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NUTRIENT EVALUATION OF WHEAT CULTIVARS' STRAW GROWN UNDER DIFFERENT MULCHING MATERIAL FOR ENHANCING LIVESTOCK PERFORMANCE

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SUMMARY

Animal husbandry and agriculture are inextricably linked in India. It is critical to the socio-economic development of millions of rural households, consequently making a significant contribution to the national economy. Livestock is a significant source of revenue and employs 8.8% of the workforce and supports two-thirds of the rural community. Thus, improving the livestock industry implies accelerating rural India's economic development. The most prevalent and persistent difficulty of dairy sector is limited access to high-quality feed throughout the year, but especially during the essential lengthy dry season. Traditional legume and non-legume crop rotations as well as crop and animal integration have been phased out in favour of a single crop for grain production, negatively impacting soil health in a number of places around the country. Due to continual changes in cropping patterns and the development of HYV of rice and wheat, the opportunity for fodder production is dwindling. Land is under severe pressure to produce food for human consumption. In this regard, an experiment was conducted on wheat crop during rabi season, 2019-20 at CCS Haryana agricultural university, Hisar, Haryana. The comparison was made between the three treatments of mulches (M_1- No mulch, M_2- Rice straw mulch @ 6 t/ha and M_3- Plastic mulch) and six wheat varieties (V_1- WH 1142, V_2- WH 1105, V_3- HD 2967, V_4- WH 1184, V_5- HD 3086 and V_6- WH 1124) to make the nutritional evaluation of straw of wheat so that it can be used as livestock feed also. Based on the findings, it is concluded that combined use of mulches and competitive varieties is one of the agronomic practices that has potential to sustainably increase the straw yield. It can be suggested as better tool to gain fodder advantage under prevalent cropping system without compromising the grain production.

Key words : Wheat varieties, straw, NPK Content, NPK uptake and soil health

India is the world's agricultural superpower. It is the world's greatest producer of milk, pulses and spices and has the world's largest herd of cattle (buffaloes) as well as the largest area planted in wheat, rice and cotton. It is the world's second greatest producer of rice, wheat, cotton, sugarcane, farmed fish, sheep and goat meat as well as fruits and vegetables. The nation has over 195 million hectares under agriculture, of which approximately 63% are rainfed (approximately 125 million hectares) and 37% are irrigated (70 m ha). Agriculture is critical to India's economy. More over half of the population lives in villages, where agriculture and animal husbandry are the primary occupations. Animal husbandry and agriculture are inextricably linked in India. It is critical to the socioeconomic development of millions of rural households, consequently making a significant contribution to the national economy. The livestock sector employs 8.8% of the workforce and supports two-thirds of the rural community. The majority of women work in the cattle industry. Thus, improving the livestock industry implies accelerating rural India's economic development. India has the world's biggest cattle population (about 515 million) and the highest milk output (approximately 208 million tonnes), accounting for 22% of worldwide milk production (Singh, 2020). Additionally, this sector has emerged as a critical component in ensuring an equitable and sustainable agriculture system.

Furthermore, when urbanisation and economic levels rise, there is a parallel increase in demand for animal-sourced food (ASF). The growing demand for ASF necessitates an increase in the availability of feed and fodder for livestock production, putting pressure on governments and development organisations to spend more in the feed, fodder and livestock sectors. The most prevalent and persistent difficulty is limited access to high-quality feed throughout the year, but especially during the essential lengthy dry season (Owen *et al*., 2012). The scarcity of high-quality feed is due to a variety of factors, including extended dry seasons, deteriorated soils, a lack of or insufficient adoption of optimum management techniques such as fertilisation and irrigation and a paucity of seed for better cultivars. Feeds and forage production at the farm level is a priority, as is the implementation of breeding policies, strengthening veterinary services, enforcing sanitary regulations and legal frameworks, introducing good manufacturing practises for traditional dairy products and developing human resources to expedite the country's dairy development. But, losses owing to a lack of preservation and processing facilities or user ignorance and natural disasters has exacerbated the feed crisis for animal producers and made dairy and fattening farms the most competitive and difficult to sustain under open market trade policies. Appetite satisfaction, a necessary prerequisite for providing nourishment to ruminants, needs the availability of bulk from fodder. Fodder quality is a necessary condition for improving intake and digestion kinetics in the rumen and hence for efficient and economic output. The farmer's difficulty of fluctuating fodder quantity and quality due to crops, seasons and regions impedes dairy and fattening cattle output in the country.

Rice farming has been enhanced during the previous four decades, resulting in a strong relationship between crop, livestock and households. Traditional legume and non-legume crop rotations as well as crop and animal integration have been phased out in favour of a single crop for grain production, negatively impacting soil health in a number of places around the country. Due to continual changes in cropping patterns and the development of HYV rice, the opportunity for fodder production is dwindling. Additionally, land scarcity, seed scarcity for economically viable fodder crops, a lack of production technology that is compatible with the environment (land, climate, cropping system), and the economics of dairy farming all impact the introduction of a forage crop into an established agricultural system. The substitution of rice for pulses and oilseeds results in a significant loss in nutritious feed for ruminants, such as pulse straw, pulse bran and oilcakes. Straw and other crop residues are used for fuel and a variety of other applications. The National Academy of Agricultural Sciences, a think tank, has suggested that the Budget for 2022-2023 include a comprehensive livestock development programme with an emphasis on three critical components: feed, health and breeding.

First, to begin, improved reproduction and productivity require the availability of high-quality feed and fodder. According to estimates, India is 12 and 30% short of dry and green fodder, respectively. Over the last few decades, the area under fodder farming has been stable at roughly nine million hectares. Need for animal products will continue to expand, as will demand for feed and fodder (Singh, 2020). The third, and most critical, component is preserving indigenous species' genetic integrity. This necessitates the establishment of semen conservation facilities for indigenous breeds. For this, there is a need to improve and update semen centres to ensure the availability of quality semen for cow and buffalo pregnancy and fertility.

India has a surplus of food grains but a shortfall of feed and fodder. According to studies, high-quality seeds of enhanced fodder kinds are unavailable. The most challenging element for farmers seeking to maintain fodder farming is the scarcity of seed banks. Climate change and salinity are the country's primary challenges today. Around 6.727 million hectares of land in India are impacted by salt, accounting for around 2.1 percent of the country's geographical area, with 2.956 million hectares being salty and the other 3.771 million hectares being sodic (Arora *et al*., 2016; Arora and Sharma, 2017).

Additionally, population expansion and urbanisation have reduced the country's total operated and gross cultivated area, leaving no extra land for fodder farming and compressing common land utilised mostly for grazing by indigenous animals. Thus, in order to fulfil the demands of an expanding population and animal husbandry, it is necessary to rely on agronomic approaches that address both of these issues concurrently.

In this regard, an experiment was conducted on wheat crop during rabi season, 2019-20 at CCS Haryana Agricultural University, Hisar, Haryana. The comparison was made between the three treatments of mulches (M_1- No mulch, M_2- Rice straw mulch @ 6 t/ha and M_3- Plastic mulch) and six wheat varieties (V_1- WH 1142, V_2- WH 1105, V_3- HD 2967, V_4- WH 1184, V_5- HD 3086 and V_6- WH 1124) to make the

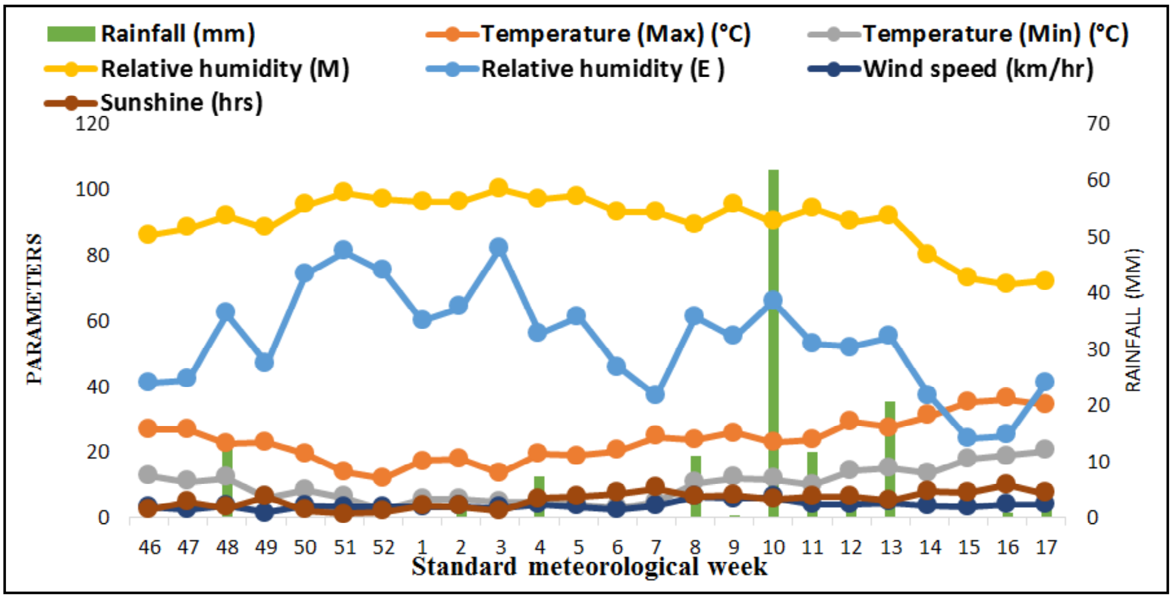

Fig. 1. Mean weekly values of important weather elements during *Rabi*, 2019-20.

nutritional evaluation of straw of wheat so that it can be used as livestock feed also.

MATERIAL AND METHODS

The experiment was done in *Rabi*, 2019-20 at the Agronomy Farm of Chaudhary Charan Singh Haryana Agricultural University in Hisar, Haryana (India), which is located at 29°10' N latitude and 75°46' E longitude and has an elevation of 215.2 m above mean sea level. Hisar has a continental climate with very hot summers and relatively cool winters. It is situated in the tract of semi-arid and subtropical monsoonal climate. The main characteristics of climate in Hisar are dryness, extreme of temperature and scanty rainfall. The soils of Hisar are derived from Indo-Gangetic alluvium, which are very deep and sandy loam in texture and contain some amount of calcium carbonate in its profile. Weather data during the crop season represented in Fig. 1. The comparison was made between the three treatments of mulches (M_1- No mulch, M_2- Rice straw mulch @ 6 t/ha and M_3- Plastic mulch) and six wheat varieties (V_1- WH 1142, V_2- WH 1105, V_3- HD 2967, V_4- WH 1184, V_5- HD 3086 and V_6- WH 1124). The design of the experiment was Factorial randomized block design having three replications. Sowing of the wheat was done manually with the help of hand plough by *pora* method at 5 cm depth on 17th November, 2019. Rice straw was spreaded manually and strips of plastic mulch laid out in respective plots. The crop was fertilized with 150 kg N and 60 kg P_2O_5/haiamid the test. Diammonium phosphate @ 130 kg/ha (23 kg/N/ha and 60 kg P_2O_5i/ha) was bored at the time of sowing. Remaining half dose of nitrogen was top dressed at 1st irrigation. Urea was broadcasted at 52 kg N/ha only preceding wheat sowing and at 75 kg N/ha immediately before the first irrigation. For recording data, crop was harvested on 24th April, 2020. Plant height of five randomly tagged plants from each net plot was recorded at harvest. The height of each plant was measured with the help of wooden scale from the soil surface to fully opened top leaf of the plant before ear emergence and up to the earhead after heading stage. Plants in per metre row length from the second row on either side in each net plot, representing the whole plot, were cut close to the ground at harvest to record dry matter accumulation per metre row length. At the time of selection, it was taken care that area of one metre near the bunds was excluded for sampling. These samples were first sun dried and then oven dried at 65°C ± 2°C till a constant weight was obtained at each stage. After drying, the samples were weighed for recording dry weight in grams per metre row length (g/mrl). N, P and K content in straw at harvest was determined. For analysis of N, P and K, oven dried plant material (straw at harvest) from each plot was grinded separately with grinder and analysis the Nitrogen (Nessler's reagent method, Lindner, 1944), phosphorus (Vanadomolybdo-phosphoric acid yellow colour method, Jackson, 1973) and potassium (Flame photometer method, Richards, 1954) contents in sample as described earlier. The uptake of each nutrient was computed as: Nutrient conc. In straw (%) x straw yield (kg/ha)/100. Straw yield (kg/ha) was calculated by substracting grain yield from biological yield for each of net plot area and expressed in kg/ha.

RESULTS AND DISCUSSIONS

Growth is a gradual development in size, weight or height, age and maturity or is a permanent gain in the plant's volume, dry weight and size. Plants collect their energy for growth from the sun via photosynthesis. The growth of a plant is influenced by variety of physiological and metabolic processes, which are in turn modified by prevailing environmental conditions and cultural management practices adopted during the crop growth. However, it is not possible to manipulate environmental conditions under field conditions. Hence, judicious selection of agronomic practices like sowing method, irrigation management, weed management and nutrient management can improve yield of crop upto a great extent. Moreover, different varieties responded differently to agroclimatic conditions. So, screening of many varieties is necessary to select those which perform better under diverse weather conditions and can ultimately mitigate the negative impacts of environmental conditions on overall productivity of wheat. Therefore, combination of soil cover (mulch) and varieties can prove to be better alternative under the concept of conservation agriculture (CA) in order to obtain high crop productivity.

Growth with respect to plant height, dry matter accumulation revealed that maximum plant height (cm) were observed in WH 1142 but difference was non-significant. Dry matter accumulation (Table 1) of different wheat varieties varied significantly during all crop stages. At harvest, WH 1142 produced 358.59 g mrl^{-1} dry matter, which was significantly higher than rest of the varieties. On contrary to, HD 2967 reported 281.27 dry matter accumulation (g per metre row length) at harvest. This was probably because of similar pattern of plant height as dry matter accumulation depends on the height of plant. Significant differences among varieties with respect to dry matter accumulation was also reported by Singh *et al*., 2017. The longest plant of 98.96 cm was observed in (M_2) rice straw mulch at harvest. While, shortest plant of 91.34 cm was obtained from (M_1) no mulch treatment (control) at harvest. The reason behind this is that mulches increase soil moisture availability and maintain an optimal soil temperature. These both factors are positively correlated with plant height. However, it is widely recognised that cereals such as wheat have the capacity to develop an increased number of tillers in order to compensate for a decreased emergence rate under mulched conditions (Solie *et al*.,1991; Porter and Khalilian, 1995; Ram *et al*., 2012).

Dry matter accumulation rises with the progress of phenological stages. Moreover, the highest dry matter of 363.67 g per metre row length was observed in (M_2) rice straw mulch at harvest. Whereas, the lowest dry matter of 284.59 g per metre row length was obtained from (M_1) no mulch treatment (control)

TABLE 1

Effect of different mulch materials on Plant Height, dry matter accumulation, nutrient uptake, nutrient content in straw and straw yield on different wheat varieties at harvest

Treatments	Plant height (cm)	Dry matter accumulation (g per metre row length)	Nutrients uptake by Straw (kg/ha)		
			N	P	K
Varieties					
V_1-WH 1142	97.98	358.59	33.95	4.42	126.69
V_2-WH 1105	92.34	336.60	10.69	1.37	60.42
V_3-HD 2967	95.92	281.27	28.71	3.72	110.20
V_4-WH 1184	99.66	333.55	18.78	2.54	82.43
V_5-HD 3086	91.30	341.52	21.75	2.73	87.48
V_6-WH 1124	92.07	309.88	18.96	2.40	90.45
SE(m)	2.73	0.53	0.42	0.05	1.44
CD (p=0.05)	NS	1.54	1.20	0.14	4.15
Mulches					
M_1-No mulch	91.34	284.59	17.96	2.36	77.48
M_2-Rice straw mulch @ 6 t/ha	98.96	363.67	25.84	3.33	105.61
M_3-Plastic mulch	94.33	332.44	22.62	2.89	95.74
SE (m)	1.93	0.38	0.30	0.04	1.02
CD (p=0.05)	5.58	1.09	0.85	0.10	2.93

at harvest. Although, plant population was less under rice straw due to load of mulch, but later it was curtailed by producing more no. of tillers as documented by Ram *et al*., 2013.

The uptake of nutrients by straw affected significantly due to varieties. Among the varieties, considerably higher straw N uptake was observed under the variety WH 1142 over others five varieties. This result supported by the findings of Maltas *et al*., 2018 who reported the significant effect of cultivar on total N uptake as distribution of nutrients in plant parts is one of the most important determination of yield and quality. Nitrogen uptake is positively correlated with grain yield, protein content and grain quality. Increase in efficiency of nitrogen is an important way for increasing straw N concentration. While, highest P uptake by straw was reported by WH 1142 (4.42 kg/ha). Like P uptake, similar pattern was followed in terms of K uptake by plants. Nutrient distribution in various plant parts is influenced by genotypes, environment condition and their interaction (Fageria, 2001). The results have conformity with the literatures of Balla *et al*., 2009 and Dangi and Khatkar, 2017 who revealed that varieties presented broad spectrum of variation in quality parameters especially nutrient uptake as represented in Table 1.

Different mulch treatments significantly influenced the uptake of nitrogen, phosphorus and potassium by wheat plants. Out of various mulch treatments, the highest nitrogen, phosphorus and potassium uptake were recorded under (M_2) rice straw mulch (25.84, 3.33 and 105.61 kg/ha N, P and K, respectively) followed by (M_3) plastic straw mulch. While, the lowest total nitrogen, phosphorus and potassium uptake were recorded under (M_1) no mulch treatment. Apart from providing essential macro and micronutrients, organic mulch also contributes a suitable quantity of humic substances to the soil, maintaining the pH of soil that is favorable for plant growth and development resulting in improved nutrient uptake. The uptake of nutrients by plants from the soil system is dependent on a number of interrelated factors, the most significant of which are the absolute and relative concentrations of ions in the external medium as well as in the plant tissues, the roots' capacity for cation exchange and the relative mobility of hydration (Stewart, 1947).

The increased absorption of N, P and K by straw under mulch application is due to the increased availability of these nutrients which promotes crop growth and development, resulting in increased straw production. This is feasible due to increased mineralization of nutrients caused by the application of mulch which increases wheat's nutrient usage efficiency (Maurya *et al*., 2017).

TABLE 2

Effect of different mulch materials on nutrient content in straw and straw yield and harvest index on different wheat varieties at harvest

Treatments	Nutrient content in straw (%)			Straw yield (kg/ha)	Harvest index (%)
	N	P	K		
Varieties					
V_1-WH 1142	0.344	0.045	1.286	9852	35.68
V_2-WH 1105	0.209	0.027	1.184	5084	40.46
V_3-HD 2967	0.329	0.043	1.266	8701	37.47
V_4-WH 1184	0.280	0.038	1.234	6667	36.71
V_5-HD 3086	0.312	0.039	1.258	6948	36.14
V_6-WH 1124	0.253	0.032	1.222	7381	33.68
SE(m)	0.003	0.001	0.005	115	0.50
CD (p=0.05)	0.009	0.001	0.016	332	1.45
Mulches					
M_1-No mulch	0.273	0.036	1.220	6300	35.95
M_2-Rice straw mulch @ 6 t/ha	0.303	0.039	1.262	8341	37.99
M_3-Plastic mulch	0.288	0.037	1.243	7676	36.13
SE (m)	0.002	0.001	0.004	81	0.36
CD (p=0.05)	0.006	0.001	0.011	235	1.02

Nutrient contents were estimated in straw of wheat crop at the time of harvest (Table 2). The varieties differed significantly with respect to nitrogen, phosphorus and potassium contents in straw. The highest (0.344 %) and lowest (0.209 %) nitrogen contents in straw were recorded from WH 1142 and WH 1105, respectively. The probable reason for this is that varieties showed significant variation in nitrogen content in straw because of their unique genetical characteristics as reported by Belete *et al*., 2018. The maximum phosphorus content in straw was recorded by WH 1142.

Whereas, the lowest phosphorus content in straw was recorded by WH 1105. Highest potassium concentration (1.286%) in straw was recorded from WH 1142, whereas the lowest potassium content (1.184 %) in straw was recorded from WH 1105. Varieties differed significantly in terms of nutrient content in grain and straw as reported from the literatures of Dangi and Khatkar, 2017.

The effect due to different mulch treatment was significant on nitrogen concentration in straw. Although, highest nitrogen concentration in straw was significant. The similar findings documented by

Maurya *et al*., 2017 and Ahmed *et al*., 2020 as they reported that application of mulch will improve the nitrogen concentration in straw because of availability of adequate moisture and more nutrient preservation than no mulch plots.

It has been observed that mulch influence the phosphorus and potassium contents in straw significantly. The maximum nutrient contents in straw were recorded under (M_2) rice straw mulch and the lowest nutrient concentration in straw was achieved under (M_1) no mulch treatment. The possible reason is uptake of more nutrients by crop in the presence of sufficient moisture because of application of mulch, that helped to increase in the growth of the crop which subsequently leads to increase in yield of wheat. Similar findings have been discovered by Hussian *et al*., 2017 and Ahmed *et al*., 2020 who documented that there is positive influence of mulch on nutrient content in straw.

Similar, like above yield attributes, straw yield markedly influenced by varieties and mulches. The maximum straw yield (Table 2) was recorded in WH 1142 (9852 kg/ha). Whereas, lowest straw yield was recorded in WH 1105 (5084 kg/ha). Similar pattern followed by varieties in terms of dry matter accumulation could be the reason behind this. The results are corroborated by the relevant literatures of Deshmukh *et al*., 2015 and Kumari, 2015. Significantly the highest straw yield was reported under (M_2) rice straw mulch (8341 kg/ha) followed by (M_3) plastic mulch (7676 kg/ha), while lowest was observed under (M_0) no mulch treatment (6300 kg/ha). Although, the plant population was less under rice straw due to load of mulch, but later it was curtailed by producing more no. of tillers as reported by Ram *et al*., 2013. Hence, more straw yield reported under rice straw mulch. Further, the straw yield depends upon the plant height, dry matter accumulation and yield contributing parameters. Subsequent absorption of stored soil moisture moderated the water status of plants, soil temperature and soil mechanical resistance, resulting in improved root development and straw yields. (Pervaiz *et al*., 2009).

In contrast to straw yield, the highest harvest index was reported in WH 1105 because of cumulative effect of grain and biological yield. The variation in yield attributes and yield may be because of the variation in genetic potential of varieties and environmental factors. The annual variation in productivity of wheat resulted because of climate change. As a result of climate change, the incidence of extreme weather events has increased. Extremely high temperature during grain filling stage are the primary factor causing crop yield losses. Ram *et al.,* 2012 reported similar genotypic variation in yields and harvest index. Several researchers have also noticed the variation in the varieties of wheat for yields attributes (Yadav *et al*., 2017).

Among different mulch materials, similar trend like other yield attributes was observed in case of harvest index (%) as represented in Table 2. These are critical parameters that indicate the efficiency with which dry matter is partitioned to economic portion of the crop. Under different agronomic practices, the higher the harvest index, greater the economic return of crop. The other possible reason for this may be availability of sufficient moisture for proper vegetative growth and development of the crop increased the plant height, dry matter accumulation, no. of tillers and leaf area index of crop, which contributed in increased photosynthesis activity, and in turn higher yield attributes were produced (Rummana *et al*., 2018).

CONCLUSION

From one year study, it can be concluded that growth parameters and straw yield were considerably greater under the variety WH 1142 than other five varieties. Rice straw mulch considerably increased growth metrics, yield characteristics and yield as well as N, P and K content and NPK absorption by straw. Overall, it can be said that combined use of mulches and competitive varieties is one of the agronomic practices that has potential to sustainably increase the straw yield. It can be suggested as better tool to gain fodder advantage under prevalent cropping system without compromising the grain production.

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