Effect of Straw Mulching and Nitrogen Doses on Nutrient Status, Yield and Economics of *Rabi* Maize

ABSTRACT

At experimental farm of M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha, India, an experiment was conducted to know the effect of nitrogen doses and mulching on nutrient status, yield and economics of maize during the *rabi* season of 2021-22. The hybrid maize seed (Hybrid variety 4226) was sown in a spilt plot design with three levels of mulching in main plot and four doses of nitrogen in sub-plot. The grain yield, nutrient composition of maize seeds and stover, N, P, K status of pre harvest soil were increased significantly in combination of nitrogen and mulching. Application of straw mulch significantly increased the N content of grain and stover as well as the N uptake by grain and stover as compared to no mulch treatment. It also influenced the protein content of seeds. Application of higher dose of N significantly increased the N content of grain and stover as well as the N uptake by grain and stover over the control and also influenced the NPK status of soil and protein content of the seeds. Maximum values of grain and stover yield (7.26 and 9.21 t ha^{-1} respectively) were recorded from 5 t ha^{-1} mulch and 150% RDN ($N:P_2O_5:K_2O$ = 120:60:60) plot. Whereas this interaction effect (5 t ha^{-1} and 150% RDN) significantly increased the N content of seeds (1.40 %), stover (0.47 %), and protein content of seeds (8.76 %). After decomposition of straw mulch in soil with additional application of nitrogen increased the available N (195.43 kg ha^{-1}) over low level of nitrogen dose with no mulching. The combined application of mulching @ 5 t ha^{-1} with 150% RDN resulted highest net return (₹76,365/- ha^{-1}) with maximum B:C ratio (1.29).

Keywords: Mulching, nitrogen, Yield, Protein, Nutrient uptake and content

1. INTRODUCTION

In present time, the need for food to meet nutritional demands has increased significantly day by day due to the phenomenal rise of global civilization [1]. So Queen of cereals i.e. maize which belongs to Poaceae family is a crucial & most demanding cereal crop after rice and wheat to fulfill the food demand of the world, also offering a huge nutritional value to human body [2]. Currently, over world nations produce 116 million t of maize from an area of 202 million ha, with a productivity of 5.75 t ha^{-1}, and in India maize was cultivated in area 9.2 million ha with production of 27.23 million t [3], and productivity of 2965 kg ha^{-1}. According to Government of Odisha (2020) [4], maize production is 7.41 million t cultivated over an area of 2.54 lakh ha with an average productivity of 2791 kg/ha. Due to improper essential nutrient management as well as water and weed, late sowing, etc. are the key reason for low yield of maize in India. Therefore proper research addressing these problems needs to be done to increase the productivity of maize.

Mulching is a technique to cover the soil surface to reduce the evaporation loss along with maintain the soil physical properties along with reduce the weed infestation [5]. The meaning of mulch is "soft to decay" [6]. In comparison between the two types of mulching i.e. organic and plastic mulch; organic mulch requires lesser time to decompose in soil [7]. After the decomposition of organic mulch in soil it enriches the soil properties. In maize mulching is an effective techniques because maize is a moisture dependent cereals crop [8]. Mulching maintains the soil temperature in the field which will be benefits for crop growth. The soil mulching reduces the weed infestation as a result, the crop can easily grow. Now a day's people are facing a huge problem to handle the crop residue. In this regards straw residue of *kharif* rice in *rabi* maize production is a good advantage for conservation agriculture and protected cultivation, which will be benefits to conserve moisture. By mulching application the nutritional composition of seeds and as well as in stover were influenced [9].

Among different types of plant nutrients, nitrogen is an important nutrient which plays an essential role in plant metabolism and protein synthesis process also it determines the yield [10]. Maize crop is of exhaustive nature, normally demanding a significant amount of nitrogen (N) for improved growth and development. So if low level of nitrogen will apply to field it will reduce the crop growth, grain yield, leaf area, photosynthesis, nutritional value of seeds and stover where as if excess amount of nitrogen will apply then the crop will be susceptible to disease and pest. Similarly root growth, above ground biomass and the nutritional value of fruits are influenced by proper nitrogen management [11]. The combine application of mulching and nitrogen enhance nutrient composition of soil, along with nutritional value of seeds and stover and economics of the production [12]. Therefore, an experiment was conducted to check the interaction effect of mulching and nitrogen management on the nutritional value of seeds and stover, along with chemical properties of soil and economics.

2. MATERIALS AND METHOD

2.1 Description of the Study Area and soil status

The present investigation was conducted during *rabi* season of 2021-22 at Experimental farm (23^{o}39‟N latitude and 87^{o}42‟E longitude) of M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi on sandy loam, with soil ph (6.4), organic carbon (0.3%), EC (0.50 dS m^{-1}), available P (13 kg ha^{-1}) and available K (160 kg ha^{-1}) and available N (177 kg ha^{-1}) soil.

2.2 Experimental Design and Treatments

In this experiment Split Plot Design with three levels of straw mulch viz. (no mulching, Straw mulch @2.5 t/ha, Straw mulch @5 t/ha) in main plot and four doses of nitrogen (150% RDN (recommended dose of nitrogen), 125%RDN, 100%RDN and 75%RDN) in sub plots was adopted, which was allocated in three replications. A total of twelve treatments combinations viz. no mulch + 75 %RDN, no mulch + 100 %RDN, no mulch + 125 %RDN, no mulch + 150 %RDN, Straw mulch @2.5 t ha^{-1} + 75 %RDN, Straw mulch @2.5 t ha^{-1} + 100 %RDN, Straw mulch @2.5 t ha^{-1} + 125 %RDN, Straw mulch @2.5 t ha^{-1}+ 150 %RDN, Straw mulch @5 t ha^{-1} + 75 %RDN, Straw mulch @5 t ha^{-1} + 100 %RDN, Straw mulch @5 t ha^{-1} + 125 %RDN, Straw mulch @5 t ha^{-1} + 150 %RDN were included. Hybrid maize variety "Hybrid corn seed 4226" was selected and sown on 2nd December 2021 at 60 cm row to row and 25 cm plant to plant spacing with a seed rate of 20 kg/ha and a net plot size of 4.75 m × 4.8 m in this experiment.

2.3 Fertilizer application and Intercultural operations

The essential nutrients for proper plant growth of *i.e.* N, P, K were applied through urea, SSP and MOP with the recommended dose 120:60:60::N:P_2O_5:K_2O kg ha^{-1}. Fifty per cent of the dose of N and full dose of P and K were applied as a basal dose and the remaining N was applied in two split doses at knee high stage and pre-tasseling stage through band placement. Straw mulching, and other intercultural operations like gap filling & thinning were done at 7 and 10 days after sowing (DAS) respectively. To suppress the weed growth, a pre-emergence spray of weedicide Atrazine @ 1 kg ha^{-1} was applied at 2 DAS in all the experimental plots irrespective of mulching treatments. Two hand weedings at 20 and 35 DAS were done in no mulch plot due to excessive weed growth. One post-emergence herbicide mixtures Topramezone (12.5 g ha^{-1}) was applied at 25 DAS in the plots treated with mulching @2.5 g ha^{-1} to suppress the weed growth.

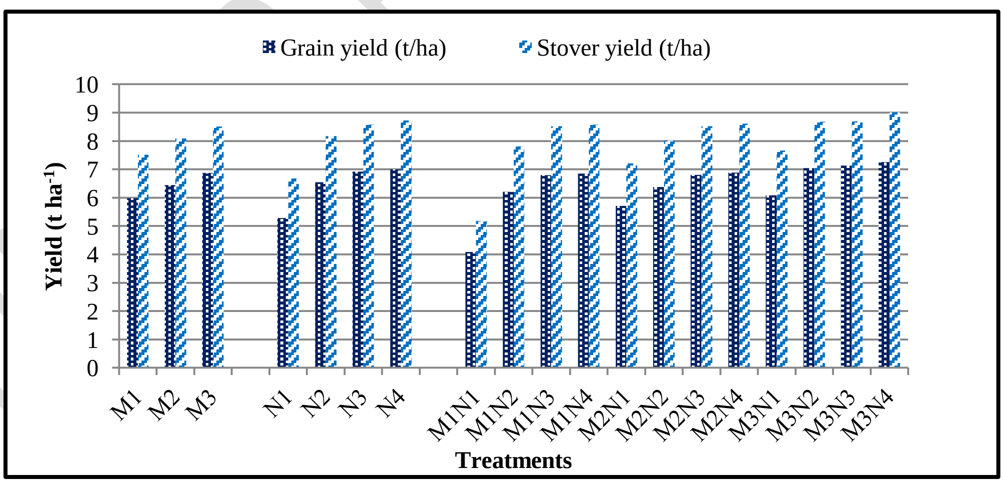
2.4 Data Collection and Measurements

The Yield, Nitrogen content of seeds and stover, nitrogen uptake by seeds and stover, pre harvest soil analysis, economics were recorded. The ANOVA method, as defined by Gomez and Gomez (1984) [13], was used to statistically evaluate the obtained data, and at 5% level of probability, the F value was determined. Excel from Microsoft Office 365 standard version 2022-en-us, Microsoft Inc., Redmond, Washington (DC, USA), was used for statistical analysis.

3 RESULTS AND DISCUSSION

3.1 Effect on yield

Yield parameters *i.e.* grain yield, stover yield were significantly influenced by straw mulch and nitrogen levels (Fig 1). The highest mulching level *i.e.* straw mulching @ 5 t ha^{-1} recorded maximum grain yield and stover yield (6.88 and 8.51 t ha^{-1} respectively) over no mulching. Whereas, the treatments under straw mulching @5 t ha^{-1} and 2.5 t ha^{-1} were statistically at par. Regarding the N- doses in sub plots, maximum grain yield and stover yield (7 and 8.73 t ha^{-1} respectively) were obtained from 150% RDN and which remained at par with 125% RDN. Whereas the lowest grain yield and stover yield were obtained from 75% RDN treated plot. Interaction effect of mulch and nitrogen was significant with respect to grain yield and stover yield. The highest grain yield (7.26 t ha^{-1}) and stover yield (9.01 t ha^{-1}) were obtained under the maximum dose of mulching *i.e.*5 t ha^{-1} with 150% RDN. However 75% RDN without mulching plot produced low grain yield as well as stover yield. It concluded that with proper mulching and nitrogen management helped the crop to utilize soil moisture and provided competitive advantage towards the high crop growth, yield attributes that resulted in grain and stover yield. Similar result was also reported by Wang *et al.* (2020) [12] and Qin *et al.* (2021) [14].



* M_1= No mulching, M_2= straw mulching @ 2.5 t ha^{-1}, M_3= straw mulching @ 5 t ha^{-1}, N_1= 75% RDN, N_2= 100% RDN, N_3= 125% RDN, N_4=150% RDN

Fig 1: Grain and Stover Yield of *rabi* maize as influenced by levels of mulching and nitrogen

3.2 Effect on nitrogen content and uptake by seeds and stover

The mulching as well as the nitrogen influenced nitrogen content of seeds and stover and uptake by seeds and stover (Table 1). Significantly more nitrogen content and uptake was found in grains as compared to stover. As regard of mulching, straw mulching @ 5 t ha^{-1} registered maximum nitrogen content of seeds and stover as well as the highest nitrogen uptake by seeds and stover (1.31%, 0.44%, and 90.18 kg ha^{-1}, 37.86 kg ha^{-1} respectively), which was statistically at par with straw mulching @ 2.5 t ha^{-1}, whereas the no mulching plot recorded the lowest values with respect to nitrogen content and uptake by seeds and stover. Similarly, among subplot treatments (N levels), application of 150% RDN recorded significantly higher nitrogen content of seeds and stover as well as the highest nitrogen uptake by seeds and stover (1.35%, 0.45%, and 94.87 kg ha^{-1}, 39.80 kg ha^{-1} respectively) over 125% RDN,100% RDN and 75% RDN. The 100% RDN and 125% RDN treatments were at par with respect to N content of stover, whereas low nitrogen content and uptake by seeds and stover was recorded from 75% RDN treated plot.

Combination effect of mulching and nitrogen was found to be significant in case of nitrogen content of seeds and stover. Interaction between straw mulching @ 5 t ha^{-1} with 150% RDN recorded maximum value of nitrogen content of seeds and stover, and remained superior over other treatment combinations, and it was statistically at par with straw mulching @ 5 t ha^{-1} with 125% RDN, straw mulching @ 5 t ha^{-1} with 100% RDN, straw mulching @ 2.5 t ha^{-1} with 150% RDN, straw mulching @ 2.5 t ha^{-1} with 125%, RDN, 150% RDN without mulching, 125% RDN without mulching. But nitrogen uptake by seeds and stover showed non-significant character to mulching and nitrogen. This might be attributed to the loss of nitrogen due to high moisture content in the soil due to the combined effect of irrigation and mulching during the initial phase of the crop as reported by Gao *et al*. (2009) in wheat [15]. The mulching and nitrogen played a vital role in root development as well as nutritional value of the grains and nitrogen uptake by seeds and stover. Similar results were reported by *Wang et al.*, (2018) [16] and Singh *et al*., (2019) [17].

3.3 Effect on Protein content of grains

Different mulching levels differed in performance in the protein content of grains (Table 1). The highest protein content of grains (8.17%) was found in mulching @ 5 t ha^{-1}, which was found at par with straw mulching @ 2.5 t ha^{-1}, whereas the lowest level of protein in grain (7.01%) obtained from no mulching. Similarly nitrogen doses significantly affected the protein content of seeds. 150% RDN produced maximum protein content (8.42%) which was statistically at par with 125% RDN. The lowest protein content (6.04%) was recorded from 75% RDN. The combined effect of straw mulching @ 5 t ha^{-1} with 150% RDN remained superior over other treatment combinations with more protein content in grains. Literature reported that mulching influences the grain quality in maize [18]. Mulching influences the soil moisture conservation and improves nitrogen utilization efficiency of the crop which in turn increases the protein content in seed [19]. Similar mulching effects were described by Awopegba *et al*., (2017) [9] and Ariraman *et al*., (2020) [20].

3.4 Effect on available N, P, K in pre-harvest soil

The analysis of data revealed that mulching and nitrogen doses had a significant impact on available N, P, and K in pre-harvest soil (Table 1). As regard of mulching, maximum available N, P, and K in soil were recorded under the application of straw mulching @ 5 t ha^{-1} followed by straw mulching@ 2.5 t ha^{-1}, where these two mulching levels were statistically at par with each other. The lowest available N, P, K (162.40 kg ha^{-1}, 18.82 kg ha^{-1}, 124.29 kg ha^{-1}) were recorded from no mulching. Similarly subplot treatments (N levels) significantly influenced the available N, P, and K in the soil. Maximum N, P and K (189.08, 21.89 and 144.77 kg ha^{-1}) were recorded from 150% RDN followed by 125% RDN, 100% RDN, and 75% RDN, but 75% RDN registered low level of available nitrogen, along with low level of available phosphorus, and potassium in soil. 150% RDN found at par with 125% RDN with respect to available N in soil. But the result recorded from 150% RDN found at par with 125% RDN and 100% RDN with respect to available P and K in soil.

The interaction between mulching and nitrogen found to be non-significant in case of available phosphorus, and potassium in soil, whereas it significantly influenced the available N in soil. The interaction was found to be significant in case of available N in soil, because in the initial days of application of straw mulch immobilization of N occurred but as time preceded the straw mulch started to decompose in soil due to mineralization of N which added extra nitrogen from mulch to the soil [21]. This effect was more pronounced by the split application of higher dose of nitrogen as it somehow masked the immobilization effect of straw mulch not hampering the availability of N to the crop [22]. So after decomposition of straw in soil along with additional split application of nitrogen in soil increased the soil properties boosting the available Nitrogen in soil. Earlier similar result was described by Chatterjee *et al.*, (2018) [23] and Kumar *et al*., (2021) [24].

Table 1: Nitrogen content and uptake by grain and stover; protein content of grain; and available N, P and K in pre-harvest soil as influenced by levels of mulching and nitrogen in *rabi* maize

Treatments	Yield		Nutrient status of crop					Pre-harvest soil		
	Grain (t ha^{-1})	Stover (t ha^{-1})	Nitrogen content of grain (%)	Nitrogen content of stover (%)	Nitrogen uptake by grain (kg ha^{-1})	Nitrogen uptake by stover (kg ha^{-1})	Protein content of grain (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
Mulching (M)										
M_1	5.99	7.52	1.12	0.38	70.17	29.69	7.01	162.40	18.82	124.29
M_2	6.45	8.10	1.23	0.41	80.13	33.87	7.67	174.77	20.43	135.02
M_3	6.88	8.51	1.31	0.44	90.18	37.86	8.17	184.26	21.29	140.80
S.Em.±	0.14	0.16	0.03	0.01	3.74	1.48	0.19	3.62	0.25	1.65
CD (P=0.05)	0.56	0.64	0.12	0.04	14.67	5.81	0.75	14.23	0.97	6.47
Nitrogen (N)										
N_1	5.29	6.69	0.97	0.33	52.96	22.57	6.04	144.07	16.55	109.19
N_2	6.55	8.17	1.24	0.42	81.51	34.40	7.76	176.49	20.76	137.28
N_3	6.92	8.58	1.32	0.44	91.31	38.45	8.24	185.61	21.51	142.25
N_4	7.0	8.73	1.35	0.45	94.87	39.80	8.42	189.08	21.89	144.77
S.Em.±	0.13	0.17	0.03	0.01	3.76	1.65	0.19	3.50	0.46	3.10
CD (P=0.05)	0.38	0.52	0.09	0.03	11.16	4.90	0.55	10.40	1.38	9.20
Interaction (M × N)										
M_1N_1	4.09	5.18	0.69	0.23	28.32	12.16	4.32	111.44	13.09	86.10
M_1N_2	6.21	7.81	1.17	0.40	72.87	30.89	7.33	168.49	19.54	129.14
M_1N_3	6.80	8.52	1.31	0.44	89.01	37.64	8.16	184.13	21.19	140.09
M_1N_4	6.86	8.58	1.32	0.44	90.50	38.09	8.24	185.53	21.45	141.83
M_2N_1	5.71	7.22	1.06	0.36	60.74	25.90	6.64	155.40	17.76	117.26
M_2N_2	6.38	8.02	1.21	0.41	77.35	32.76	7.57	173.01	21.07	139.34
M_2N_3	6.81	8.53	1.31	0.44	90.07	38.00	8.18	184.39	21.24	140.48
M_2N_4	6.89	8.61	1.32	0.45	92.37	38.82	8.28	186.29	21.63	143.02
M_3N_1	6.09	7.67	1.15	0.39	69.83	29.66	7.17	165.36	18.80	124.21
M_3N_2	7.05	8.68	1.34	0.45	94.33	39.56	8.36	187.96	21.67	143.34
M_3N_3	7.14	8.69	1.34	0.45	94.84	39.71	8.38	188.31	22.10	146.18
M_3N_4	7.26	9.01	1.40	0.47	101.74	42.49	8.76	195.43	22.59	149.46
S.Em.±	0.22	0.30	0.05	0.02	6.51	2.86	0.32	6.06	0.80	5.36
CD (P=0.05)	0.65	0.90	0.15	0.05	NS	NS	0.95	18.01	NS	NS

*M x N =Mulching x Nitrogen, NS = Non-significant, M_1= No mulching, M_2= straw mulching @ 2.5 t ha^{-1}, M_3= straw mulching @ 5 t ha^{-1}, N_1= 75% RDN, N_2= 100% RDN, N_3= 125% RDN, N_4=150% RDN

3.5 Effect on Economics

The economics of different levels of mulch and nitrogen is depicted in Table 2. The highest value of net return (₹76,365/- ha^{-1}) was recorded from the treatment combination where mulch was applied @ 5 t ha^{-1} and nitrogen 150% RDN with benefit cost ratio (1.29). The highest value of net return was obtained from the combination because from this combination maximum yield with highest gross return was obtained as compared to other treatments. The lowest net return along with low B:C ratio (0.36) was obtained from 75% RDN without mulching.

Table 2: Economics of *rabi* maize as influenced by levels of mulching and nitrogen

Treatment combination	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
No mulching + 75% RDN	55987	76410	20423	0.36
No mulching + 100% RDN	56493	116065	59571	1.05
No mulching + 125% RDN	57000	127222	70223	1.23
No mulching + 150% RDN	57506	128282	70776	1.23
Straw mulching@ 2.5 t ha^{-1} + 75% RDN	55287	106762	51475	0.93
Straw mulching@ 2.5 t ha^{-1} + 100% RDN	55793	119244	63450	1.14
Straw mulching@ 2.5 t ha^{-1} + 125% RDN	56300	127434	71134	1.26
Straw mulching@ 2.5 t ha^{-1} + 150% RDN	56806	128906	72100	1.27
Straw mulching@ 5 t ha^{-1} + 75% RDN	57787	113800	56013	0.97
Straw mulching@ 5 t ha^{-1} + 100% RDN	58293	131835	73542	1.26
Straw mulching@ 5 t ha^{-1} + 125% RDN	58800	133518	74718	1.27
Straw mulching@ 5 t ha^{-1} + 150% RDN	59306	135671	76365	1.29

4. CONCLUSION

The different levels of straw mulch and nitrogen doses significantly influenced the nitrogen content and uptake by grain and stover, protein content of grain, nutrient status of the pre-harvest soil as well as the grain and straw yield. The combined application of straw mulch @ 5 t ha^{-1} and nitrogen level @150% RDN increased the grain protein content (8.76%), grain yield (7.26 t ha^{-1}) and stover yield (9.01 t ha^{-1}) of *rabi* maize fetching higher net return (₹76,365/- ha^{-1}) and B:C ratio (1.29) as compared to other combinations. This treatment combination can be recommended to the farmers to increase the productivity and profitability of *rabi* maize.

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