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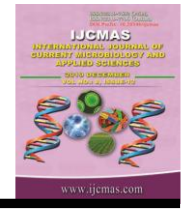

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Influence of Straw Mulch and Nitrogen Management on Yield and Input Use Efficiency of Maize (*Zea mays* L.)

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A B S T R A C T

The present investigation entitled "Influence of straw mulch and nitrogen management on yield and input use efficiency of maize (*Zea mays* L.)" was conducted at Students' Research Farm, Khalsa college, Amritsar. The experiment was laid out in split plot design with twelve treatments comprising of T_1 : N_0 + 0 t ha^{-1} (straw mulch); T_2 : N_{100} + 0 t ha^{-1}; T_3 : N_{125} + 0 t ha^{-1}; T_4 : N_{150} + 0 t ha^{-1}; T_5 : N_0 + 6 t ha^{-1}; T_6 : N_{100} + 6 t ha^{-1}; T_7 : N_{125} + 6 t ha^{-1}; T_8 : N_{150} + 6 t ha^{-1}; T_9: N_0 + 10 t ha^{-1}; T_{10}: N_{100} + 10 t ha^{-1}; T_{11}: N_{125} + 10 t ha^{-1}; T_{12}: N_{150} + 10 t ha^{-1}. The soil was sandy loam, moderately alkaline in reaction, medium in available K and available P and low in organic carbon and available N. The results showed that soil properties *viz*., pH and EC were not significantly affected under straw mulching treatments whereas organic carbon slightly improved through straw addition. The availability of macro nutrient (NPK) increase with increase rate of wheat straw mulch. Plant growth parameters, yield as well as nutrient uptake were highest in straw mulch as compared to no mulch treatment. Straw mulch increases the NUE (%) of maize crop. However, with increasing the rate of nitrogen, soil EC was significantly affected. The availability of macro (N, P and K) nutrient increased with increasing the rate of nitrogen fertilizer but 125 kg N ha^{-1} remain at par with 150 kg N ha^{-1}. Plant growth parameters, yield as well as nutrient uptake were highest in 150 kg N ha^{-1} which was at par with 125 kg N ha^{-1}.So, as by economical analysis @10 t ha^{-1} straw mulch and 125 kg N ha^{-1} will more beneficial treatment with highest B:C ratio as compared to other treatment.

Introduction

Maize (*Zea mays* L.) belonging to family Poaceae, has roots in America and Mexico. It is the third most important cereal crop with respect to area and productivity after wheat and rice. It was firstly cultivated more than 7,000 years ago and further extended to both North and South America. It is a staple food crop for the rural. Presently, India ranks 4th, 7th, and 6th with respect to area, production and consumption of maize, respectively in worldwide level (Kaur, 2014).

Because of its expanded use in the agro industries, it is recognized as a leading commercial crop of great agro economic value. In Punjab, maize is mainly grown during *Kharif* season and was cultivated on 114 thousand hectares with a production of 423 thousand tonnes and average yield of 37.52 q ha^{-1} (Anonymous, 2018). Maize being C_4 plant is considered to be energy efficient and has high yield potential which also add towards its importance in agriculture. Because of its expanded use in the agro industries, it is recognized as a leading commercial crop of great agro economic value.

The continuous adoption of rice-wheat cropping system has led to a number of problems such as severe depletion of underground water, deterioration of soil health, increased environment pollution and emergence of new insect-pests, diseases and resistant weeds. The above mentioned factors have led to the need for replacing high water requiring rice crop with comparatively low water demanding maize crop. So, it is an attractive alternative to rice for diversification by farmers of the state. Jalota and Arora (2002) suggested that maize-wheat cropping system have low water requirement and this can be an appropriate alternative to rice-wheat cropping system for maintaining soil health and balanced hydrology in the Punjab state

Nitrogen (N) is a main important nutrient that improves growth and yield parameters of crop. Use of mineral, organic, microbial and fertilizer at optimum level not only increase the yield of crop, but also helps to lead sustainable higher maize yield (Glamaoclija *et al.,* 2011). By concerning agricultural and environmental objectives, it is necessary to enhance nitrogen use efficiency. To increase crop yield, it is very important to add continuously fertilizer for favourable nutrient supply (Fagaria *et al.,* 2005). However, nitrogen can leach down to the soil profile or will be lost to environment through denitrification or retained by soil matrix by injudicious application of nitrogen (Wang *et al.,* 2011).

Furthermore, straw mulching has many advantageous effects when compared with no mulching. Research results have shown that mulch provides numerous benefits to crop production by improving the physical, chemical, and biological soil properties. It dampens the influence of environmental factor on soil by decreasing soil temperature and controlling diurnal/seasonal fluctuation in soil temperature (Novak *et al.,* 2000; Li *et al.,* 2013). Organic carbon content of the soil increased by straw mulching during the maize-growing season (Monneveux *et al.,* 2006). Removal of crop residues (to feed animals and to be used as fuel for cooking with only partial return of manure and ashes to cropped land) and burning of crop residues have led to nutrient depleted soils on various places that has led to erosion of top fertile soil. The crop residue or organic matter helps to recycle the nutrients to correct their deficiencies. A better N:P ratio and high yield can be maintained by organic matter or crop residue mulch (Bakhtiar *et al.,* 2002*;* Khanam *et al.,* 2001). Organic mulches improves plant canopy and provide better soil water status in terms of biomass, root growth, leaf area index and grain yield, which subsequently resulted in higher water and N uptake and improved their use efficiency in maize crop (Chakraborty *et al.,* 2010). A step further, is to combine improved nutrients management practices with conservation tillage, including the recycling of crop residues, because amounts of crop residues are left in the field is increasing, especially in areas where fossil energy is used for cooking. In early 1990's, reduced tillage was introduced in the study area and it showed to be highly effective in decreasing wind erosion and soil drying (Wang *et al.,* 2006).

Long term continuous use of mineral fertilizers leads to environmental pollution and decreasing soil fertility due to soil mining and higher input cost of nutrients compel farmers to think about recycling of crop residue mulch (straw) (Kiani *et al.,* 2005). This study is based on the hypothesis that wheat straw mulch with inorganic N fertilizer application will significantly improve soil properties in maize crop. Hence, the present investigation was aimed to evaluate the effect of straw mulch with different nitrogen application rates on the yield and nitrogen use efficiency of maize crop.

Materials and Methods

The field experiment was conducted during Rabi season (Aug to Dec) of 2017 at Students' Research Farm, Khalsa College, Amritsar, India on sandy loam, moderately alkaline (pH 8.22), medium in organic carbon (0.45 %), EC (0.32 dS m^{-1}), available P (20.53 kg ha^{-1}) and available K (261.36 kg ha^{-1}) and low in available N (215.21 kg ha^{-1}) soil. Wheat straw was obtained from a nearby village in Amritsar. Wheat straw applied with different rate *viz.,* 0 t ha^{-1}, 6 t ha^{-1} and 10 t ha^{-1} and different rate of inorganic dose of nitrogenous fertilizers were applied according to the treatments.

The experiment was laid out in Split Plot Design (SPD) with the three replications. A total of twelve treatments; T_1 - no mulch + 0 kg N ha^{-1}, T_2 – no mulch + 100 kg N ha^{-1}, T_3 – no mulch + 125 kg N ha^{-1}, T_4 – no mulch + 150 kg N ha^{-1}, T_5 – 6 t ha^{-1} + 0kg N ha^{-1}, T_6 – 6 t ha^{-1} + 100 kg N ha^{-1}, T_7 – 6 t ha^{-1} + 125 kg N ha^{-1}, T_8- 6 t ha^{-1} + 150 kg N ha^{-1}, T_9- 10 t ha^{-1} + 0 kg N ha^{-1}, T_{10} – 10 t ha^{-1} + 100 kg N ha^{-1}, T_{11} – 10 t ha^{-1} + 125 kg N ha^{-1}, T_{12} – 10 t ha^{-1} + 150 kg N ha^{-1} for evaluated of nitrogen use efficiency (NUE). The cultivar PMH 1 is hybrid maize developed by PAU. It is a main season and highly adaptable variety of maize that produce good quality cobs. Crop was sown in 3 m × 3 m plots with spacing of 60 cm × 20 cm. Fertilizers used were urea (46% N), single superphosphate (16% P) and muriate of potash (60% K). All the dose of P, K and nitrogen was given in three split doses - first dose was given at the time of field preparation and second at knee-high stage and third at pre-tasseling stage as per package of practices for cultivation of crops published by Punjab Agricultural University, Ludhiana.

Soil samples were taken from all the replications before starting the experiment and after the harvest of maize from each treatment. Soil Samples were air dried and ground to pass through a 2 mm sieve. Soil samples were analysed for pH and EC in 1:2 soil: water suspension, organic carbon (Walkley and Black, 1934), available N (Subbiah and Asija, 1965), available P (Olsen, 1954), available K. Total N, P (Chapman and Pratt, 1961; Jackson, 1987) and K (Jackson, 1987) uptake in plant samples was analyzed after the harvest. Agronomic nitrogen use efficiency (Dilz, 1988) and apparent nitrogen recovery were calculated as described by Novoa and Loomis (1981).

Results and Discussion

Wheat straw mulching substantially lowered the maximum soil temperature at 5cm depth (Table 1). Maximum soil temperatures in un-mulched plots ranged from 29.7-34.3^{0}C in maize. The lower soil temperature in the mulched plots is in agreement with the results of Kader *et al.,* (2017). On average, soil temperature in straw mulch was 3.8^0 C lower than in un-mulched plots, whereas in 6 t ha^{-1} mulched plots soil temperature was lowered by 2.8^0 C as compared to control.

Use of wheat straw mulch and nitrogen inorganic fertilizers showed significant impact on yield and other attributes of maize. Highest plant height (204.45 cm), no of leaves $plant^{-1}$ (15.67), leaf area index (4.80) with straw mulch at harvest was recorded under the application of 10 t ha^{-1} straw mulch fertilizers which was statistically higher than other treatment in which 0 and 6 t ha^{-1} straw mulch was applied. However, with different rate of nitrogen fertilizer highest plant height (217.46 cm), no of leaves $plant^{-1}$ (16.08), leaf area index (5.22 cm) was recorded during harvest under application of 150 kg N ha^{-1} which was statistically at par with 125 kg N ha^{-1} and significantly higher than other treatment in which 0 and 100 kg N ha^{-1} was applied (Table 2).

Increase in plant height, leaf area index of maize under straw mulch treatments may be attributed to better conservation of soil moisture and low temperature and therefore, improved soil enzyme activities, nutrient availability, carbon stocks and ultimately, soil functionality and sustainability as reported by (Sidhu *et al.,* 2007). The improvement in plant height, leaf area index with each successive increment of nitrogen might be attributed to nitrogen usage by plants in active cell division to form building blocks for cell expansion. Nitrogen also helps in manufacturing more leaf area as a consequence more assimilates production and increases plant height. Similarly more vegetative development by nitrogen resulted in increased mutual shading and intermodal expansion (Iqbal *et al.,* 2016).

The increase in number of leaves $plant^{-1}$ with mulching treatments may be related to increase in plant height and better crop growth Uwah and Iwo (2011). The increase in number of leaves $plant^{-1}$ with each increment of nitrogen level might be attributed to increase in plant height and better crop growth with higher nitrogen availability. Moreover, nitrogen is a primary nutrient required for better development of leaves Singh *et al.,* (2010) and Ayub *et al.,* (2003).

The observation on number of grains $cobs^{-1}$, 1000 grain weight, dry matter accumulation and yield showed an increasing trend with higher level of straw mulching rate (Table 3). The highest number of grains $cobs^{-1}$ (359.75) and 1000 grain weight (282.5 g) was recorded with application of 10 t ha^{-1} which was at par with treatment 6 t ha^{-1} straw mulching. However, with increasing the nitrogen levels number of grains $cobs^{-1}$ and 1000 grain weight was increased upto150 kg N ha^{-1} (388.63 and 293.3 g) but it was statistically at par with 125 kg N ha^{-1} (385.31 and 290.1 g) Number of grains $cobs^{-1}$ as well as 1000 grain weight was increased under straw mulch treatments is due to higher weed control efficiency and is supported by significantly large source size and capacity as indicated by higher number of leaves $plant^{-1}$, dry matter accumulation and leaf area index. This better source size filled with adequate quantity of food reserves helped the plant to develop better sink size and ultimately produced more number of grains cob^{-1} Kumar (2015) and Kamar *et al.,* (2018). Increased number of grains cob^{-1} with higher dose of nitrogen was due to increased cob length, cob girth and number of rows cob^{-1} under these treatments.

Dry matter accumulation was increased significantly from 190.25 g $plant^{-1}$ in 0 t ha^{-1} straw mulch to 201.75 g $plant^{-1}$ in 10 t ha^{-1} straw mulch. Whereas, dry matter accumulation varied from 179.40 g $plant^{-1}$ to 204.36 g $plant^{-1}$ in different nitrogen levels. Treatments N_{125} and N_{150} in which 125 kg N ha^{-1} and 150 kg N ha^{-1} was applied were at par and superior to all other treatments. The higher DMA may be attributed to the fact that mulch helped in controlling the weeds and changed the microclimatic conditions near plant base leading to better growth of roots and more availability of nutrients that helped the plants to maintain higher photosynthetic efficiency and significantly higher number of leaves retained (Kumar and Angadi, 2014). This increase in DMA might be due to the fact that highest nitrogen level produced maximum plant height and number of leaves $plant^{-1}$ as compared to its lower levels thus resulting in higher DMA Parija (2011) and Zhao *et al.,* (2014). Yield of maize ranged from 43.60 q ha^{-1} to 48.14 q ha^{-1} in all the straw mulch treatments. The effect of different rate of nitrogen fertilizer have resulted significant influence on yield of maize and highest yield was found under 150 kg N ha^{-1}, however it was statistically at par with 125 kg N ha^{-1} treatment. Higher grain yield under straw mulch may be attributed to better above and below soil surface conditions which helped the plants for better growth through reduction in the soil temperature and resulted in better weed control efficiency and initial crop growth as evident from significantly higher plant height and higher number of leaves $plant^{-1}$. The higher leaf number $plant^{-1}$ with fully expanded leaf blades resulted in significantly higher values of LAI which intercepted higher proportion of PAR for the production of photosynthates. There was significantly higher accumulation of dry matter by the plants under mulch applied treatments as compared to no mulch treatment. Even during later stages of plant growth, all the yield attributing parameters recorded significantly higher values and ultimately higher grain yield was obtained under straw mulch treatments as compared to no mulch treatment. The higher grain yield at higher doses of nitrogen might be attributed to increased chlorophyll content index since nitrogen is an important constituent of chlorophyll. Thus, the photosynthesis might have taken place at an efficient level there by producing more photosynthates for higher growth and development as indicated by higher plant height and number of leaves $plant^{-1}$. Higher number of leaves $plant^{-1}$ resulted in higher values for LAI which captured the photosynthetically active radiation very effectively. Due to better above ground plant parts higher amount of dry matter accumulation was obtained. With the shift of plant from vegetative to reproductive phase higher amount of source resulted in better development of sink size as indicated by number of cobs $plant^{-1}$. Better pollination under adequately supply of nitrogen helped to develop the sink capacity i.e., higher number of grains cob^{-1} which was well filled as indicated by higher 1000-grain weight. Even at harvest higher number of leaves $plant^{-1}$ and consequently the higher leaf area index leading to higher values of PAR interception are further indicators of the fact that with application of 150 kg N ha^{-1} the translocation of photosynthates must have continued for longer period and senescence was delayed as indicated by delayed physiological maturity. All these factors helped to fill the sink resulting in higher yield under higher nitrogen level Ullah *et al.,* (2015) and Parija *et al.,* (2013).

Application of 10 t ha^{-1} straw mulch resulted in highest N (132.88 kg ha^{-1}), P (37.13 kg ha^{-1}) and K (59.12 kg ha^{-1}) uptake by maize which was found to be statistically higher to treatment M_6 and M_0 in which 6 t ha^{-1} and 0 t ha^{-1} straw mulch was applied (Table 4). Least N, P and K uptake was found in control due to less growth of plants in such plots. The increase in uptake of nitrogen with application of straw mulch was consistent with the findings Chatterjee *et al.,* (2017). It might be due to the increase in the soil water availability and reduction in the soil temperature fluctuation by straw mulching. The two factors might have favoured the development of root system there by improved the ability of root system to absorb more water and nutrients. Straw mulching significantly promotes the fixation, conversion and storage of soil nutrients due to the improvement of the soil physical and chemical properties; this improvement promotes soil enzyme activity and increases soil microbial growth, thus promoting the nutrient uptake and utilization efficiency of crop. Furthermore, straw mulching plays a role in maintaining the balance of the soil temperature of crop by ensuring that the soil temperature is low at high ambient temperatures and high when the ambient temperature is low. Thus, straw mulch efficiently maintains and promotes the growth and vigour of roots, which ensured the dry matter accumulation and nutrient absorption. Different rate of nitrogen fertilizer also influenced the uptake of NPK. By increasing the nitrogen levels, uptake of N (146.19 kg ha^{-1}), P (40.07 kg ha^{-1}) and K (64.33 kg ha^{-1}) was noticed with 150 kg N ha^{-1} which was statistically at par with 125 kg N ha^{-1}. The increase in NPK uptake was due to the fact that nitrogen promotes NPK uptake by increasing top and root growth, altering plant metabolism and increasing NPK solubility and availability. These results were also in accordance with Tiwari *et al.,* (2018).

Likewise, Maximum agronomic nitrogen use efficiency was recorded under 10 t ha^{-1} straw mulch (10.41%) and in different nitrogen levels maximum AE was in 125 kg N ha^{-1} (19.01 kg N ha^{-1}) which was started decreasing with increasing nitrogen levels (Table 5). Similar trend was observed for apparent nitrogen recovery (%). Qin *et al.,* (2015) and Wang *et al.,* (2018) who recorded that mulching increase the NUE and ANR of crop and with increasing nitrogen fertilizer rate NUE and ANR decreased.

In Table 6, it is showed that by increasing the rate of straw mulch, pH of soil was decreased non-significantly from 8.12 to 8.07 whereas electrical conductivity (EC) was also decreased from 0.37 to 0.35 but remain non-significant. However, organic carbon was increased significantly from 0.45% to 0.54% in 10 t ha^{-1} straw mulch. Nitrogen fertilizer rates influence on pH and organic carbon was not significant with increasing the rate of nitrogen. However, Electrical conductivity was increased with increasing the rate of nitrogen fertilizer. This effect may be due to the fact that surface applied organic mulches after decomposition added nutrients and carbonaceous material to soil which caused a steep increase in organic carbon contents of the soil. These findings are in accordance with Khokhar *et al.,* (2001), Bhat (2004), Singh *et al.,* (2010) and Kumar (2014) who also observed higher organic carbon contents in soil with organic mulches.

Available N, P and K mean values were lower in 10 t ha^{-1} straw mulch treatment (M_{10}) and it increased significantly with the decreasing the straw mulch treatment (Table 7). Maximum available N, P and K was observed in M_0 which was significantly higher than other straw mulch treatment. Higher availability of nitrogen was observed in case of M_0 treatments because it revealed that the available nitrogen status in soil after harvesting of maize crop was affected significantly by different mulching rates. The wheat straw mulching significantly affected soil urease activity. The urease activity was significantly higher in the straw mulch treatment than that of the non-mulch treatments (Akhtar *et al.,* 2017).

Table.1 Effect of straw mulch treatments on soil temperature at 5 cm depth in maize

Days after sowing (DAS)	10 t ha^{-1}	6 t ha^{-1}	0 t ha^{-1}
20	30.5^0 C	31.5^0 C	34.3^0 C
40	30.1^0 C	30.5^0 C	31.5^0 C
60	29.1^0 C	29.5^0 C	30.4^0 C
At harvest	28.5^0 C	29.1^0 C	29.7^0 C

Table.2 Effect of straw mulching and nitrogen levels on periodic plant height (cm), number of leaves plant^{-1} and leaf area index of *Kharif* maize

Treatments	At harvest (90 days)		
	Plant height	No of leaves plant^{-1}	Leaf area index
Straw mulching rate (t ha^{-1})			
0	190.8	13.32	4.41
6	197.54	14.82	4.60
10	204.45	15.67	4.80
CD (p=0.05)	**3.44**	**0.65**	**0.13**
SE (m)	**0.86**	**0.16**	**0.03**
CV (%)	**4.73**	**4.65**	**5.90**
Nitrogen levels (kg ha^{-1})			
0	163.35	12.42	3.49
100	196.47	14.2	4.55
125	213.13	15.72	5.16
150	217.46	16.08	5.22
CD (p=0.05)	**5.28**	**0.45**	**0.09**
SE (m)	**1.77**	**0.15**	**0.03**
CV%	**6.13**	**5.16**	**6.90**
Interaction	**NS**	**NS**	**NS**

Table.3 Effect of straw mulching and nitrogen levels on periodic dry matter accumulation (g) plant^{-1}, number of grains cobs^{-1} and 1000 grain weight of *Kharif* maize

Treatments	At harvest (90 days)		
	Dry matter accumulation	No of grains cob^{-1}	1000 grain weight
Straw mulching (t ha^{-1})			
0	190.25	334.93	272.7
6	195.19	357.64	278.6
10	201.75	359.75	282.5
CD (p=0.05)	**3.95**	**5.45**	**4.08**
SE (m)	**1.00**	**1.39**	**1.04**
CV (%)	**5.55**	**7.50**	**7.33**
Nitrogen levels (kg ha^{-1})			
0	179.4	285.26	253.5
100	196.13	343.90	275.0
125	203.01	385.31	290.1
150	204.36	388.63	293.3
CD (p=0.05)	**3.62**	**9.08**	**3.73**
SE (m)	**1.21**	**3.05**	**1.25**
CV (%)	**5.20**	**7.98**	**7.40**
Interaction	**NS**	**NS**	**NS**

Table.4 Effect of straw mulching and nitrogen levels on Total uptake of nitrogen, phosphorus and potassium in grain and stover of *Kharif* maize

Treatments	Total Nitrogen uptake (kg ha^{-1})	Total phosphorus uptake (kg ha^{-1})	Total potassium uptake (Kg ha^{-1})
Straw mulching (t ha^{-1})			
0	117.02	31.60	50.01
6	124.85	35.40	56.66
10	132.88	37.13	59.12
CD (p=0.05)	**4.8**	**1.01**	**2.30**
SE (m)	**2.50**	**2.10**	**2.02**
CV (%)	**8.10**	**9.10**	**7.56**
Nitrogen levels (kg ha^{-1})			
0	83.64	20.95	43.09
100	122.07	31.83	53.91
125	145.33	39.41	63.47
150	146.19	40.07	64.33
CD (p=0.05)	**9.7**	**2.04**	**1.50**
SE (m)	**2.95**	**1.50**	**2.75**
CV (%)	**7.10**	**11.01**	**8.12**
Interaction	**NS**	**NS**	**NS**

Table.5 Agronomic efficiency and fertilizer-N use efficiency (NUE) as influenced by mulch and nitrogen levels

Treatments	Agronomic Efficiency (Kg yield Kg^{-1} N applied)	Apparent nitrogen recovery (NUE) (%)
Straw mulching (t ha^{-1})		
0	-	-
6	4.65	6.69
10	10.41	13.55
Nitrogen levels (kg ha^{-1})		
0	-	-
100	14.54	38.43
125	19.01	49.35
150	16.58	41.70

Table.6 Effect of straw mulching and nitrogen levels on soil pH, electrical conductivity and organic carbon of *Kharif* maize

Treatments	pH	EC (ds m^{-1})	OC (organic carbon) (%)
Straw mulching (t ha^{-1})			
0	8.12	0.37	0.45
6	8.08	0.36	0.50
10	8.07	0.35	0.54
CD (p=0.05)	**NS**	**NS**	**0.02**
SE (m)	**0.01**	**0.002**	**0.003**
CV (%)	**3.50**	**4.50**	**3.70**
Nitrogen levels (kg ha^{-1})			
0	8.10	0.33	0.49
100	8.09	0.35	0.50
125	8.10	0.37	0.49
150	8.08	0.39	0.50
CD (p=0.05)	**NS**	**0.01**	**NS**
SE (m)	**0.01**	**0.003**	**0.006**
CV (%)	**3.95**	**6.70**	**4.10**
Interaction	**NS**	**NS**	**NS**

Table.7 Effect of straw mulching and nitrogen levels on available nitrogen, phosphorus and potassium status in soil after harvesting of *Kharif* maize

Treatments	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
Straw mulching (t ha^{-1})			
0	137.93	23.41	155.69
6	131.83	21.66	146.54
10	126.03	19.58	142.33
CD (p=0.05)	**5.55**	**1.46**	**4.10**
SE (m)	**2.31**	**1.10**	**1.11**
CV (%)	**6.08**	**6.91**	**4.95**
Nitrogen level (kg ha^{-1})			
0	111.6	21.73	154.82
100	128.42	21.56	149.58
125	141.30	21.48	145.46
150	146.4	21.45	142.42
CD (p=0.05)	**6.87**	**NS**	**NS**
SE (m)	**2.31**	**1.01**	**1.06**
CV (%)	**5.26**	**5.05**	**5.80**
Interaction	**NS**	**NS**	**NS**

Table.8 Economic analysis of different treatment

Treatments		Total cost of production	Gross returns	Net return	B:C ratio
Straw mulching @ 0 t ha^{-1} + 0 kg N ha^{-1}	**T_1**	27,200	47,676	20,476	0.75
Straw mulching @ 0 t ha^{-1} + 100 kg N ha^{-1}	**T_2**	28,925	75,272	46,347	1.60
Straw mulching @ 0 t ha^{-1} + 125 kg N ha^{-1}	**T_3**	29,565	87,278	57,713	1.95
Straw mulching @ 0 t ha^{-1} + 150 kg N ha^{-1}	**T_4**	30,145	89,401	58,956	1.94
Straw mulching @ 6 t ha^{-1} + 0 kg N ha^{-1}	**T_5**	29,900	50,164	20,264	0.67
Straw mulching @ 6 t ha^{-1} + 100 kg N ha^{-1}	**T_6**	31,625	76,908	45,283	1.43
Straw mulching @ 6 t ha^{-1} + 125 kg N ha^{-1}	**T_7**	32,265	93,194	60,929	1.88
Straw mulching @ 6 t ha^{-1} + 150 kg N ha^{-1}	**T_8**	32,845	94,456	61,611	1.87
Straw mulching @ 10 t ha^{-1} + 0 kg N ha^{-1}	**T_9**	31,200	59,090	27,890	0.89
Straw mulching @ 10 t ha^{-1} + 100 kg N ha^{-1}	**T_{10}**	32,925	80,301	47,576	1.44
Straw mulching @ 10 t ha^{-1} + 125 kg N ha^{-1}	**T_{11}**	33,565	1,00,224	66,659	1.98
Straw mulching @ 10 t ha^{-1} + 150 kg N ha^{-1}	**T_{12}**	34,145	95,317	61,172	1.79

Available P varied from 23.42 kg ha-1 under control to 19.58 kg ha^{-1} in 10 t ha^{-1} straw mulch. The use of straw mulch in crop increased the phosphorus availability consumed more phosphorus as a consequence lower value of available P under these treatments was noticed. Sinkevicience *et al.*, (2009) and Shivakumar *et al.*, (2019) also observed similar results of soil available P. The increased uptake of P might be due to lower soil temperature, optimum soil moisture level and improved root growth of maize. Available potassium was higher in M_0 plots over the other straw mulch treatments. The increased uptake of K might be due to lower soil temperature, optimum soil moisture level and improved root growth of maize by which crop uptake more potassium Hundal *et al.*, (2000) and Yan *et al.*, (2018).In contrast, with different nitrogen levels available nitrogen was increased with increasing the nitrogen rate. Maximum available N, P and K was observed in N_{150} which was significantly higher than other nitrogen levels treatments.

Economic analysis

The highest benefit: cost ratio of 1.98 was recorded in treatment T_{11} in which Straw mulching @ 10 t ha^{-1} + 125 kg N ha^{-1} was applied (Table 8). While, minimum benefit: cost ratio of 0.67 was observed where Straw mulching @ 6 t ha^{-1} + 0 kg N ha^{-1} was applied. In T_{11} benefit: cost ratio was recorded highest due to reason that maximum yield was obtained with highest gross return as compared to other treatment.

It is concluded that maize yield was significantly higher where straw mulch @ 10 t ha^{-1} applied and @ 125 kg N ha^{-1} was applied because it was economically better than other treatments. With the application of mulching, enhance NUE, soil organic carbon, available NPK and decrease soil temperature. To conclude, it can improve physico-chemical properties as well as maize yield besides saving fertilizers N. However, mulching rate @10 t ha^{-1} is more economical beneficial than

6 t ha^{-1} because it increased more yield by which farmer can recover their cost of production. So, Instead of wasting the straw, it should be wisely used as mulch material by the farmers because it will not only increase the fertility status of soil but also give us pollution free environment.

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