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Mulch Induced Eco-physiological Growth and Yield of Maize

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Abstract: Mulching effects of sawdust, ash, rice straw and water hyacinth on growth, dry matter partitioning, earliness, yield attributes and yield of maize were studied. All mulches except sawdust significantly influenced the SLA, CGR, NAR and DM partitioning, but with no apparent effect on RGR. Water hyacinth and rice straw mulches hastened the tasseling, silking and maturity time by 6, 8 and 8 days respectively and produced double the amount of biological and economic yield as compared to the control and sawdust, the ash mulch behaved intermediately. Significantly higher harvest index was also observed under water hyacinth and rice straw mulches.

Key words: Maize, mulches, growth, yield, harvest index

Introduction

Maize ranks after wheat and rice as the third most important cereal crop in the world. It is a minor crop among the cereals in Bangladesh and covers only about 2952 hectares having a production of 3000 metric tons (Anonymous, 1996). The crop is well suited to the existing agro-climatic conditions of Bangladesh and has the potentiality to supplement self-sufficiency in food, feed and fodder to a great extent. So, the crop is reasonably gaining priority for further improvement with other cereals. There are many underlying principles by which such goals are achieved. Mulching is one such step forward in that direction which through the regulation of soil temperature and also the moisture creates favourable crop conditions.

Mulching, the creation of any soil cover, increases the different growth estimates of crop plants (Gunadi, 1988; Roy *et al.*, 1990) and helps to enhance advancement of flowering and maturity time (Park *et al.*, 1987; Izakovic, 1990) and yield improvement in maize in different parts of the globe (Crutchfield, 1985; Kalaghati *et al.*, 1988; Yildiz and Lal, 1 996). However, the creation of favourable temperature and moisture conditions is dependant largely upon the spectral composition of the mulches used.

The present work was, therefore, carried out to study the effect of different indigenous mulches on the growth rates, dry matter partitioning, flowering and maturity time, yield attributes and yield of maize plants under the existing agro-climatic conditions of Bangladesh.

Materials and Methods

Mulching experiment on maize (cv. Kaivutta) using sawdust, ash, rice straw and water hyacinth was conducted on a sandy loam soil at the Crop Botany Field Laboratory Bangladesh Agricultural University, Myme ingh. The seeds were sown on 29 November, 1996 in lines which were 75 cm apart with a 25 cm spacing between plants. All mulches were applied immediately after seed sowing at 10 t/ha in randomized complete block design (RCBD) with 4 replications. Recommended doses of manure and fertilizers were applied together with the intercultural operations as and when required.

Plants of 1 m^2 were uprooted at 10 days interval, starting components like roots, stems, leaves and ears (cobs) were separated and their corresponding dry matter (DM) were taken in an electronic balance after being oven-dried for 24 hours at 80°C. Days required to tasseling and silking and maturity of grains were recorded. The biological yield (total dry matter) and economic yield (seed or grain yield) and yield attributes such as number of cobs per plant, cob length, cob breadth, number of seed rows per cob, number of seeds per row, total number of seeds per cob, 1000-seed weight were recorded separately at final harvest. Different growth parameters like specific leaf area (SLA), crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) and harvest index (HI) were determined using the standard formulae. All the data were statistically analyzed and their mean differences adjudged with DMRT.

Results and Discussion

Specific leaf area (SLA): The SLAs both in the mulched and unmulched plants, from their low initial values suddenly climbed to their peaks at 60 DAS (Table 1a). Thereafter, with a slight decrease the SALs remained apparently static between 70 to 100 DAS in almost all the treatments. The ash, control and sawdust mulched plants, however, had significantly higher SLAs until about 110 DAS, then trailed behind the rice straw and water hyacinth.

All mulches except sawdust had a significant retardive effects on the SLA--a measure of the leaf thickness of the plants, during the most active period of the leaf growth i.e., 30 to 110 DAS. These behaviour of specific leaves of mulched plants were the indication of their ability to harness greater assimilatory matter by utilizing lesser photosynthetic areas. With the approach of crop maturity, the SLAs drastically declined due to rapid reduction of green leaf areas and increase of dead leaves compared to the leaf dry matter.

Crop growth rate (CGR): The CGR from the lower initial values sharply increased and maximized at about 60 DAS and then it declined very rapidly between 70 and 90 DAS at all treatments (Table 1 b). However, water hyacinth and the rice straw mulched plants had the higher and sawdust and the control had the minimum CGR. The CGR between

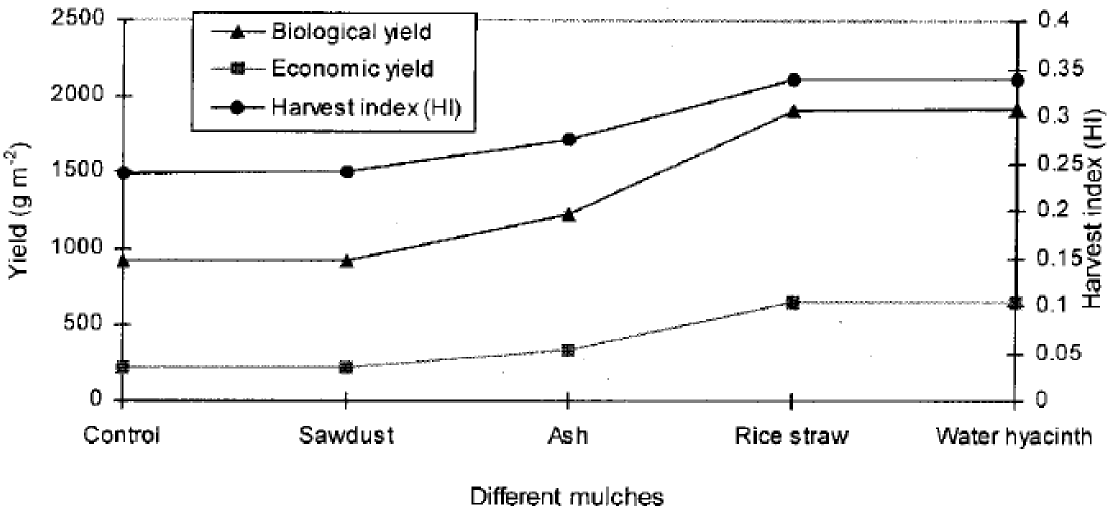

Fig. 1: Effect of different mulches on biological yield, economic yield and harvest index (HI) in maize and their interrelationship

Table 1: Effect of different mulches on the specific leaf area (SLA), crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) in maize with time.

Treatments	Days after sowing (DAS)										
	30	40	50	60	70	80	90	100	110	120	130
SLA, $dm^2\ g^{-1}$											
Control	0.695a	0.675a	0.715a	1.303a	1.098a	1 ,103a	1.053a	1.020a	0.777a	0.445b	0.173b
Sawdust	0.695a	0.688a	0.735a	1.297a	1.088a	1.098a	1.012ab	1.022a	0.765a	0.385c	0.150b
Ash	0.657b	0.637b	0.665b	1.005b	0.825b	0.882b	0.963bc	0.898b	0.743c	0.442b	0.173b
Rice straw	0.577c	0.618b	0.555c	0.858c	0.770c	0.767c	0.885d	0.817c	0.712d	0.545a	0.347a
Water hyacinth	0.560c	0.608b	0.545c	0.862c	0.767c	0.770c	0.897cd	0.815c	0.757b	0.548a	0.348a

Treatments	Days after sowing (DAS)									
	40	50	60	70	80	90	100	110	120	130
b) CGR, gd^{-1}										
Control	2.36d	8.25c	32.16c	24.31c	6.60d	4.45a	0.38d	1.26c	8.86c	1.89a
Sawdust	2.29d	8.00c	31.78c	24.02c	6.84d	4.40a	0.82d	1.33c	8.93c	1.12b
Ash	3.25c	11.35b	43.31b	30.37b	8.85c	2.48b	1.67c	2.75b	15.04b	-0.38c
Rice straw	4.70b	16.50a	62.72a	47.70a	19.66a	1.46c	3.22b	5.27a	29.34a	-0.97e
Water hyacinth										
RGR, $mg\ g^{-1}\ d^{-1}$	4.84a	16.70a	63.56a	48.04a	18.84b	1.47c	3.71a	5.36a	29.30a	-0.83d
Control	279.0	258.00	280.80a	55.70	9.70d	6.00a	1.10d	1.60c	10.70c	2.10a
Sawdust	279.0	257.60	286.30a	56.00	10.20c	6.00a	1.00d	1.70c	11.00c	1.20b
Ash	277.6	256.90	274.80b	55.60	9.60d	2.50b	1.60c	2.60b	14.00b	-0.30c
Rice straw	276.6	257.60	273.90b	55.70	14.70a	1.00c	2.10b	3.30a	18.00a	-0.50d
Water hyacinth	276.6	257.40	272.60b	55.20	13.90h	1.00c	2.40a	3.40a	17.80a	-0.4Ocd
NAR, $mgdm^{-2}\ d^{-1}$										
Control	155.6c	155.1bc	172.0c	65.1c	14.7d	9.3a	1.9d	3.2c	36.9d	18.2a
Sawdust	153.6c	151.0c	172.0c	65.6c	15.5d	9.5a	1.8d	3.7c	43.1c	12.2b
Ash	159.1bc	159.5b	195.0b	81.0b	17.8c	4.3b	2.9c	5.7b	48.4b	-2.8c
Rice straw	165.5ab	175.1a	223.6a	88.3a	29.0a	1.9c	4.1b	7.9a	58.5a	-3.2c
Water hyacinth	169.3a	177.9a	221.9a	86.9a	27.3b	1.8c	4.6a	7.6a	55.9a	-2.7c

Figures in a column followed by no common letters are significantly different at 1% level

the water hyacinth and rice straw mulches had significant higher CGR during the more expressive time of plant due to water hyacinth and straw mulching at different stages of growth was also observed by Gunadi (1988) and

Table 2: DM partitioning (whole fraction) in different components of maize plants as affected by various mulches

Treatments	Components	Days after sowing (DAS)										
		30	40	50	60	70	80	90	100	110	120	130
Control	Root	0.17	0.19	0.22	0.19	0.22	0.23	0.23	0.22	0.20	0.17	0.016
	Stem	0.25	0.29	0.28	0.45	0.53	0.52	0.51	0.50	0.48	0.39	0.37
	Leaf	0.58	0.52	0.50	0.36	0.25	0.25	0.26	0.24	0.22	0.18	0.16
	Cob	-							0.04	0.10	0.26	0.31
Sawdust	Root	0.17	0.19	0.21	0.21	0.22	0.23	0.23	0.21	0.20	0.17	0.15
	Stem	0.25	0.29	0.298	0.54	0.53	0.52	0.52	0.51	0.49	0.40	0.37
	Leaf	0.58	0.52	0.50	0.25	0.25	0.25	0.25	0.24	0.22	0.18	0.15
	Cob	-	-	-	-	-	-	-	0.04	0.09	0.25	0.33
Ash	Root	0.16	0.17	0.198	0.18	0.20	0.21	0.21	0.20	0.18	0.15	0.14
	Stern	0.25	0.29	0.28	0.50	0.53	0.53	0.453	0.51	0.49	0.39	0.37
	Leaf	0.59	0.54	0.53	0.32	0.27	0.26	0.26	0.25	0.22	0.18	0.15
	Cob	-	-	-	-	-	-	0.01	0.05	0.12	0.32	0.39
Rice straw	Root	0.14	0.16	0.18	0.19	0.19	0.20	0.20	0.19	0.17	0.14	0.13
	Stem	0.25	0.29	0.28	0.54	0.54	0.53	0.53	0.51	0.48	0.37	0.34
	Leaf	0.61	0.55	0.54	0.27	0.27	0.27	0.26	0.25	0.23	0.17	0.14
	Cob	-	-	-	-	-	-	0.01	0.05	0.12	0.32	0.39
Water hyacinth												
	Root	0.14	0.16	0.18	0.19	0.19	0.20	0.20	0.18	0.17	0.14	0.13
	Stem	0.25	0.29	0.28	0.54	0.54	0.53	0.53	0.52	0.48	0.37	0.35
	Leaf	0.61	0.55	0.54	0.27	0.27	0.27	0.236	0.25	0.23	0.18	0,14
	Cob							0.01	0.05	0.12	0.32	0.38

Table 3: Flowering and maturity time and yield attributes of maize plants as affected by various mulches.

Treatment	Days required to			Yield attributes						
	Tasseling	Silking	Grain Maturity	No.of cobs/ plant	Cob length (cm)	Cob breadth (cm)	No.of seed rows/ cob	No.of seeds/ row	No.of seeds/ cob	1000-seed weight (g)
Control	84.3a	97.3a	137.3a	1.13c	11.8c	3.08b	12.14c	22.71	275.8c	140.8b
Sawdust	84.5a	97.5a	135.5a	1.11c	11.7c	3.08b	12.08c	22.68b	274.1c	140.6b
Ash	82.5b	93.5b	132.3c	1.30b	15.5b	3.82ab	13.23b	25.34b	348.6b	147.2a
Rice straw	78,5c	89.5c	129.3d	2.01a	19.3a	4.23a	14.36a	29.76a	427.5a	151.1a
Water hyacinth	78.3c	89.3c	129.5d	2.01a	19.3a	4.25a	14.37a	29.78a	428.1a	151.1a

Figures in a column followed by no common letters are significantly different at 1% level.

on RGR in maize is presented in Table 1 c. The RGR from initial high rate abruptly declined with the advancement of plant growth and remained more or less static between 80 and 130 DAS in all the treatments. It is also apparent that no mulch had any significant effect on the RGR at any stages of plant growth. Non-significant apparent effect on RGR due to mulching was also reported by Roy *et al*. (1990) in potato.

Net assimilation rate (NAR): During the most active growing periods the NAR, as calculated between 40 to 130 DAS, remained significantly higher in plants mulched with water hyacinth and rice straw followed by the ash, and least in the control and sawdust (Table 1d). In general the NARs were in phase with CGRs (Table 1 b). Water hyacinth and rice straw induced NAR was also reported by Roy *et al*. (1990) in potato.

Partitioning of dry matter (DM): The pattern of DM presented in Table 2. During the early stage of plant growth (30 DAS) about 15, 25 and 60 percent of total plant DM were partitioned in the root, stem and leaf fractions, respectively. Thereafter, with the advancement of plant growth the leaf fractions continually declined with a concomitant increase in stem fractions until about 90 DAS in all the treatments. With the initiation of ear/cob (90 to 100 DAS) the stem DM investment was either halted or declined but with *a* gradual increasing investment in the reproductive organ (cob). The root fractions very slowly increased upto 90 DAS, then declined at the approach of maturity at 130 DAS. The general pattern of either investment or disinvestment in all the components appeared to be identical in all the treatments.

The continued variation of DM partitioning in different components is a common adaptive features in many cereals (Brouwer, 1962; Fukai *et al*., 1976; Tehlan *et al*., 1978; Khan *et al*., 1981). A closes analysis of the data presented in Table 2 does not suggest any appreciable change in the

DM investment in the reproductive organ (cob) and the least in the control, the sawdust and ash mulched plants again being the intermediate ones.

Tasseling and silking time: Other than sawdust all mulches significantly advanced the time of flowering in maize plants (Table 3). The time of tasseling and silking were hastened by 6 and 8 days, respectively in water hyacinth and rice straw mulched plants compared to the control and sawdust. Advancement of flowering time in maize were also reported by Crutchfield (1985) and Park *et al*. (1987). The earliness of tasseling and silking time in water hyacinth and the rice straw mulched plants might have been initiated due to the increased metabolic activities accompanied by higher soil temperature (Liakatas, 1981).

Time of grain maturity: The duration of grain maturity was shortened by about 8 days in water hyacinth and rice straw and 5 days in ash mulched plants (Table 3). Similar results were also observed by Izakovic (1990) and Wang *et al.* (1994). The earliness of corn maturity might be due to favourable regulation of soil temperature in mulched plants (Liakatas, 1981) and required heat units (Kataria and Bassi, 1997).

Yield attributes: Water hyacinth and rice straw mulches significantly increased the number of cobs per plant, cob length, cob breadth, number of seed rows per cob, number of seeds per row, number of seeds per cob and 1000-seed weight compared to the control and sawdust (Table 3). Higher yield components in mulched plants were also supported by Crutchfield (1985) and Kalaghati *et al*. (1988) and was the consequence of greater biomass accumulation (Giri and Singh, 1985) and its favourable distribution (Table 2).

Biological yield, economic yield and harvest index (HI): The water hyacinth and rice straw mulched plants brought about a two fold increase both in biological yield and economic (seed) yield compared to the control and sawdust, the ash mulched plants being the intermediate one (Fig. 1). Irrespective of the quality all mulches induced the harvest index (HI) over the control. However, the water hyacinth and rice straw mulches had the superiority over the ash and sawdust.

The biological yield, economic yield and HI were reported to be influenced by various edaphic and climatic factors (Donald and Humblin, 1976). Therefore, grain (economic) yield increase is highly correlated with HI. The most efficient way to increase grain yield is to increase the HI which in turn is dependant on more efficient partitioning of DM between grain and straw (Kramer, 1979). The water hyacinth and rice straw mulches on maize plants during the winter season (rabi) remarkedly improved both grain yield and HI together with the biomass production indicating an enhanced partitioning of DM into the economic part (cob) at maturity.

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