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IMPROVEMENT IN PRODUCTIVITY AND QUALITY OF WHEAT FODDER WITH VARIOUS RICE RESIDUE MANAGEMENT PRACTICES AND FERTILIZER LEVELS

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SUMMARY

A field experiment was conducted at Agricultural Farm, Krishi Vigyan Kendra, Damla (Yamunanagar) of CCSHAU, Hisar during Rabi, 2019-20. The study was conducted on HD 3086 variety of wheat crop grown in split plot design with six main plot and three subplot treatments in three replications. The main plot comprised of various residue management practices: Combine harvesting of paddy without SMS, burning of crop residues and sowing of wheat by conventional tillage method; Combine harvesting of paddy without SMS, residue shredding with mulcher followed by happy seeder sowing of wheat; Combine harvesting of paddy without SMS, direct sowing of wheat with happy seeder; Combine harvesting of paddy with SMS followed by sowing of wheat using happy seeder; Combine harvesting of paddy without SMS, residue shredding with straw chopper followed by happy seeder sowing of wheat; Manual harvesting of paddy, residue removal and sowing of wheat with conventional tillage practice. Subplot treatments comprised of different fertilizer levels: 75% RDF, 100% RDF and 125% RDF. The investigation was planned with the objective of improving the production as well quality of wheat fodder. Results of the experiment revealed that among different residue management practices, treatment having residue shredding with mulcher followed by happy seeder sowing of wheat ($C_0R_2T_1$) improved straw yield, protein content and protein yield by 7.7, 3.30 and 13.06 per cent respectively over Manual harvesting of paddy, residue removal and sowing of wheat with conventional tillage practice ($C_2R_0T_3$). Among various fertilizer levels, treatment with 125% RDF (Recommended dose of fertilizer) recorded higher straw yield, protein content and protein yield by 12.7, 8.74 and 24.35 per cent respectively compared to 75% RDF treatment.

Key words: Residue, fertilizer, happy seeder, mulcher

Livestock is intimately associated with crop production and plays an essential role in the development of the country. India holds the first rank in milk production (208 MT), sharing 22 per cent of milk production across the globe (Singh, 2020). But, the productivity of the cattle is still very low in India compared to other countries due to limited quality feed and fodder supply (Owen *et al.,* 2012). Rice-Wheat cropping system is the predominant one in Indo-Gangetic plains (IGP), contributing most to the global caloric food intake. Not only the human diet, but the two are also significant components of crop-livestock systems supporting a number of farmers all over the world (Herrero *et al.,* 2012). Farmers grow rice and wheat preferably for the grain purpose, however, their straws which is considered a by-product is the basal feed source as well as a tradable commodity in IGP's particularly for dairy animals (Samireddypalle and Sampath, 2014; Teufel *et al.,* 2010). Wheat fodder is considered a nutritious and high-quality feed by virtue of its 4.2 per cent crude protein, 4.8 (g/kg DM) calcium, 0.7 (g/kg DM) phosphorus and 11.2 (g/kg DM) potassium. Wheat straw holds 15.1 percent share of total feed dry matter for a population of 520 million herd in India (Samireddypalle *et al.,* 2019). The Indian IGP annually produces 620 MT of crop residue with 1/3rd being contributed by rice-wheat cropping system alone (Singh *et al*., 2020). Nearly 44.5 MT rice straw is burned annually (Singh and Sidhu, 2014) which contains 5-8 kg N, 0.7-1.2 kg P, 12-17 kg K, 0.5-1 kg S, 3-4 kg Ca, 1-3 kg Mg per tonne on dry weight basis (Dobermann and Witt, 2000).Residue burning contributes to the degradation of visibility and air quality (Zhang *et al.,* 2017) due to emissions of greenhouse gases, air pollutants, particulate matter and fumes that threaten human health (Nagar *et al.,* 2020). Burning of residues not only destroys environmental health but also depletes nutrients and affects soil health in the long run. In addition to declining soil fertility, high GHG emissions from the agricultural sector can accelerate the wrath of climate change on grain as well as fodder production. Conservation agriculture is a viable option to handle crop stubble, soil and environmental health all at once. Conservation agriculture practices involving retention and incorporation of residues improve soil health and maintain the favorable conditions (soil temperature, canopy temperature and moisture retention) necessary for plant growth. Turmel *et al.* (2015) also suggested that crop residue returns organic matter to the soil where it is retained through a combination of physical, chemical and biological activities that influence and affect soil quality, including the recycling of nutrients. Furthermore, the role of nitrogen and other nutrients in mainitaining plant homeostatsis (well managed physiological plant system) for lush crop growth is very well known. And since, some nutrients may become immobilized or bio-available during the adoption of in-situ residue management practices, management of fertilizer become crucial when farmers are retaining previous crop residue and moving towards conservation agriculture. Nutrient supply from crop residue can affect the amount of fertilizer required for optimization of crop yield. Therefore, the present investigation was planned to improve the yield as well as the quality of wheat fodder by various in-situ rice residue management practices and adequate fertilizer levels.

MATERIAL AND METHODS

The field investigation was conducted during *Rabi*, 2019-20 at Agricultural Farm, Krishi Vigyan Kendra, Damla (Yamunanagar) of Chaudhary Charan Singh Haryana Agricultural University, Hisar located between 30°08’ N latitude and 77°21’ E longitude. The site experiences a humid subtropical climate and is situated 270 m above mean sea level. Weather data during the crop period was recorded at the meteorological observatory of Krishi Vigyan Kendra, Damla of Chaudhary Charan Singh Haryana Agricultural University, Hisar. Mean weekly maximum temperature ranged from 13.3 to 35.5 °C and the minimum varied from 4.2 to 19.1 °C during 15th and 6th standard meteorological week, respectively. Relative humidity varied from 71 to 100 and 28 to 84 per cent during morning and evening hours, respectively. A total of 298.9 mm rainfall was received during the crop season. The experimental field was slightly alkaline in reaction (pH 7.84) with EC 0.55 dSm^{-1}, low in organic carbon (0.34%), low in available N (132 kg ha^{-1}), medium in available phosphorus (16 kg ha^{-1}) and high in available potassium (366 kg ha^{-1}). The investigation was performed with HD 3086 variety of wheat sown on 03-12-2019 and harvested on 26-04-2020. The research work was conducted in split-plot design with six residue management practices and three fertilizer levels in main plot and sub plot, respectively; and replicated thrice. Main plot included treatments *viz.,* Combine harvesting of paddy without SMS, burning of crop residues and sowing of wheat by conventional tillage method ($C_0R_1T_3$); Combine harvesting of paddy without SMS, residue shredding with mulcher followed by happy seeder sowing of wheat ($C_0R_2T_1$); Combine harvesting of paddy without SMS, direct sowing of wheat with happy seeder ($C_0R_2T_0$); Combine harvesting of paddy with SMS followed by sowing of wheat using happy seeder ($C_1R_2T_0$); Combine harvesting of paddy without SMS, residue shredding with straw chopper followed by happy seeder sowing of wheat ($C_0R_2T_2$); Manual harvesting of paddy, residue removal and sowing of wheat with conventional tillage practice ($C_2R_1T_3$). Subplot treatment comprised of 75% RDF (Recommended dose of fertilizer), 100% RDF and 125% RDF. The crop was grown in accordance with the package of practice for maize crop recommended by CCSHAU, Hisar. Absolute growth rate (AGR) was calculated for shoot dry matter and expressed as g day^{-1} (Radford, 1967).

$$AGR = \frac{w_2 - w_1}{t_2 - t_1}$$

Where, w_1 and w_2 are dry weights of plant at time t_1 and t_2, respectively.

Plant analysis for N, P and K content in straw was done using Nessler’s reagent method (Lindner, 1944), Vanadomolybdo-phosphoric acid yellow colour method (Jackson, 1973) and flame photometer method (Richards, 1954). N, P and K uptake were calculated as per following formula:

$$\text{Nutrient uptake by grain} = \frac{\text{Nutrient content in grain (\%)} \times \text{Grain yield (kg/ha)}}{100}$$

Protein content in grain was worked out by multiplying the nitrogen percentage of straw by a factor of 6.25 and protein yield was worked out using following formula:

$$\text{Protein yield} = \frac{\text{Grain yield (kg/ha)} \times \text{Protein content (\%)}}{100}$$

Statistical analysis was done using OPSTAT software and the data were analyzed at both 1 and 5 percent level of significance. "F" (variance test) was used to evaluate the significance of different treatment effects.

RESULTS AND DISCUSSION

Effect of residue management practices: All the residue retained treatments were observed at par and significantly higher compared to $C_0R_1T_3$ and $C_2R_0T_3$ for AGR during 30-60 and 60-90 DAS (Fig. 1). However, no significant effect of various residue management practices was observed on AGR during 90-120 DAS. Absolute growth is the direct depiction of dry matter accumulated in plants and high dry matter accumulation with residue retention practices due to enough moisture and maintained temperature might have resulted in higher plant growth. Similar findings for improved plant growth when straw is returned to soil were also observed by Li *et al.* (2021) and Guo *et al.* (2015). Straw yield is the depiction of total dry matter accumulated by the plant leaving the portion

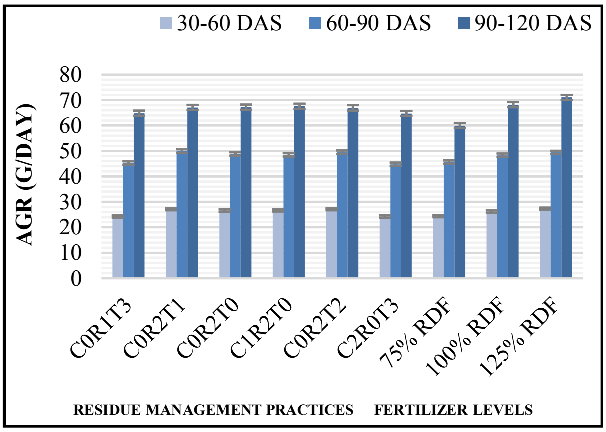

Fig. 1. Effect of residue management practices and fertilizer levels on AGR (g/day).

translocated to grains. Straw yield (Table 1) was significantly increased with inclusion of paddy residue on the soil surface. Maximum straw yield was achieved with $C_0R_2T_1$ (7531 kg ha^{-1}) which was at par with other residue retention treatments but significantly higher than treatments ($C_0R_1T_3$ and $C_2R_0T_3$) with either burning or removal of paddy residue. This positive effect of crop residue on soil moisture conservation, soil nutrient availability by mineralization directly increases the dry matter accumulation and may have contributed to higher straw yield. Singh *et al.* (2013) also reported higher straw yield in happy seeder sown wheat with residue retained conditions as compared to conventional tillage practices. Numerically higher value of N and P was recorded for $C_0R_2T_1$ and $C_0R_2T_2$ treatment as compared to all other treatments (Fig.

TABLE 1

Effect of residue management practices and variable fertilizer levels on straw yield and quality parameters of wheat

Treatments	Straw yield (kg/ha)	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	Protein content (%)	Protein yield (kg/ha)
Residue management practices						
$C_0R_1T_3$	7137	31.28	9.59	100.82	2.74	135.2
$C_0R_2T_1$	7531	33.80	10.30	106.42	2.81	148.0
C_0R2T_0	7396	32.61	9.88	103.65	2.75	142.0
$C_1R_2T_0$	7414	32.77	9.99	104.35	2.76	143.0
$C_0R_2T_2$	7483	33.41	10.24	105.50	2.78	146.2
$C_2R_0T_3$	6991	30.41	9.17	97.29	2.72	130.9
S. Em±	80	0.68	0.20	1.36	0.04	2.5
C. D. (P=0.05)	256	2.17	0.64	4.34	NS	7.9
Fertilizer levels						
75% RDF	6830	28.68	9.00	94.67	2.63	123.98
100% RDF	7450	33.20	9.98	104.90	2.79	144.57
125% RDF	7696	35.25	10.61	109.44	2.86	154.17
S. Em±	44	0.24	0.17	0.76	0.01	0.88
C. D. (P=0.05)	129	0.69	0.49	2.22	0.04	2.58

C_0= Combine harvesting without SMS (Straw management system); C_1= Combine harvesting with SMS; C_2= Manual harvesting leaving short anchored stubbles; R_0= Residue removed; R_1= Residue burned; R_2= Residue retained; T_0= Direct seeding with Happy Seeder in no till conditions; T_1= Residue shredding with mulcher followed by sowing with Happy Seeder in no till conditions; T_2= Residue shredding with paddy straw chopper followed by sowing with Happy Seeder in no till conditions; T_3= Conventional tillage.

2). K content was numerically lower in $C_2R_0T_3$ and $C_0R_2T_0$ treatments as compared to all other residue management practices. Significantly higher N (33.80 kg ha^{-1}), P (10.30 kg ha^{-1}) and K (106.42 kg ha^{-1}) uptake was exhibited by $C_0R_2T_1$ treatment which was statistically at par with all other residue retention practices ($C_0R_2T_0$, $C_1R_2T_0$ and $C_0R_2T_2$) but significantly higher than $C_2R_0T_3$ treatment. This might be due to better nutrient availability due to residue decomposition, higher nutrient content availability, higher grain and straw yield in residue retention treatments. Virk *et al.* (2020) also reported higher N, P, K uptake under happy seeder sowing in which residues were retained on the top soil surface than conventional method. No significant effect of residue management practices was observed on protein content. However, all the treatments except $C_0R_1T_3$ were significantly superior over $C_2R_0T_3$ for protein yield. Treatment $C_0R_2T_2$ significantly increased protein yield by 8.14 and 11.69 per cent compared to $C_0R_1T_3$ and $C_2R_0T_3$, respectively.

Effect of fertilizer levels: Treatments with 100% RDF and 125% RDF were observed at par and significantly higher for AGR compared to 75% RDF during intervals of 30-60, 60-90 and 90-120 DAS (Fig. 1). It might be due to higher nutrient availability which has resulted in higher plant growth. Yadav and Dhanai (2017) also reported an increase in plant height and dry matter with an increase in nitrogen levels. Straw yield is attributed by vegetative growth parameters (Table 1). Higher plant height, number of tillers and dry matter accumulation with 125% RDF resulted in significantly higher straw yield (7696 kg ha^{-1}) than other fertilizer levels. The straw yield obtained with 125% RDF was 3.3 and 12.7 per cent higher than 100% RDF and 75% RDF, respectively. High dry matter accumulation as a result of ample nutrient availability might have attributed to high straw yield. Ullah *et al.* (2018) reported higher biological yield with increased fertilizer dose. Fertilizer levels posed a significant effect on N and K content of straw. Significantly higher N and K content were recorded

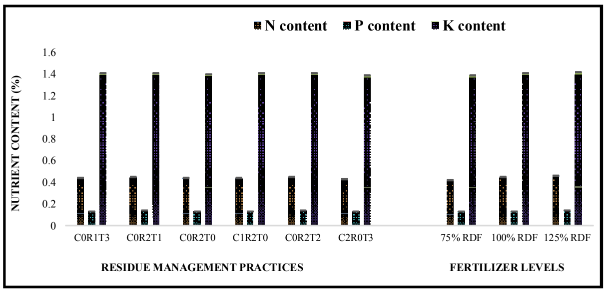

Fig. 2. Effect of various residue management practices and fertilizer levels on nutrient content of wheat straw.

TABLE 2

Interaction effect of residue management practices and fertilizer levels on protein yield of straw (kg/ha)

Treatments	Fertilizer levels		
	75% RDF	100% RDF	125% RDF
Residue management practices			
$C_0R_1T_3$	121.1	139.1	145.4
$C_0R_2T_1$	127.1	152.3	164.8
$C_0R_2T_0$	124.6	145.5	155.9
$C_1R_2T_0$	125.1	147.0	157.0
$C_0R_2T_2$	126.6	150.2	161.9
$C_2R_0T_3$	119.4	133.4	140.1
Factors		C. D. (P=0.05)	S. Em±
Fertilizer level at same level of residue management practice		6.7	4.3
Residue management practices at same level of fertilizer		9.4	3.0

in 125% RDF over 75% RDF treatment. P content in straw was not significantly affected by various fertilizer levels. However, numerically higher P content was observed in 125% RDF over the other treatments. Fertilizer level of 125% RDF also recorded significantly higher N, P and K uptake in straw than in other treatments. N (35.25 kg ha^{-1}), P (10.61 kg ha^{-1}) and K (109.44 kg ha^{-1}) uptake with 125% RDF treatment was 23, 17.9 and 15.6 per cent higher than 75% RDF treatment. Similar results were reported by Ullah *et al.* (2013). Both protein content and yield were significantly improved as fertilizer dose was increased from 75 to 100 and 125%. Treatment having 125% RDF recorded 6.64 and 2.51; 8.74 and 24.35 per cent higher protein content and protein yield over 100 and 75% RDF, respectively. Higher N content and straw yield resulted in more protein content and yield with 125% RDF.

Interaction effect of residue management practices and fertilizer levels on protein yield: No significant difference was observed in grain yield due to various residue management practices at 75% RDF. At 100% RDF and 125% RDF, significantly more protein yield in straw was observed with residue retention treatments ($C_0R_2T_1$, $C_0R_2T_0$, $C_1R_2T_0$ and $C_0R_2T_2$) as compared to residue burned and residue removed treatments ($C_2R_0T_3$ and $C_0R_1T_3$). Significant improvement in protein yield was observed with an increase in fertilizer dose from 75% RDF to 100% RDF in all residue management practices. However, when fertilizer dose is increased from 100% RDF to

125% RDF, only residue retention treatments ($C_0R_2T_1$, $C_0R_2T_0$, $C_1R_2T_0$, $C_0R_2T_2$) showed a significant positive response.

REFERENCES

Dobermann, A., and C. Witt, 2000 : The potential impact of crop intensification on carbon and nitrogen cycling in intensive rice systems. In: Carbon and nitrogen dynamics in flooded soils (Kirk G J D, Olk D C eds) pp. 1-25. International Rice Research Institute, Los Baños, Philippines.

Guo, L.J., Z.S. Zhang, D. D. Wang, C.F. Li, and C.G. Cao, 2015 : Effects of short-term conservation management practices on soil organic carbon fractions and microbial community composition under a rice-wheat rotation system. *Biology and Fertility of Soils*, **51**(1) : 65-75.

Herrero, M.T., P.K. Thornton, A.M.O. Notenbaert, S. Msangi, S. Wood, R.L. Kruska, and P. Parthasarathy Rao, 2012 : Drivers of change in crop–livestock systems and their potential impacts on agro-ecosystems services and human wellbeing to 2030: A study commissioned by the CGIAR Systemwide Livestock Programme. *ILRI Project Report*.

Jackson, M.L., 1973 : Soil Chemical Analysis. Prentice Hall of India. Pvt. Ltd. New Delhi pp. 498.

Li, S.H., L.J. Guo, C.G. Cao, and C.F. Li, 2021 : Effects of straw returning levels on carbon footprint and net ecosystem economic benefits from rice-wheat rotation in central China. *Environmental Science and Pollution Research,* **28(**5) : 5742-5754.

Lindner, R.C., 1944 : Rapid analytical methods for some of the more common inorganic constituents of plant tissues. *Plant Physiology,* **19** : 76-86.

Nagar, R., S.K. Trivedi, D. Nagar, and M. Karnawat, 2020 : Impact of Agriculture Crop Residue Burning on Environment and Soil Health. *Biotica Research Today*, **2**(5) : 171-173.

Owen, E., T. Smith, and H. Makkar, 2012 : Successes and failures with animal nutrition practices and technologies in developing countries: A synthesis of an FAO e-conference. *Animal Feed Science and Technology*, **174**(3-4) : 211-226.

Radford, P.J., 1967 : Growth analysis formulae, their use and abuse. *Crop Science*, **8** : 171-175.

Richards, L.A., 1954 : Diagnosis and improvement of saline and alkali soils. USDA Hand Book No. 60, Washigton, D.C.

Samireddypalle, A., and, K.T. Sampath, 2014 : The Indian feed inventory in conducting national feed assessments. Michael, B., Coughenour, Harinder PS Makkar (Eds.), FAO. Animal Production and Health Manual, **15** : 75-81.

Samireddypalle, A., K.V.S.V. Prasad, D. Ravi, A.A Khan, R. Reddy, U.B. Angadi, and M. Blümmel, 2019 : Embracing whole plant optimization of rice and wheat to meet the growing demand for food and feed. *Field Crops Research*, **244** *:* 107634.

Singh, A., 2020 : Livestock Production Statistics of India–2019. Originally uploaded at www.vetextension.com and updated till, **9**: 19.

Singh, A., J.S. Kang, and M. Kaur, 2013 : Planting of wheat with happy seeder and rotavator in rice stubbles. *Indo-American Journal of Agricultural and Veterinary Sciences,* **1**(8) : 372-379.

Singh, P., G. Singh, and G.P.S. Sodhi, 2020 : Energy and carbon footprints of wheat establishment following different rice residue management strategies vis-à-vis conventional tillage coupled with rice residue burning in north-western India. *Energy,* 117554.

Singh, Y., and H. S. Sidhu, 2014 : Management of cereal crop residues for sustainable rice-wheat production system in the Indo-Gangetic plains of India. Proceedings of the Indian National Science Academy, **80**(1) : 95-114.

Teufel, N., A. Samaddar, M. Blümmel, and O. Erenstein, 2010 : Quality characteristics of wheat and rice straw traded in Indian urban centres. Presentation at Tropentag 2010 ?World food system-A contribution from Europe (pp. 14-16). Switzerland 14-16/09.

Turmel, M.S., A. Speratti, F. Baudron, N. Verhulst, and B. Govaerts, 2015 : Crop residue management and soil health: A systems analysis. *Agricultural Systems*, **134** : 6-16.

Ullah, G., E.A. Khan, I.U. Awan, M.A. Khan, A.A. Khakwani, M.S. Baloch, Q.U. Khan, M.S. Jilani, K. Wasim, S. Javeria, and G. Jilani, 2013 : Wheat response to application methods and levels of nitrogen fertilizer: I. Phenology, growth indices and protein content. *Pakistan Journal of Nutrition*, **12**(4) : 365.

Ullah, I., N. Ali, S. Durrani, M.A. Shabaz, A. Hafeez, H. Ameer, M. Ishfaq, M.R. Fayyaz, A. Rehman, and A. Waheed, 2018 : Effect of different nitrogen levels on growth, yield and yield contributing attributes of wheat. *International Journal of Scientific and Engineering Research*, **9** : 595.

Virk, H.K., G. Singh, and G.S. Manes, 2020 : Nutrient uptake, nitrogen use efficiencies, and energy indices in soybean under various tillage systems with crop residue and nitrogen levels after combine harvested wheat. *Journal of Plant Nutrition*, **43**(3) : 407-417.

Yadav, M.S., and C.S. Dhanai, 2017: Effect of different doses of nitrogen and seed rate on various characters and seed yield of wheat (*Triticum aestivum* L.). *Journal of Pharmacognosy and Phytochemistry*, **6**(2): 01-05.

Zhang, H., J. Hu, Y. Qi, C. Li, J. Chen, X. Wang, J. He, S. Wang, J. Hao, L. Zhang, L. Zhang, Y. Zhang, R. Li, S. Wang, and F. Chai, 2017 : Emission characterization, environmental impact, and control measure of PM 2.5 emitted from agricultural crop residue burning in China. *Journal of Cleaner Production*, **149**: 629-635.