Residue Retention and Potassium Nitrate Improvise the Yield and Economics of Wheat Crop

Manpreet Jaidka* and Amandeep Singh Brar

Krishi Vigyan Kendra, Budh Singh Wala, Moga, Punjab (142 002), India

Abstract

The experiment was conducted during rabi (October, 2021-April, 2022) season at farmers’ field in the NICRA adopted village Meenia, District Moga, Punjab to check the integrated effect of crop residue management practices and KNO₃ spray on the productivity of wheat crop. The trial was replicated four times with eight treatments viz., conventional sowing by residue burning, conventional sowing by residue burning fb foliar spray of KNO₃ (2%) at heading and anthesis stage, sowing of wheat with happy seeder, sowing of wheat with happy seeder fb foliar spray of KNO₃ (2%) at heading and anthesis stage, sowing of wheat with surface seeding, sowing of wheat with surface seeding fb foliar spray of KNO₃ (2%) at heading and anthesis stage, sowing of wheat after incorporation of paddy straw, sowing of wheat after incorporation of paddy straw fb foliar spray of KNO₃ (2%) at heading and anthesis stage. Results showed that surface seeding fb KNO₃ spray, happy seeder technology fb KNO₃ spray recorded significantly higher 1000 grain weight than conventional tillage. Surface seeding and KNO₃ spray recorded highest grain yield (4.91 t ha⁻¹) followed by happy seeder and KNO₃ spray (4.84 t ha⁻¹). A synergistic effect between CRM technologies and foliar application of KNO₃ was recorded where they resulted in 16.65 (4.84 t ha⁻¹), 18.34 (4.91 t ha⁻¹) and 5.38% higher grain yield in comparison to conventional sowing (4.15 t ha⁻¹). A highly significant positive correlation (r=0.449) was recorded between number of grains ear⁻¹ and grain yield. Surface seeding and happy seeder technology significantly increased net returns and B:C of wheat crop than conventional practices.

Keywords: B:C, correlation, KNO₃, surface seeding, synergistic effect

1. Introduction

The Indo-Gangetic plains, covering about 10.5 mha, represent India’s bread basket. In the prevailing rice-wheat cropping system in north western India, a large share out of the 2.5 million farmers burn an estimated 23 million metric tons of rice stubble in October and November to prepare their fields for the subsequent wheat crop (Anonymous, 2017). In addition to this, recurrent aberrant weather conditions pose a threat to sustainable food production across the globe. Among biotic and abiotic factors, heat stress is a significant factor affecting the wheat growth and yield (Karla et al., 2023). National Innovations in Climate Resilient Agriculture (NICRA) project provides platform to demonstrate proven technologies at the farmer’s field in various Agro Climatic Zones (ACZ) and Agro-Ecological Situations (AES) (Lenka et al., 2023). As a result, farmers are considerably adopting climate-resilient agro-technologies along with income-generating activities for higher profit and sustainable development (Medhi et al., 2018). Stable and high yielding varieties under different environmental conditions would be the most important step in any breeding program before release as a variety (Gadisa et al., 2020). Climate change has an impact on agriculture, livestock, forestry, weather trends and patterns, rainfall and energy security (Hussain et al., 2020). Weather extremities have not only threatened food security but also added to the woes of the farming community along with loss of farm outputs. For instance, hike in temperature above 32°C at anthesis, leads to shorter grains, and decrease in grain filling duration which ultimately affects the wheat yield. Climate smart agriculture include water, energy, nutrient, weather oriented suitable practices for various crops and cropping systems. Technological intervention for climate smart agriculture is an integral part for modern day agriculture (Barua et al., 2023). Climate smart agriculture (CSA) includes technologies like happy seeder, surface seeding, KNO₃ spray etc. that certainly prove fruitful in developing climate resilient agriculture (CRA) (Jaidka et al., 2024). Agricultural and rural development strategies are now-a-days solely driven by climate resilience of any system (Taylor and Bhasme, 2021). The climate resilient agro-technologies (CRA) can prove

*Corresponding Author
Manpreet Jaidka
e-mail: mjaidka@pau.edu

Article History
Received on 05th March, 2024
Received in revised form on 05th June, 2024
Accepted in final form on 18th June, 2024
propitious in modifying the present scenario for sustaining agricultural production (Lenka et al., 2022). The happy seeder can sow wheat crop in standing stubbles of preceding rice crop by leaving residue on the soil surface which acts as mulch and helps in soil moisture conservation, soil temperature regulation (Sidhu et al., 2015; Singh et al., 2015). The use of the happy seeder can reduce labour requirements up to 80%, irrigation requirement up to 20% (Saunders et al., 2012) and improve productivity, especially during harsh weather conditions (Aryal et al., 2016; Anonymous, 2012; Sidhu et al., 2015). The highest energy efficiency was recorded in happy seeder technology, which used 19.97 l of diesel to sow one-hectare area in comparison to 69.77 and 71.60 l in disc harrow-roto drill and disc harrows-broadcasting-rotavator techniques, respectively (Jaidka et al., 2020). Surface seeding technique, an eco-friendly method, has the potential to improve crop productivity on a sustainable basis. Compared to existing crop establishment methods, it has certain benefits with respect to crop productivity, environment, and socio-economic issues (Singh et al., 2022). Promoting surface seeding based management practices along with improved seeds, integrated soil and crop management is the key to sustainable production system (Gathala et al., 2020). Two foliar sprays of potassium nitrate @ 0.5% at boot and anthesis stage resulted in higher grain yield followed by one foliar spray @ 1.0% at anthesis stage of wheat in contrast to farmers’ practice (no foliar spray) (Singh and Singh, 2020). Keeping in view the betterness of these techniques, the experiment was conducted in NICRA village to study the integrated effect of crop residue management technologies and foliar spray of potassium nitrate on productivity of wheat crop.

2. Materials and Methods

The experiment was conducted during rabi (October, 2021–April, 2022) season at farmers’ fields in the NICRA adopted village to study the effect of crop residue management practices with and without foliar application of potassium nitrate on the productivity of wheat crop. The trial consisted of eight treatments viz., $T_1$ - Conventional sowing by residue burning, $T_2$- Conventional sowing by residue burning $fb$ two foliar sprays of potassium nitrate @ 2% at heading and anthesis stage, $T_3$- Sowing of wheat with happy seeder (no potassium nitrate), $T_4$- Sowing of wheat with happy seeder $fb$ two foliar sprays of potassium nitrate @ 2% at heading and anthesis stage, $T_5$- Sowing of wheat with surface seeding (no potassium nitrate), $T_6$- Sowing of wheat with surface seeding $fb$ two foliar sprays of potassium nitrate @ 2% at heading and anthesis stage, $T_7$- Sowing of wheat after incorporation of paddy straw (no potassium nitrate), $T_8$- Sowing of wheat after incorporation of paddy straw $fb$ two foliar sprays of potassium nitrate @ 2% at heading and anthesis stage. Each treatment was conducted on an area of 0.5 acre. The weather data showed an increased maximum temperature and less rainfall during 2022 than 2021 especially during the month of March and April. In March, 2022 maximum temperature was 30.3°C but it was 29.7°C in 2021. Similarly in April, 2022, the maximum temperature was 39.5°C but in 2021 it was 34.9°C. The total rainfall received in March 2021 and 2022 was 11.0 and 0.5 mm, respectively. Similarly, the total rainfall received in April 2021 and 2022 was 8.5 and 2.5 mm, respectively. The trial was replicated at four locations in the same village and all the data for various parameters was expressed as an average of those locations for data analysis. Sowing of wheat variety PBW 766 in all the treatments was done in first fortnight of November. All other crop management practices were followed as per the recommendations of Punjab Agricultural University, Ludhiana (Anonymous, 2023). The data pertaining to plant height and ear length were collected by measuring the height of 10 plants and ears, respectively, per treatment which was expressed as an average in cm. Data on number of ears was calculated by randomly throwing tetrads at 5 locations per treatment and expressed as an average value. Number of grains ear$^{-1}$ was expressed as an average value by counting grains in 10 randomly selected ear heads per treatment. 1000-grain weight was calculated 10 times per treatment to express as an average value. The data on grain yield was taken by harvesting the crop from an area of 0.25 acre by nullifying the border effect and was expressed as t ha$^{-1}$. Statistical analysis of the data was performed by using the statistical software OPSTAT. Benefit cost ratio was calculated by determining the gross returns and total cost of cultivation of wheat crop.

3. Results and Discussion

3.1. Grain yield and yield attributes

Data on plant height of wheat showed a non-significant difference among the treatments (Table 1). Similarly, an increase in ear length could not achieve level of significance in surface seeding and happy seeder technology relative to conventional tillage. Data on number of ears (Table 1) revealed that the highest number of ears was recorded in surface seeding treatments (464.79 and 467.33 in $T_3$ and $T_6$, respectively) which was statistically at par with conventional tillage. Data on number of ears in surface seeding can be attributed to better crop germination, better tillering due to favourable soil moisture regime and less mortality of tillers due to heat stress faced during heading stage due to alleviation of harmful effect of heat stress by potassium nitrate. Data pertaining to number of grains per ear depicted that surface seeding of wheat $fb$ foliar spray of potassium nitrate recorded highest number of grains ear$^{-1}$ (46.85) followed by happy seeder $fb$ foliar spray of potassium nitrate i.e., 46.67 which was statistically at par with surface seeding and happy seeder techniques alone. Furthermore, foliar application of potassium nitrate showed an enhancement effect on number of grains per ear in all the treatments irrespective of methodology used for management of paddy straw. Surface seeding $fb$ foliar spray of potassium
nitratenitrate showed an increase by 0.69% as compared to sole
surface seeding treatment (T1). The increase in number of
grains ear-1 can be due to increase in ear length, better seed
setting, and better alleviation of heat stress imparted by
potassium nitrate. Interestingly, the data showed a peculiar
effect of residue retention and foliar application of potassium
nitrate on the 1000 grain weight of wheat. Surface seeding/fb
foliar spray of potassium nitrate, happy seeder technology/fb
foliar spray of potassium nitrate recorded significantly higher
1000 grain weight in comparison to conventional tillage
and residue incorporation. Increase in 1000 grain weight due
to residue retention alone as well as in combination with
potassium nitrate can be due to favourable soil moisture
and temperature regulation during heat stress, which in turn
resulted in, better nutrient availability, longer period of grain
filling, and better grain filling due to efficient translocation of
assimilates towards the sink. Straw retention and foliar spray
of potassium nitrate significantly increased the grain yield
of wheat as compared to conventional tillage. Surface seeding
/fb foliar spray of potassium nitrate recorded highest grain
yield (4.91 t ha-1) followed by happy seeder/fb foliar spray
of potassium nitrate (4.84 t ha-1). Increase in grain yield in
residue retention and potassium nitrate can be attributed
to favourable soil moisture regime and better temperature
regulation, more number of grains ear-1, consistently high
1000 grain weight even in the scenario of hike in ambient
temperature. The results of increase in wheat yield by foliar
spray of potassium nitrate are in line with Vijayakumar et
al. (2019) who reported increased fertility percentage by 5
and grain yield of wheat by 6%. The data on the economics
of wheat crop indicate show better B:C in happy seeder
and surface seeding technology in contrast to conventional
practice. Surface seeding/fb foliar spray of potassium nitrate
recorded highest B:C (3.46), which was statistically at par
with T1, T4 and T6 treatments but significantly different from
rest of the treatments including conventional cultivation as
well as incorporation of paddy straw. The improvisation in
B:C in happy seeder and surface seeding technique with and
without foliar spray of potassium nitrate can be attributed to
decline in cost of cultivation, increase in grain yield and net
returns. Kadam et al. (2023) also reported 65.53% saving in
cost of operation by sowing of wheat crop with happy seeder
technique relative to conventional practice.

3.2. Effect of residue retention and potassium nitrate
The conservation practices recorded an increase in grain yield
of wheat (Table 2). Cultivation of wheat crop with happy
seeder, surface seeding and incorporation of paddy straw
reported 15.57 (4.79 t ha-1), 15.98 (4.81 t ha-1) and 2.63% (4.26
t ha-1) higher grain yield in contrast to conventional sowing
(4.15 t ha-1), respectively. Analysis of data depicted an increase
in grain yield of wheat by foliar application of potassium
nitrate irrespective of the conservation practices followed,
although a range of variation was there among the practices.
For instance, in conventional and surface seeding practices,
potassium nitrate resulted in 1.88% (4.23 t ha-1) and 2.36%
(4.91 t ha-1) higher grain yield than the conventional treatment
(T1). At the same time, CRM technologies i.e., happy seeder,
surface seeding and residue incorporation, demonstrated
synergistic effect with foliar application of potassium nitrate
whereby reporting a hike of 16.65% (4.84 t ha-1), 18.34% (4.91
t ha-1) and 5.38% in grain yield relative to conventional sowing
(4.15 t ha-1), respectively.

3.3. Correlation and regression analysis
Analysis of data revealed highly significant positive correlation
(r=0.449) between number of grains ear-1 and grain yield
(Table 3). Positive correlation between other yield attributes
and grain yield was also recorded but it could not reach
level of significance. Furthermore, positive correlation of ear
length with number of grains ear-1 (r=0.120) and 1000-grain
weight (r=0.233) was also observed. Same in the line, highest
value of regression coefficient was there in case of number of
grains ear-1 (0.409) followed by ear length (0.250) and ear
number (0.182).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>Ear length (cm)</th>
<th>Ear (m-2) (Numbers)</th>
<th>Grains ear-1 (Nos.)</th>
<th>1000 grain wt (g)</th>
<th>Grain yield (t ha-1)</th>
<th>B:C</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>101.14</td>
<td>9.78</td>
<td>461.39</td>
<td>44.17</td>
<td>41.19</td>
<td>4.15</td>
<td>2.74</td>
</tr>
<tr>
<td>T2</td>
<td>101.16</td>
<td>9.80</td>
<td>464.27</td>
<td>45.00</td>
<td>41.61</td>
<td>4.23</td>
<td>2.74</td>
</tr>
<tr>
<td>T3</td>
<td>100.30</td>
<td>10.10</td>
<td>458.43</td>
<td>46.33</td>
<td>45.03</td>
<td>4.79</td>
<td>3.35</td>
</tr>
<tr>
<td>T4</td>
<td>101.44</td>
<td>10.16</td>
<td>461.36</td>
<td>46.67</td>
<td>45.54</td>
<td>4.84</td>
<td>3.36</td>
</tr>
<tr>
<td>T5</td>
<td>100.16</td>
<td>10.20</td>
<td>464.79</td>
<td>46.53</td>
<td>45.23</td>
<td>4.81</td>
<td>3.45</td>
</tr>
<tr>
<td>T6</td>
<td>100.36</td>
<td>10.23</td>
<td>467.33</td>
<td>46.85</td>
<td>45.79</td>
<td>4.91</td>
<td>3.46</td>
</tr>
<tr>
<td>T7</td>
<td>101.30</td>
<td>10.06</td>
<td>461.28</td>
<td>45.07</td>
<td>41.64</td>
<td>4.26</td>
<td>2.69</td>
</tr>
<tr>
<td>T8</td>
<td>100.46</td>
<td>10.10</td>
<td>463.71</td>
<td>45.29</td>
<td>42.07</td>
<td>4.37</td>
<td>2.71</td>
</tr>
<tr>
<td>SE(m±)</td>
<td>0.25</td>
<td>5.95</td>
<td>2.19</td>
<td>2.20</td>
<td>1.71</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>LSD (p&lt;0.05)</td>
<td>NS</td>
<td>NS</td>
<td>3.37</td>
<td>0.88</td>
<td>0.74</td>
<td>0.38</td>
<td>0.45</td>
</tr>
</tbody>
</table>

Table 1: Effect of residue retention and potassium nitrate on grain yield, yield attributes and B:C of wheat crop
Table 2: Rate of change in grain yield of wheat due to potassium nitrate and residue retention techniques (CSTs)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grain yield ((t\ ha^{-1}))</th>
<th>ROI* by CRM technology over (T_1) (%)</th>
<th>ROI by potassium nitrate over (T_1) (%)</th>
<th>Additive effect of CSTs over (T_1) (%)</th>
<th>ROI by (\text{KNO}_3) over CRM technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>(T_1)</td>
<td>4.15</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(T_2)</td>
<td>4.23</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.88</td>
</tr>
<tr>
<td>(T_3)</td>
<td>4.79</td>
<td>15.57</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(T_4)</td>
<td>4.84</td>
<td>-</td>
<td>1.08</td>
<td>16.65</td>
<td>0.94</td>
</tr>
<tr>
<td>(T_5)</td>
<td>4.81</td>
<td>15.98</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(T_6)</td>
<td>4.91</td>
<td>-</td>
<td>2.36</td>
<td>18.34</td>
<td>2.04</td>
</tr>
<tr>
<td>(T_7)</td>
<td>4.26</td>
<td>-</td>
<td>-</td>
<td>16.65</td>
<td>0.94</td>
</tr>
<tr>
<td>(T_8)</td>
<td>4.37</td>
<td>-</td>
<td>2.75</td>
<td>5.38</td>
<td>2.68</td>
</tr>
<tr>
<td>LSD ((p&lt;0.05))</td>
<td>0.38</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* ROI: Rate of increase; CRM: Crop residue management; CSTs: Climate smart technologies

Table 3: Correlation matrix and regression coefficients of grain yield and yield attributes

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Ear length</th>
<th>Ear number</th>
<th>Grain number</th>
<th>1000-Grain weight</th>
<th>Grain yield</th>
<th>Regression coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ear length</td>
<td>1.00</td>
<td>-0.008(^{NS})</td>
<td>0.120(^{NS})</td>
<td>0.233(^{NS})</td>
<td>0.095(^{NS})</td>
<td>0.250</td>
</tr>
<tr>
<td>Ear number</td>
<td>-0.008(^{NS})</td>
<td>1.00</td>
<td>0.137(^{NS})</td>
<td>0.059(^{NS})</td>
<td>0.288(^{NS})</td>
<td>0.182</td>
</tr>
<tr>
<td>Grain number</td>
<td>0.120(^{NS})</td>
<td>0.137(^{NS})</td>
<td>1.00</td>
<td>0.271(^{NS})</td>
<td>0.449**</td>
<td>0.409</td>
</tr>
<tr>
<td>1000- Grain weight</td>
<td>0.233(^{NS})</td>
<td>0.059(^{NS})</td>
<td>0.271(^{NS})</td>
<td>1.00</td>
<td>0.229(^{NS})</td>
<td>0.112</td>
</tr>
<tr>
<td>Grain yield</td>
<td>0.095(^{NS})</td>
<td>0.288(^{NS})</td>
<td>0.449**</td>
<td>0.229(^{NS})</td>
<td>1.00</td>
<td>-</td>
</tr>
</tbody>
</table>

\(^{**}\)Highly significant; \(^{NS}\): Non-significance at \((p<0.05)\) level

4. Conclusion

Residue retention, either by surface seeding or by happy seeder technology, as a sole and in integration with foliar application of potassium nitrate improvised the grain yield, yield attributes and B:C of wheat crop. Correlation analysis showed that number of grains ear\(^{-1}\) showed highly significant positive correlation with grain yield of wheat.

5. Acknowledgement

The authors acknowledge the ICAR-CRIDA, Hyderabad and Agricultural Technology Application Research Institute (ATARI), Zone-I, PAU Campus, Ludhiana for funding the project and providing platform to conduct this research.

6. References


Ethiopian Journal of Crop Sciences 8(1), 87–104.


