar alphabets are non significant (LSD 5%).

ZT\(_{SB}\) = zero tillage straw burnt
ZT\(_{SAS}\) = zero tillage straw as such on soil surface

### Table 9: Impact of zero tillage plus residue management and potassium rate on K agronomic efficiency

| Year  | Potassium rate (kg ha\(^{-1}\)) | Zero tillage plus residue management | Mean |
|-------|---------------------------------|-------------------------------------|------|
|       |                                 | ZT\(_{SB}\) | ZT\(_{SAS}\) |      |
| Y1 (2018) | 0                              | 2.64 c | 3.75 a | 3.20 a |
|         | 20                              | 2.45 d | 3.52 b | 2.99 b |
|         | 40                              | 1.94 f | 2.47 d | 2.21 c |
|         | 60                              | 1.08 g | 2.00 e | 1.54 d |
| Mean   |                                 | 1.62 b | 2.35 a |      |
|        | LSD\(_{0.05}\) for ZT= 0.0470, K= 0.0215, ZT × K= 0.0304 |      |      |      |
| Y2 (2019) | 0                              | -      | -      | -      |
|         | 20                              | 2.57   | 3.74   | 3.16 a |
|         | 40                              | 2.17   | 3.57   | 2.87 a |
|         | 60                              | 1.96   | 2.66   | 2.31 b |
|         | 80                              | 1.11   | 2.1    | 1.59 c |
| Mean   |                                 | 1.56 b | 2.41 a |      |
|        | LSD\(_{0.05}\) for ZT= 0.2798, K= 0.5283 |      |      |      |

Means of similar alphabets are non significant (LSD 5%).

ZT\(_{SB}\) = zero tillage straw burnt
ZT\(_{SAS}\) = zero tillage straw as such on soil surface