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Research Article

Effects of Leaf Clipping and Population Density on Green Fodder and Grain Yield in Hybrid Maize

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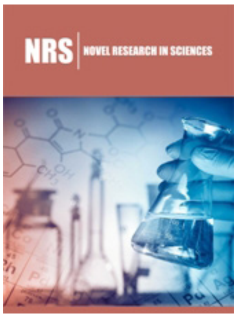

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Abstract

Smallholder farmers having fragmented lands need fodder and grains simultaneously for earning food security for their families. A study was conducted in Crop Physiology and Ecology Research Field And Laboratory at Hajee Mohammad Danesh Science and Technology University, Bangladesh during the period of March to July-2013 to investigate the effect of leaf clipping and population density on fodder and grain yield in maize. Three population densities (D_1=75cm×25cm, D_2=60cm×20cm and D_3=50cm×20cm) and three clipping treatments (C_1=no clipping, C_2=removal of all leaf blades below the lowermost cob and C_3=removal of all leaf blades above the uppermost cob) at the silking stage were included as experimental treatments. The experiment was laid out in a two factors Randomized Complete Block Design (RCBD) with three replications. Results revealed that D_1 required the maximum days to attain most of the phenological stages of maize. Higher population density (D_3) with C_3 clipping treatment gave the highest plant height, whereas D_1 with non-clipping treatment gave the lowest. Highest total dry matter (TDM) was found in D_2 with C_1 and the lowest was found in D_1 with C_1 treatment. Highest yield (8.88 t ha^{-1}) and harvest index (36.2%) were found in D_3 treatment whereas the lowest yield (5.92 t ha^{-1}) in D_1 population density but harvest index (32.6%) was lowest in D_2. The highest yield (8.33 t ha^{-1}) and harvest index (35.5%) were obtained from C_1 treatment and the lowest yield (6.55 t ha^{-1}) and harvest index (33.5%) were obtained from C_3 treatment. The highest fodder yield (3.33 t ha^{-1}) was obtained from D_3 treatment and the lowest (2.11 t ha^{-1}) in D_1 treatment. In C_2 treatment, the highest amount of fodder (4.67 t ha^{-1}) was obtained. The interaction between population density and leaf clipping treatment showed a significant variation among the yield and yield attributes in maize. It is indicated that D_3 and C_1 combination showed the best performance in respect of grain yield (9.67 t ha^{-1}) and harvest index (38.3 %) of maize. But for both grain and fodder yield, D_3 with C_2 showed the best performance.

Keywords: Defoliation; yield; Green fodder; Leaf clipping; *Zea mays*

Introduction

Maize (*Zea mays* L.), an important cereal crop over the world, is now well-fits in diversified cropping systems in the Indo-Gangetic plains (Gathala et al., 2015). Its demand is increasing day by day as various food items, fodder for livestock, feed for poultry, and fuel and raw materials for industry [1,2]. Maize production (as well as other cereals) doubled in the past 40 years due to increased yields resulting from the use of improved crop varieties, along with greater inputs of fertilizer, water and pesticides (Evenson and Gollin, 2003). Maize is one of the most important food crops in the world and, together with rice and wheat, provides at least 30% of the food calories to more than 4.5 billion people in 94 developing countries

(FAOSTAT 2016). Its grain can be used for human consumption in various ways, such as corn meal, fried grain and flour. The corn grain has high nutritive value containing 66.2% starch, 11.1% protein, 7.12% oil and 1.5% minerals. Moreover, it contains 90 mg carotene, 1.8 mg niacin, 0.8 mg thiamin and 0.1 mg riboflavin per 100 g grains (Chowdhury and Islam, 1993). Maize oil is used as the best quality edible oil. The green parts of the plant and grain are used as livestock and poultry feed, respectively. Stover and dry leaves are used as good fuel for cooking [3]. Like many other parts in the world [4], market demand for maize in South Asia and Bangladesh has significantly increased in the last decade as a result of the expanding poultry and fish feed industries, and for use in processed foods [5,6]. The increasing use and demand of maize have caused escalation of area and production substantially in the region. This trend has been especially remarkable in Bangladesh, where cultivated land area with maize jumped from 0.05 M ha in (2000) to > 0.33 M ha in (2016) [http://www.fao.org/faostat/en/#data/QC]. Almost all maize grown in Bangladesh is hybrid, with average yield being highest among the South Asian countries (FAOSTAT, 2016). Excluding Pakistan, for which exact area data for rice–maize (R–M) systems are not available, these systems occupy approximately 1.31M ha in Bangladesh, India, and Nepal, indicating their importance in the region. Maize produces a greater quantity of epigeous mass than other cereals, so it can be used as fodder. Depending on the variety, a maize plant produces 15 to 20 leaves [7] during its life cycle. Canopy structure of maize is such that adjoining leaves overlap one another and develop mutual shading [8] found that mutual shading, particularly at high population density, reduces number of grains cob^{-1}. After anthesis, the staminate inflorescence, the tassel may have very little or no effect on grain filling Leakey et al. [9] Similarly, the leaves below the cob may have less contribution to grain filling as they are mutually shaded and photosynthetically less efficient. So, these organs of plant might function as relative sink rather than source [10] The removal of these relative sink organs may play an important role in reducing competition for assimilates. Furthermore, the growers can get some green fodder for their animal [1,9].

Yield is a function of inter-plant and intra-plant competitions. Competitions associated with different plant population alter plant morphology in various ways Abuzar et al. [4]. Researchers have shown that weaker plants become barren when plant population was increased. These plants utilized water and nutrients but contributed to lower yield [11]. As such, there is a considerable scope for increasing yield by adjusting plant population to an optimum level [12]. Adjustment of proper plant spacing in the maize field is important to ensure maximum utilization of solar energy by the crop and reduce evaporation of soil moisture (FAO, 2012). Radiation intercepted by the leaf surface and the efficiency or its use in developing biomass govern the total dry matter production. Optimum population levels should be maintained to exploit maximum natural resources, such as nutrients, sunlight, soil moisture etc. and to ensure satisfactory yield [13]. Very closest planting is undesirable because it encourages inter-plant competition for resources. Biomass production of a crop largely depends on the function of leaf area development and consequential photosynthetic activity [4,11,14]. The present study was, therefore, undertaken to assess the growth and yield response of maize with higher levels of plant population and different degrees of defoliation for finding out the effect of population density and leaf clipping on yield (fodder and grain) and yield attributes of hybrid maize.

Materials and Methods

A field experiment was conducted at the experimental farm of the Department of Crop Physiology and Ecology at Hajee Mohammed Danesh Science and Technology University, Basherhat, Dinajpur, Bangladesh, during kharif-1 season (the season stretching from the middle of March to the end of June, [15] in 2013. The experiment was laid out in two factor randomized complete block design (RCBD) with three replications. The plot size was 2m×1.5m. The total number of treatments was nine (three levels of population density and three levels of leaf clipping). In factor A: three levels of population density were used, whereas density-1 (D_1): 75cm row to row×25cm plant to plant distance (53333 plants ha^{-1}), density-2 (D_2): 60cm row to row×20cm plant to plant distance (83333 plants ha^{-1}) and density-3 (D_3): 50cm row to row×20cm plant to plant distance (100000 plants ha^{-1}). In factor B, these were (C_1)–No clipping, (C_2)–Removal of all leaf blades below the lowermost cob at silking stage and (C_3)–Removal of all leaf blades above the uppermost cob at silking stage. Seeds of the maize variety, Hybrid maize 36-Super Gold, were collected from the local seed market of Dinajpur and were sown on 14 March 2013. Fertilizers such as urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc sulphate and boric acid were applied @ 500kg, 240kg, 180kg, 240kg, 10kg and 6kg ha^{-1}, respectively. For each treatment, cow dung was applied @ 6ton (t) ha^{-1}. One third of urea and MoP and full dose of all other fertilizers were applied in the plots during final land preparation. Remaining urea and MoP were applied in two equal installments at 35 and 65 days after seeding (DAS).

The application of fertilizer installments was followed by irrigating the plots at the rate of 4cm. The source-sink manipulation treatments were imposed by removing the designated source-sink organs with scissors at silking stage (at 56 days after sowing). Malathion60 EC (1 cc. in 1liter water) was sprayed on the infested plants for leaf roller and leaf hopper insects, 10% Sevin dust at 10kg ha^{-1} in the form of ring for cutworm. The removed portions of the plants of each treatment were separately dried in a drier at 70 °C for 72 hours and weighed separately. The maize from each treatment was harvested after 103 to 106 days as the maturity varied among treatments. Five maize plants, from each unit plot were randomly selected excepting first row from the border for data collection. The parameters recorded from the sample plants were plant height, total dry matter (stem and leaf dry weight), cob length, cob diameter, number of grains cob^{-1}, grain yield plant^{-1}, grain yield ha^{-1}, 1000 grain weight, fodder yield plant^{-1} and fodder yield ha^{-1}.

Results and Discussion

Phenological stages of maize, as affected by the interaction effect of population density (D) and leaf clipping (C), is presented in Table 1. Neither the days to tasseling varied among the treatments of change in plant densities nor among leaf clipping and among the combinations of plant density and leaf clipping treatments on days to tasseling. Days to cob initiation, Days to silking and days to maturity were also not significantly influenced by plant density and leaf clipping and by their combinations. These results are dissimilar to the results of [16,17]. The results of not having differences in phonological stages can be attributed by many reasons for example, the variety has these days required reaching to the corresponding stages and to the timing of clipping treatment inducement. The treatments of leaf clipping were employed at the silking stage of the crop which in the meantime had maximum vegetative growth and dry matter accumulation. Different plant density showed varied plant heights at 30 and 60 DAS. At 90 DAS, the plant density in combination with leaf clipping had varied plant height. The tallest plant was recorded with medium plant density (83333 plants ha^{-1}) in combination with removed leaf blades above the uppermost cob (Table 2), while the lowest was from low population-maintained plots with no clipping. Total dry matter production varied significantly due to different plant density and clipping. The highest total dry matter (1.65 kgm^{-2}) was found in the plot where 83333 plants were maintained ha^{-1} (D_2). The lowest total dry matter (1.18 kgm^{-2}) was found in the plot where 53333 plants were maintained ha^{-1} (D_1). We observed that among the clipping treatments, the variation of total dry matter (gm^{-2}) was not significant. Interaction effect of plant density and leaf clipping showed a significant effect on total dry matter (gm^{-2}). Highest total dry matter (2.0 kgm^{-2}) was observed in (60cm×20cm spacing where 83333 plants ha^{-1} were maintained with no clipping (D_2C_1). The lowest total dry matter (1.11 kgm^{-2}) was found in D_1C_1 where minimum number of plants was grown, and no clipping was done. This was statistically similar to D_1C_2 and D_1C_3 treatments.

Table 1: Phenological stages of maize as affected by population density (D) and leaf clipping (C).

Treatments	Day to Tasseling	Day to Cob Initiation	Days to Silking	Days to Maturity
Density				
D_1	52.4	54.4 a	59.4 a	105 a
D_2	51.4	53.4 a	58.4 a	104 a
D_3	50.4	52.4 a	57.4 a	103 a
Clipping				
C_1	51.3	53.3	58.3	105 a
C_2	51.7	53.7	58.7	104 a
C_3	51.3	53.3	58.3	104 a
Interaction				
D_1C_1	52.3	54.3	59.3	105 a
D_1C_2	52.7	54.7	59.7	106 a
D_1C_3	52.3	54.3	59.3	105 a
D_2C_1	51.3	53.3	58.3	105 a
D_2C_2	51.7	53.7	58.7	104 a
D_2C_3	51.3	53.3	58.3	104 a
D_3C_1	50.3	52.3	57.3	104 a
D_3C_2	50.7	52.7	57.7	103 a
D_3C_3	50.3	52.3	57.3	103 a
CV (%)	2.90%	2.80%	2.80%	1.40%
LSD	ns	ns	ns	ns

In a column values having same letter(s) do not differ significantly at 5% level by DMRT. ns means non-significant

D_1= 75cm row to row×25cm plant to plant distance, (53333 plants ha^{-1})

D_2= 60cm row to row×20cm plant to plant distance, (83333 plants ha^{-1})

D_3=50cm row to row×20cm plant to plant distance, (100000 plants ha^{-1})

C_1=No clipping.

C_2= Removal of all leaf blades below the lowermost cob at silking stage.

C_3=Removal of all leaf blades above the uppermost cob at silking stage.

Table 2: Plant height and total dry matter (TDM) of maize affected by plant density and clipping treatment.

Treatment	Plant Height (cm)			Total Dry Matter (TDM) Kg $^{m-}$2
	30DAS	60DAS	90DAS	
Density				
D_1	101.3 b	164.8 b	226 a	1.18 b
D_2	111.8 a	175.3 a	242 a	1.65 a
D_3	117.3 a	180.8 a	242 a	1.56 a
Clipping				
C_1	107.8	171.3	232 a	1.54 a
C_2	110.1	173.6	235 a	1.51 a
C_3	112.5	176	242 a	1.34 a
Interactions				
D_1C_1	98.2	161.7	223 b	1.11 e
D_1C_2	104.1	167.6	229 b	1.24 de
D_1C_3	101.6	165.1	226 b	1.20 de
D_2C_1	110.1	173.6	235 ab	1.96 a
D_2C_2	109.2	172.7	234 ab	1.63 b
D_2C_3	116	179.5	257 a	1.35 cd
D_3C_1	115.1	178.6	240 ab	1.56 b
D_3C_2	116.8	180.3	241 ab	1.66 b
D_3C_3	119.8	183.3	244 ab	1.48 bc
CV (%)	4.50%	2.85%	5.20%	7.90%
LSD	8.6	8.6	21.1	0.2

In a column values having same letter(s) do not differ significantly at 5% level by DMRT.

D_1=75cm row to row×25cm plant to plant distance, (53333 plants ha^{-1})

D_2=60cm row to row×20cm plant to plant distance, (83333 plants ha^{-1})

D_3=50cm row to row×20cm plant to plant distance, (100000 plants ha^{-1})

C_1=No clipping.

C_2=Removal of all leaf blades below the lowermost cob at silking stage.

C_3=Removal of all leaf blades above the uppermost cob at silking stage.

Cob length varied significantly among population density treatments (Table 3). The highest cob length (17.7cm) was found in D_1 whereas the lowest cob length value (16.4cm) was recorded in D_3. Cob length was non-significant due to leaf clipping (Table 3), while the interaction effect of population density and leaf clipping showed significant effect on cob length (Table 3). The highest value of cob length (17.9cm) was recorded in D_1C_1 treatment (the treatment with wider plant spacing and no clipping) which was statistically similar to D_1C_2, D_1C_3, D_2C_1, and D_2C_2. The lowest cob length (16.010cm) was found in D_3C_2 (the treatment with the shorter plant spacing and leaf removed below the lowermost cob) which was similar to D_3C_3 (the treatment with the shorter plant spacing and leaf removed above the upper-most cob). Other combination showed the intermediate values. Similar findings were reported by [17-20]. The diameter of cob was decreased significantly with the increasing level of population density. The highest cob diameter (5.05cm) was found in D_1 followed by D_2. The lowest cob diameter (4.07cm) was found in D_3. Leaf clipping did not significantly affect the cob diameter. Interaction effects of population density and leaf clipping showed significant effect on cob diameter. The highest cob diameter (5.17cm) was recorded in D_1C_2 which was also similar to D_1C_1, D_1C_3, D_2C_1 and D_2C_2. The lowest cob diameter (3.96cm) was found in D_3C_2 which was also similar to D_3C_1 and D_3C_3. A gradual reduction was observed in number of grains cob^{-1} with the increasing level of plant density. The maize produced highest grains cob^{-1} (434) was found in D_1 which was as par with D_2 and D_3 but there was no significant difference. Similar result was given by Hsu and Huang (1984) who reported that number of grains cob^{-1} was different under different plant densities and decreased as plant density increased. Leaf clipping had little effects on decreased the number of grains cob-

^{1} but there was no significant difference in number of grains cob^{-1}. The maximum number of grains cob^{-1} (421) was recorded in C_2 treatment which was at par with C_1 and C_2 treatments. Interaction effects of plant density and leaf clipping showed significant effect on number of grains cob^{-1}. The highest number of grains per cob^{-1} (456) was obtained from D_1C_2 and the lowest number of grains cob^{-1} (391) was obtained from D_3C_2

Table 3: Yield and yield attributes of maize as influenced by density and clipping.

Treatments	Cob length (cm)	Cob diameter (cm)	No of gains cob^{-1}	Grain yield (kg ha^{-1})	Thousand grain weight (g)	Fodder yield plant^{-1} (g)	Fodder yield (kg ha^{-1})	Harvest index (%)
Density								
D_1	17.7 a	5.1 a	434 a	5.9 c	263 a	39.6 a	2.1 c	34.3 ab
D_2	17.2 a	4.6 a	408 a	7.9 b	232 b	34.4 ab	2.9 b	32.6 b
D_3	16.4 b	4.1 b	396 a	8.9 a	228 b	33.3 b	3.3 a	36.2 a
LSD	0.61	0.48						
Clipping								
C_1	17.4 a	4.7 a	420 a	8.3 a	267 a	0 c	0 c	35.5 a
C_2	17.0 a	4.6 a	421 a	7.8 a	241 b	60.6 a	4.7 a	34.0 a
C_3	17.0 a	4.5 a	397 a	6.5 b	215 c	46.7 b	3.6 b	33.5 a
Interactions								
D_1C_1	17.9 a	5.0 ab	447 a	6.8 d	313 a	0 e	0 e	38.1 a
D_1C_2	17.7 a	5.2 a	456 a	6.2 d	256 b	68.9 a	3.7 c	33.4 bcd
D_1C_3	17.6 a	5.0 ab	399 c	4.7 e	220 cde	50.0 cd	2.7 d	31.4 cd
D_2C_1	17.6 a	4.8 ab	412 b	8.5 bc	247 bc	0 e	0 e	30.3 d
D_2C_2	17.3 ab	4.6 abc	415 b	8.1 c	235 b-e	58.0 b	4.8 b	33.3 bcd
D_2C_3	16.8 bc	4.4 bcd	397 d	7.0 d	214 de	45.1 d	3.8 c	34.2 bc
D_3C_1	16.7 bc	4.2 cd	402 c	9.7 a	241 be	0 e	0 e	38.3 a
D_3C_2	16.0 d	4.0 d	391 d	9.0 ab	232 be	55.0 bc	5.5 a	35.4 ab
D_3C_3	16.5 cd	4.1 cd	394 d	7.9 c	211 e	45.0 d	4.5 b	34.9 abc
CV (%)	2.23%	6.83%	9.97%	5.97%	6.16%	9.20%	8.67%	5.46%
LSD	0.66	0.54	26.8	0.78	25.7	5.7	0.42	3.2

In a column values having same letter(s) do not differ significantly at 5% level by DMRT.

D_1= 75cm row to row×25cm plant to plant distance, (53333 plants ha^{-1})

D_2= 60cm row to row×20cm plant to plant distance, (83333 plants ha^{-1})

D_3=50cm row to row×20cm plant to plant distance, (100000 plants ha^{-1})

C_1=No clipping.

C_2= Removal of all leaf blades below the lowermost cob at silking stage.

C3=Removal of all leaf blades above the uppermost cob at silking stage

Grain yield plant^{-1} is the product of number of cobs plants, grains cob^{-1} and individual grain weight. A positive change in any one of these characters due to density and clipping treatment might provide a detailed appraised for the reasons for increasing grain yield plant^{-1}. Maize plant was influenced significantly by the different density levels (Table 3). Grain yield ha^{-1} was increased gradually with the increasing level of density. The plant gave the highest grain yield (8.8 t ha^{-1}) in D_3 and the lowest grain yield ha^{-1} (5.9 t ha^{-1}) was obtained from D_1. Similar result was found by [21]. The leaf clipping played a significant role in grain yield ha^{-1}. The highest grain yield ha^{-1} (8.33 t) was found in C_1 which was similar with C_2 and the lowest grain yield ha^{-1} (6.55 t) was obtained from C_3. Interaction of plant density and leaf clipping showed a significant effect on grain yield per hectare. The highest grain yield ha^{-1} (9.67 t) was found in D_3C_1 which was as par with D_3C_2 the lowest grain yield ha^{-1} (4.68 t) from D_1C_3. Similar result was found by Hassen et al. [26] Significant variations were found in 1000- grain weight among different population density levels. The highest 1000- grain weight (263g) was found in D_1 and the lowest 1000- grain weight (228g) was found in D_3 which was statistically similar with D_2. Wilson and Allison (1978) found that increasing plant density decreased grain size. The leaf clipping also affects the 1000-grain weight significantly. The highest 1000-grain weight (267g) was obtained from C_1 and the lowest 1000-grain weight (215g) obtained from C_3 Interaction effects of population density and leaf clipping showed significant effects on 1000-grain weight. The highest 1000-grain weight (313g) was obtained from D_1C_1 and the lowest 1000-grain weight (211g) was obtained from D_3C_3 which was as par with D_2C_3. The leaf blades which were obtained from plant after clipping can be used as a fodder for animal. The fodder yield plant^{-1} was influenced significantly by the different plant density level. Fodder yield plant^{-1} was decreased significantly with the increasing level of plant density. The highest fodder yield plant^{-1} (39.6 g) was obtained from D_1 which was statistically similar with D_2 and the lowest fodder yield plant^{-1} (33.3g) was obtained from D_3. Leaf clipping played a significant role in fodder yield plant^{-1} among the clipping treatments, the highest fodder yield plant^{-1} (60.6g) was obtained from C_2 and the lowest fodder yield plant^{-1} (46.7g) was obtained from C_3. Interaction effect of plant density and leaf clipping showed a significant effect on fodder yield plant^{-1}. Among the clipping treatments, the highest fodder yield plant^{-1} (68.9g) was obtained from D_1C_2 combination and the lowest fodder yield plant^{-1} (45.0g) was obtained from D_3C_3 which was statistically similar with D_2C_3 Other combination showed the intermediate results. Clipping of all leaf blades below the lowermost cob produced more fodder than clipping of all leaf blades above the cob. Similar result was found by [22].

Density level and clipping treatment affects the fodder yield ha^{-1} (Table-3). The fodder yield was significantly influenced by the level of density. The highest fodder yield ha^{-1} (3.33 t) was obtained from D_3 and the lowest fodder yield ha^{-1} (2.11 t) was obtained from D_1. Leaf clipping played a great role in fodder yield ha^{-1} significantly. Among the clipping treatments, the highest fodder yield ha^{-1} (4.67 t) was obtained from C_2 and the lowest fodder yield ha^{-1} (3.64 t) was obtained from C_3. Interaction effect of plant density and leaf clipping showed a significant effect on fodder yield ha^{-1}. Among the clipping treatments, the highest fodder yield ha^{-1} (5.5 t) was obtained from D_3C_2 combination and the lowest fodder yield ha^{-1} (2.67 t) was obtained from D_1C_3 combination. Other combination showed the intermediate results. Clipping of all leaf blades below the lowermost cob produced more fodder than clipping of all leaf blades above the cob. Similar result was found by [22]. The harvest index was significantly influenced by the population density (Table 3). The highest harvest index (36.2%) was obtained from D_3 which was at par with D_1. The lowest harvest index (32.6%) was obtained from D_2. Leaf clipping played a non-significant role in harvest index. The highest harvest index (35.5%) was obtained from C_1 which was at par with C_2 and C_3. Interaction effect of plant density and leaf clipping showed a significant effect on harvest index of maize. The highest harvest index (38.3%) was obtained from D_3C_1 combination which was statistically similar with D_1C_1 D_3C_2 and D_3C_3 combination, and the lowest harvest index (30.3%) was obtained from D_2C_1 combination which was at par with D_1C_3. Other combination showed the intermediate results.

Conclusion

Based on the results of the present study following practical applications [23-26] are proposed. In case of D_3 with C_1 the grain yield ha^{-1} is highest. The highest grain yield loss was observed in D_1 with removal of all leaf blades above the cob. In case of both grain and fodder yield, the combination of D_3 with C_2 gave the highest benefits.

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