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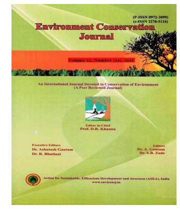

Yield and economic response of *Rabi* maize (*Zea mays* L.) to different mulching and nutrient management

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ABSTRACT

An experiment was conducted during *Rabi* season of 2019-20 with the objective of evaluating the effect of mulching and nutrient management practices on growth, yield and economics of maize (*Zea mays* L.) at Balindi Research Complex, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal, India on clay loam soil. The experiment was laid out in Randomized Block Design with nine treatment (T) combinations such as T_1- Live mulch (*Trifolium alexandrium*)+50% recommended dose of fertilizer (RDF) [120:60:40 kg /ha N, P_2O_5 and K_2O], T_2- Live Mulch+75% RDF, T_3- Live Mulch+100% RDF, T_4- Straw Mulch (rice straw)+ 50 % RDF, T_5- Straw Mulch+75% RDF, T_6- Straw Mulch+100% RDF, T_7- No Mulch+50% RDF ,T_8- No Mulch+75% RDF and T_9- No Mulch+100 % RDF, replicated thrice. Experimental results revealed that different mulching and nutrient levels exerted significant influence on growth, yield, net return and benefit-cost ratio (B:C). Application of straw mulch+100% RDF (T_6) resulted in the highest plant height (164.57 cm), grain yield (5.28 tonnes /ha), stover yield (7.65 tonnes/ha) and B: C (2.16), however, treatment T_7 recorded the lowest grain and stover yield. So, the integrated application of straw mulch along with 100% RDF could be recommended for better yield and higher profit of *Rabi* maize. Integration of organic mulch might be useful for long-term soil health benefits for the nutrient exhaustive maize crop.

Introduction

Maize is an important cereal crop ranking third after wheat and rice in area and production globally (Olaniyan, 2015). It is also familiar as the “Miracle Crop” or “Queen of Cereals” due to its high productivity potential among the cereal crops. In India, maize is grown on area of 9.47 M ha with production of 28.72 Mt and productivity of 3.03 tonnes/ha (Anonymous, 2017). The predominant *Rabi* maize growing states are Andhra Pradesh (45.5%), Bihar (20.1%), Tamil Nadu (9.3%), Karnataka (8.5%), Maharashtra (7.7%) and West Bengal (5.3%) (Anonymous, 2012). Rice being the major staple food of India which mainly comes from the winter paddy grown in *Kharif* season. So, it would be a great opportunity to promote maize cultivation in other seasons such as *Rabi*. *Rabi* season maize yielded invariably higher (>5 tonnes/ha) than *Kharif* season maize (2-2.5tonnes/ha) due to long duration of growth period and least infestation of pests and diseases. In recent years, significant changes have occurred in maize production and utilization due to increasing commercial orientation of this crop and rising demand for diversified end users, especially for feed and industrial uses. A sizable number of districts (110 districts), have potential for growing winter maize in the *Rabi* maize growing states. But, low temperature during early growth period, imbalanced use of fertilizers, low input use efficiency and high cost of cultivation are the prime

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factors of low yield of maize during the *Rabi* season. The continuous increase in the cost of chemical fertilizers has forced the farmers to resort to imbalanced nutrition of crops and thus reduction in crop yields in India. Due to nutrient based subsidies by the Government on fertilizer, farmers are convinced to apply higher doses of nitrogen containing fertilizer particularly urea. At this critical juncture, optimising nutrient use to sustain crop production without affecting soil health and protection of environment from pollution is highly required. Maize being a heavy feeder as well as nutrient exhaustive crop requires more nutrient compared to other cultivated cereals. Thus, optimizing nutrient dose for the crop will help to obtain a good yield with economic advantage. Reducing the cost of fertilizers not only have an economic advantage but also helps in conservation of soil by reducing the harmful effect caused by the excessive fertilizer use. Mulching is one of the best agronomic strategies which can be easily utilized at farmer's level for increasing input use efficiency and optimizing crop yield. Mulching practices protect the soil surface from direct radiation of the sun there by reduces evaporation, improves soil moisture content and also controls weed infestation. It maintains or improves the physical, chemical and biological properties of soil by protecting it from direct impact of raindrops, promotes soil microbial activity, soil organic content, soil aggregate formation and greatly reduced soil runoff as well as wind erosion (Liang *et al.,* 2002). It has also been reported to decrease diurnal soil temperature variations (Dahiya *et al.,* 2007). Therefore, keeping above facts in mind the present study was planned and carried out to evaluate the effects of mulching and nutrient management on crop performance and economics of *Rabi* maize.

Material and Methods

The field experiment was conducted at Balindi Research Complex, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during *Rabi* season of 2019-20 (96′ N latitude, 88° 53′ E longitude, 9.75 m MSL). It lies in the New Alluvial Zone of West Bengal and the region is characterized by tropical and semi-humid climate with annual rainfall about 1350 mm. Experimental field had fairly levelled medium-upland topography with good drainage system and clay loam soil having slightly alkaline pH (7.2) with medium fertility status. The experiment was laid out in Randomized Block Design with 3 replications, comprising of 9 treatment combinations; T_1- Live mulch (*Trifolium alexandrium*) +50% recommended dose of fertilizer (RDF), T_2- Live Mulch+75% RDF, T_3- Live Mulch+100% RDF, T_4- Straw Mulch+ 50 % RDF, T_5- Straw Mulch+75% RDF, T_6-Straw Mulch+100% RDF, T_7- No Mulch+50% RDF, T_8- No Mulch+75% RDF and T_9- No Mulch+100 % RDF. The recommended dose of fertilizer (RDF) is 120:60:40 kg/ha N, P_2O_5 and K_2O. Maize cultivar 'VMH-45' was sown on 2nd fortnight of November, 2019 with a spacing of 60cm × 20cm in 6m × 4m plots with a seed rate of 20 kg/ha by dibbling. For Fertilizer management a recommended dose of 120: 60: 40 kg/ha N: P_2O_5: K_2O for *Rabi* maize was applied as per treatments in the form of Urea, Diammonium Phosphate and Muriate of Potash respectively. 1/3rd nitrogen of the full dose of P_2O_5 and K_2O were applied as basal by broadcasting and rest 2/3rd dose of nitrogen was top dressed by band application at knee high and tasseling stage of the maize crop in equal doses. In plots with live mulch treatments, berseem was sown in the inter row spaces of maize. Straw mulch was applied at 7 DAS in the inter-row spaces in the respective plots.

The growth attributes viz., plant height (cm), leaf area index (LAI), dry matter/plant and crop growth rate (CGR) were recorded at different growth stages from five randomly tagged plants in each plot. Yield attributes *viz.,* cob length (cm), cob girth of cob (cm) recorded at harvest. Yield of grain and straw (kg/ha) were recorded after harvest from net plot. Shelling (%) and Harvest Index (HI) (%) were computed as

$$Shelling\ \% = \frac{Grain\ yield\ (q/ha)}{Whole\ cob\ weight\ (q/ha)} \times 100$$

$$HI = \frac{Economic\ yield\ (kg/ha)}{Biological\ yield\ (kg/ha)} x\ 100$$

Data recorded from various observations were statistically analyzed by adopting appropriate method of "Analysis of Variance". The significance of the treatment effect was judged by 'F' test (Variance ratio) and difference of the treatments mean was tested using critical difference (C. D.) at 5% level of probability (Sahu, 2013).

Results and Discussion

Mulching and nutrient management significantly affected plant heights, LAI at 90 DAS and CGR at 60-90 DAS (Table-1). Long stature plants (164.57 cm) were produced at 90 DAS from T_6 (Straw Mulch+100% RDF) treatment, which was statistically at par with T_3 (Live Mulch + 100% RDF) treated plots with average plant height (160.32 cm). The increase in plant height with 100 % RDF doses might be attributed to increased length of the internodes due to more cell division and cell elongation which in turn resulted in higher plant height. Highest LAI (3.70 at 90 DAS) was obtained in T_6 treatment, where straw mulch along with 100% RDF was applied, which was statistically similar to T_3 and T_9 treatment. Better soil moisture conserved under mulches with higher moisture reserve noticed under straw mulch which helped in better utilization of fertilizers and moisture which resulted in higher leaf area index in maize due to larger leaf size and broader expansion of leaf blades. This corroborates the findings of Ravindranath *et al*. (1974) and Ahmed (1989). At 90 DAS highest dry matter accumulation was found in the plants of T_6 treatment (Table-1) whereas lowest dry matter accumulation (63.32 g/plant) was recorded in T_7 treatment. The possible reason may be that straw mulches created favourable soil temperature and soil moisture conditions which encouraged higher nutrient use efficiency, that in turn, increased the dry matter accumulation in plants, reported by Khan and Pervej (2010) and Jena *et al*. (2014). Among all the date of observations taken, maximum CGR (15.53 g/m^2 /day) was recorded at 60-90 DAS at elevated 100% RDF level along with straw mulching (T_6 treatment) which was statistically similar to T_3 and T_9 treatment. The reason for superior CGR in T_6 treatment may be due to synergistic effect of mulching and 100 % recommended dose of fertilizer that resulted in increased availability and absorption of nutrients through production of growth promoting substances and greater accumulation of dry matter another possible reason of the improvement in the crop growth of maize under mulching could also be due to moisture conservation for long time and the suppression of weeds, thus competition for available resources was greatly reduced. These results are in accordance with the findings of Pramanik (1999) and Sawant (1992). Different level of fertilizer and mulching did not significantly influence the length of cob and cob girth (Table-1), however maximum cob length (15.30 cm) was recorded in T_3 (Live Mulch+100% RDF) treatment. Highest cob girth (13.86 cm) was obtained from T_6 treatment (Straw Mulch+100% RDF). The mean data revealed that cob length and girth increase with increased fertilizer levels along with mulching. This might be due to moisture conservation and reduction of weed infestation which influenced higher utilization of resources during cob formation stage. These finding are in agreement with Lal (1995) and Avval and Khan (2000).

The highest grain (5.28 tonnes/ha) and stover yield (7.65 tonnes/ha) were obtained from T_6 treatment (Table-2). Significant increase in the grain yield of maize under these treatments was due to significant increase in yield components like number of grains per cob, cob length, cob girth and hundred grain weights (seed index). This might be due to moisture conservation and reduction of weed infestation which helped in utilization of the resources from the soil in a better way. These finding are in agreement with Bhatt *et al.* (2004). The mean data also revealed that 100 % RDF and straw mulching significantly improve stover yield due to the combined effect of fertilizer and along with favourable and adequate moisture available to the crop around the root zone due to presence of mulch. Combined application of N, P_2O_5 and K_2O is beneficial in significantly increasing the dry matter yield of maize as observed by Prasad (1981), Ravindranath *et al*. (1974), Singh and Singh (1984) and Karki *et al*. (2005). Harvest index (%) and shelling % of maize significantly varied among the treatments. Treatment T_6 exhibited the maximum harvest index (37.49 %), which was statistically at par, with T_3 treatment. Higher values of harvest index indicated greater partitioning of photosynthates and other essential elements towards reproductive development and economic yield. The findings were supported by Khan and Pervej (2010). The treatment T_6 recorded maximum shelling percentage (85.09 %) which was statistically similar with treatments T_3 and T_9, which is in close conformity with the findings of Singh and Singh (1984). Results revealed that net

Table 1: Effect of different mulching and nutrient management on plant height, LAI, dry matter accumulation (DMA), CGR, cob length and girth in *Rabi* maize.

Treatments	Plant height at 90 DAS (cm)	LAI at 90 DAS	DMA at 90 DAS (g/plant)	CGR at 60-90 DAS (g/m^2 /day)	Length of cob (cm)	Girth of cob (cm)
T_1 (Live Mulch+ 50 % RDF)	132.83	1.65	64.92	12.29	12.33	12.54
T_2 (Live Mulch+ 75% RDF)	143.20	2.63	80.62	15.07	13.49	13.08
T_3 (Live Mulch+ 100% RDF)	160.32	3.37	92.22	15.37	15.30	13.00
T_4 (Straw Mulch+50 % RDF)	138.43	2.00	69.23	13.14	12.85	13.32
T_5 (Straw Mulch+75% RDF)	147.70	2.95	80.37	15.11	14.30	13.08
T_6 (Straw Mulch+100% RDF)	164.57	3.70	95.21	15.53	15.23	13.86
T_7 (No Mulch+ 50 % RDF)	126.77	1.45	63.32	12.61	12.22	12.51
T_8 (No Mulch+75% RDF)	141.37	2.25	77.77	14.49	12.93	13.09
T_9 (No Mulch+100% RDF)	152.17	3.01	89.15	15.15	13.77	13.75
SEm (±)	1.51	0.28	0.52	0.58	0.94	0.46
CD(p=0.05)	4.33	0.84	1.57	1.76	NS	NS

Table 2: Effect of different mulching and nutrient management on grain yield, stover yield, harvest index, shelling percentage and economics of *Rabi* maize.

Treatments	Grain yield (tonnes/ha)	Stover yield (tonnes/ha)	Harvest Index (%)	Shelling (%)	Net Return (Rs/ha)	B:C
T_1 (Live Mulch+ 50 % RDF)	2.81	6.16	28.33	81.53	29439.40*	1.63
T_2 (Live Mulch+ 75% RDF)	4.25	6.75	36.21	83.47	50609.70*	2.05
T_3 (Live Mulch+ 100% RDF)	5.02	7.47	37.29	84.77	55907.89*	2.13
T_4 (Straw Mulch+50 % RDF)	3.40	6.33	32.54	82.99	18385.40	1.53
T_5 (Straw Mulch+75% RDF)	4.52	7.06	36.66	84.01	33749.42	1.93
T_6 (Straw Mulch+100% RDF)	5.28	7.65	37.49	85.09	43869.44	2.16
T_7 (No Mulch+ 50 % RDF)	2.53	5.82	27.40	79.42	6997.92	1.21
T_8 (No Mulch+75% RDF)	3.76	6.54	34.19	83.10	24104.94	1.70
T_9 (No Mulch+100% RDF)	4.64	7.34	36.24	84.07	35989.96	2.00
SEm (±)	0.05	0.03	0.31	0.48	993.04	0.001
CD(p=0.05)	0.14	0.09	0.94	1.44	3,002.78	0.002

***Includes return obtained from selling berseem foliage**

return and B: C ratio was also influenced by Mulching and nutrient management significantly (Table2). Maximum net return (55907.89/- /ha) was obtained in T_3 treatment (Live Mulch+100% RDF) due to additional returns obtained from selling the berseem cuttings as an opportunity cost. But the B: C ratio for T_3 treatment (Live Mulch+100% RDF) was (2.13) which is lower than T_6 (Straw Mulch+100% RDF) treatment (2.16), the lower B:C obtained from T_3 treatment is due to higher cost of cultivation which included a high cost of labour for the purpose of cutting the berseem foliage and selling of cuttings at regular interval as well as additional cost of the berseem seeds for the intercropping. The results were confirmed by Bhatnagar *et al*. (1994).

Conclusion

Considering the findings as summarized above, it can be concluded that the integrated application of straw mulch along with 100% RDF can be recommended for better grain yield and higher profit of *Rabi* maize. The integration of organic mulching such as straw mulch may bring long-term benefits to soil health for cultivating the nutrient exhaustive maize crop.

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Conflict of interest

The authors declare that they have no conflict of interest.

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