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RESEARCH ARTICLE

ASSESSMENT OF MAIZE (*Zea mays L.*) VARIETAL PERFORMANCE UNDER DIFFERENT PLANTING DENSITY FOR SILAGE PRODUCTION IN DANG VALLEY OF NEPAL

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ABSTRACT

Suitable variety and optimum plant density selection is necessary for silage production. A field experiment was conducted to find out the maize hybrid varietal performance under different planting density for silage biomass production in Dang Valley in 2021. The experiment was laid out in two factorial Randomized Complete Block Designs with three replications. The treatment consisted of combination of five different hybrid varieties (C1415, MM1107, RH-10, JKMH502 and CP808) and three plant densities (111,111 plants/ ha, 66,666 plants/ ha and 47,619 plants/ ha). The study revealed that variety MM1107 produced highest biomass yield (85.21ton/ha) which was significantly superior over other varieties. MM1107 had higher biomass yield due to higher plant height, leaf area, leaf area index, fresh weight per plant and moisture content and was also better in terms of emergence percentage. Highest biomass yield (91.68ton/ha) and dry matter yield (38.39ton/ha) was found at plant density of 111,111plants/ha. A positive linear relationship was found between silage biomass yield and plant density within the range 47,619-111,111plants/ha. Therefore, variety MM1107 and plant density of 111,111plants/ha performed better for silage production in Dang.

KEYWORDS

Maize, Silage, Agriculture, Leaf Area Index

1. INTRODUCTION

Maize (Zea mays L.) is the second most important crop after rice in terms of area and production in Nepal. Maize covered 9,57,650 ha area with the production of 28,35,674 metric ton in the year 2076/77 contributing 9.5% to AGDP (MOALD, 2021). In Nepal, 87% of the total maize cultivated area is covered by improved varieties, 10% by local varieties and only 4-5% by the hybrid varieties (PMAMP, 2020). Out of total production, 15% is directly used for human consumption while 85% is used as animal feed (Brown and Chavalimu, 1985; FAO, 1992; Gairhe et al., 2021). Apart from being a major staple food in many parts of the world, maize is widely processed into various types of commercial products and used as animal feeds (Shah et al., 2016). Both green maize and matured plants including grains can be used for feeding the farm animals. Green fodder maize, particularly when it contains the stalks, leaves, and ears, is an energy-rich feed for the ruminant livestock (Heuzé et al., 2017). Young maize plants at the milking stage are converted into succulent feed called silage through the process of anaerobic bacterial fermentation in the silo.

Maize silage is the important source of animal feed during the lean season when other forage sources become scarce. Its importance has been increasing in recent years because cattle feeding experiments have shown that maize silage can be used effectively to provide the major part of both wintering and fattening rations (Conlon and Douglas, 1957). It is among the most preferred plants for silage in the world due to its high energy yield, suitability for mechanized agriculture from cultivation to harvesting, easy storage and use, low loss rate, high dry matter content, high digesting rate, utilization as high-quality and delicious silage, high yield per unit area, availability of seeds, and storability in silos without any additives (Taş, 2020). Demand for the feed and silage is in increasing trend as the livestock farming and poultry enterprises are rapidly growing. In Nepal feed processing industries are more than 200 while silage industries are very few. Most of the industries in Nepal are small and are not operating at full capacity because of non - availability of raw materials and lack of proper maintenance (Maharjan, 2003). It is not cost effective to procure green maize for silage and grains for feed from small farmers (Maharjan, 2003).

Choosing suitable hybrid maize is important factor for the profitable silage production. The main criteria for selecting hybrid varieties are yield, precocity, and resistance to disease, pests, and lodging. Some hybrids intended for the grain production are highly suitable for forage production because they have high yield, high dry matter and fibre digestibility. High grain content is generally considered an important determinant of silage feeding value because grain increases dry matter content and decreases loss of nutrients, water, soluble carbohydrates, and protein in seepage effluent. However, the importance of a high grain component has been questioned by researchers in the Great Britain and New Zealand (Karlen et al., 1985). Plant population density is one of the most important yield determinants of maize. As crop growth rate depends on the amount of intercepted photosynthetically active radiation (PAR), the leaf area per unit ground area (i.e., leaf area index [LAI]) plays an important role in DM production (Subedi et al., 2006).

Determining the optimum plant density in a manner that enables the plants to benefit from the available water, nutrients in the soil, and light energy is highly important for decreasing production costs. Plant populations for maximum silage production, are usually greater than for

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maximum grain production because yield by plant population relationships are parabolic for corn grain but asymptotic for dry matter production. The negative relationship between planting density and forage quality makes difficult to recommend high planting density based on biomass yield (Cusicanqui and Lauer, 1999). Plant density, seeding time, harvesting time, and varieties as well as climate and soil factors have significant effects on the yield and yield parameters like dry matter yield, crude protein yield, etc. in silage corn (Cusicanqui and Lauer, 1999). Different environmental and cultural factors that affect maize forage yield and quality result in different responses from forage maize to plant densities (Kumar et al., 2017).

Majority of the farmers in Dang are involved in maize production. They grow maize thrice in a year, i.e., spring maize, summer maize, and winter maize. Improved varieties like Rampur composite, Arun-2 and hybrid varieties like Rajkumar, Subarna, Kanchan, Biocide 1220, 3022, 3033, Nutan, 10 V 10, and Trimurti are commonly cultivated for grain purpose. Recently released Nepali hybrid maize, Rampur Hybrid-10 is gaining popularity because of its heat tolerance capacity (PMAMP, 2020). The number of feed and silage factories is emerging in Dang, demanding large amount of green as well as matured stover and grain. This has increased interest among the farmers to grow maize for silage and feed. However, farmers lack knowledge on suitable maize silage varieties and appropriate plant density that optimizes the biomass yield. Farmers have the tendency of growing same grain varieties for the silage production and do not follow the specific geometric pattern which has resulted in low biomass yield. Biomass yield of 45-51t/ha at farmer's level is not sufficient to meet the raw material requirement of feed and silage industries (Regmi, 2021). Emerging feed and silage industries are not running at their full capacity and have poor economic return because farmers are not able to supply the enough raw materials in time, (Khadka, 2021). Moreover, out of total 27 released varieties, 58 registered hybrids and 14 notified varieties of maize, no varieties have been released as silage variety in Nepal (Gairhe et al., 2021). This study focuses on the five different hybrid varieties, C1415, MM1107, RH-10, JKMH502 and CP808 and three plant densities 111,111 plants/ha, 66,666 plants/ha and 47,619 plants/ha. Through this study, farmers will benefit by planting specific silage varieties at optimum plant density rather than using same grain varieties and haphazard plant density for silage production. Along with farmers, silage and feed industries will also be benefited by getting enough raw materials within time and full capacity running of silage and feed industries would be possible.

2. Methodology

2.1 Site Selection

Research site was located in plain Terai area of Lamahi municipality, Narayanpur, Dang with geographical coordinates of 27°52'N and 82°34'E which is 629m above the sea level. Climate in Dang valley is tropical to sub-tropical which receives annual rainfall of about 1648mm.

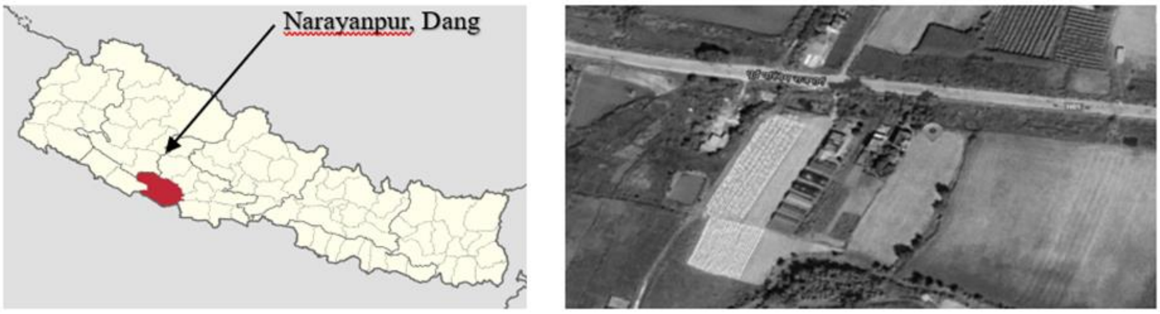

Figure 1: Map of Dang district showing research site (Source: Internet)

2.2 Experimental Design

The experiment was conducted in two factorial Randomized complete block design (RCBD) with three replications.

2.2.1 Treatments

Factor A (Variety): V_1: C1415,

V_2: MM1107

V_3: RH-10

V_4: JKMH502

V_5: CP808

Factor B (Plant Density): D_1 =111,111 plants/ha

D_2 = 66,666plants/ha,

D_3 = 47,619plants/ha

- Treatment combinations

A total of 15 treatment combinations were made as shown below:

T_1= V_1D_1(C1415 and 111,111plants/ha)
T_2=V_1D_2(C1415 and 66,666plants/ha)
T_3=V1D3(C1415 and 47,619plants/ha)
T_4=V_2D_1(MM1107 and 111,111plants/ha)
T_5=V_2D_2(MM1107and 66,666plants/ha)
T_6=V_3D_3(MM1107and 47,619plants/ha)
T_7=V_3D_1(RH-10and 111,111plants/ha)
T_8=V_3D_2(RH-10 and 66,666plants/ha)
T_9=V_3D_3(RH-10 and 47,619plants/ha)
T_{10}=V_4D_1(JKMH502 and 111,111plants/ha)
T_{11}=V_4D_2(JKMH502 and 66,666plants/ha)
T_{12}=V_4D_3(JKMH502 and 47,619plants/ha)
T_{13}=V_5D_1(CP808 and 111,111plants/ha)
T_{14}=V_5D_2(CP808 and 66,666plants/ha)
T_{15}=V_5D_3(CP808 and 47,619plants/ha)

2.2.2 Field Layout

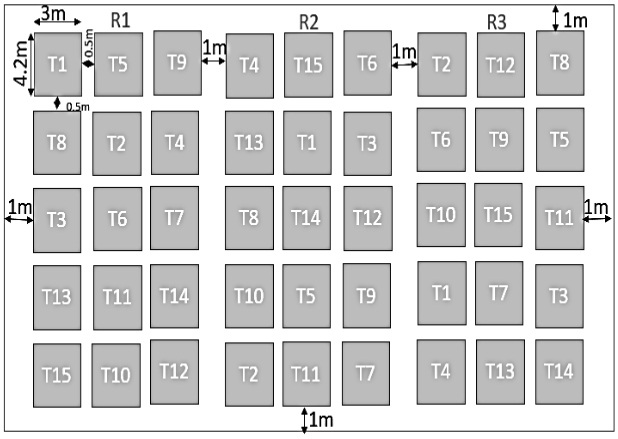

Figure 2: Schematic representation of field layout plan of the experiment at Narayanpur, Dang, Mar-June, 2021

Each plot size = 3m× 4.2m =12.6m^2

Net plot area = 567m^2

Gross plot area = 850m^2 = 2.55 kattha

2.2.3 Varietal Character

i) C-1415

- High yielding variety
- Days to maturity: Kharif (110-120), Rabi (120-125)
- Days to 50% flowering: 57-59
- Ear placement: Medium
- Grain color: orange

- Grain type: flat
- Plant height: 260-270cm
- Plant type: Vigorous, erect
- Shank color: pink
- Medium tolerance to disease and pest
- Excellent uniformity in plant height and cob

ii) MM-1107

- Medium maturity hybrid: 100-105 days (rainy)
- Consistent Hybrid: well adapted to stress as well as high management environment (both Kharif and Rabi)
- Very good standability with good root and stalk lodging resistance
- High husk cover and, large ear size (20-22cm)
- Excellent tip filling and shelling percentage (76-80%), Deep Orange Kernel Color
- Best performance at a plant population of 24,000-26,000 plants/acre

iii) Rampur hybrid- 10

- Newly released Nepali hybrid in 2074 B.S.
- Orange yellow kernel
- Erect leaves, semi-open tassel, light green stem color
- Stay green hybrid with heat tolerant capacity
- Recommended for Terai and inner Terai upto 700msl for winter season
- Matures in 120(spring)-160 days(winter)
- Potential yield: 8.05mt/ha

iv) JKMH-502

- Maturity in kharif: 105-110 days, Rabi: 125-130 days
- Big girthy cylindrical orange yellow cobs with good filling
- Cylindrical cobs with 16-18 rows with > 40 grains per row
- Bold, orange yellow semi-flint grains
- More protein and energy value
- High yielder

v) CP-808

- Maturity in kharif: 110-120 days, Rabi: 130-140 days
- Big ear
- High yield
- Deep kernel
- High row number

2.2.4 Cultivation Practices

Field was ploughed twice, first by cultivator and then by rotavator. The experimental plots were prepared after ploughing, along with proper layout. Two seeds per hill were sown in line by using jab planter. Recommended doses of NPK at the rate of 180:60:40 kg/ha was followed for all hybrid maize. Full doses of phosphorous, potassium and half dose of nitrogen were applied as basal dose. Remaining nitrogen doses were applied on split doses. 1/4th split dose was applied at knee high stage and remaining at tasseling stage. Similarly, first irrigation was given at knee high stage, and second after 15 days and proper irrigation was insured at tasseling stage. Weeding and earthing up was done by using weeder at knee high stage. Fresh biomass was harvested by cutting stem slightly above ground and then weighed using weight balance. Harvesting maturity was determined by ¼th to ½ milk line on the kernels.

2.3 Observation recorded

2.3.1 Phenological Observations

2.3.1.1 Emergence

Data on emergence were taken of each plot at 20DAS from three rows at center and expressed in percentage.

2.3.1.2 Days to Tasseling

Days to tasseling was recorded when 75% of plant showed their respective records.

2.3.1.3 Days to Silking

Days to silking was recorded when 75% of plant showed their respective records.

2.3.1.4 Days to Maturity

Days to maturity was recorded when 75% of plant showed their respective records. Maturity was determined on the basis of ½ to ¾ milk line.

2.3.1.5 Plant height

Plant height was measured from the ground level to the topmost part visible part of five randomly selected plants from each plot at vegetative stage and to the base of tassel after flowering.

2.3.1.6 Stem Diameter

Stem diameter was determined by taking the circumference of stem using plastic tape.

Stem diameter = circumference of stem (cm) / π

2.3.1.7 Leaf Number

Number of fully opened leaves per plant was counted from five randomly selected plant at 30DAS, 45DAS, 60DAS and at harvest.

2.3.1.8 Leaf Area

Leaf area was measured by taking the length and breadth of every leaves. Obtained leaf area was averaged and multiplied by a correction factor 0.75 (Montgomery, 1911).

2.3.1.9 Leaf Area Index

Leaf area index was obtained by dividing total leaf area of plant by ground cover (Elings, 2000).

$$\mathrm{LAI} = \frac{\text{Total leaf area(cm2)}}{\text{Ground cover(cm2)}}$$

2.3.2 Fresh Biomass

Two sample plants were randomly selected from second row, cut slightly above ground, and weighed at 30DAS, 45DAS, and at harvest.

2.3.3 Moisture Content

Moisture content was determined by using formula given by (Anderson, 2012).

$$\text{Moisture content}(\%) = \frac{\text{Fresh biomass} - \text{Dry matter Weight}}{\text{Fresh biomass}} * 100$$

2.3.4 Biomass Yield and Dry Matter Yield

Plants of 1m^2 area were harvested and weighed. Biomass yield was finally expressed in t/ha. Same destructive sample for fresh biomass was first sun-dried and packed in the envelope and then dried in hot oven for 48 hours at the temperature of 72 ^{o}C. Dry matter weight was taken at 30 DAS, 45 DAS, 60 DAS and at harvest. Dry matter yield was expressed as t/ha.

2.3.5 Data Analysis

The data were tabulated in Ms-Excel and subjected to analysis using Gen-Stat software. Following ANOVA table and LSD was used for mean separation.

Table 1: ANOVA Table Selection for Analysis of Data

Source of variation	Degree of freedom (df)	Sum of square	Mean sum of square	Computed F	Tabulated F	
					1%	5%
Replication	(r-1)	RSS	$\frac{RSS}{(r-1)}$	$\frac{RMS}{EMSS}$		
Treatment	(t_1×t_2-1)	TrSS	$\frac{TSS}{(t_1t_2-1)}$	$\frac{TrMS}{EMSS}$		
Variety	t_1-1	Tr_1SS	$\frac{Tr_1SS}{(t_1-1)}$	$\frac{Tr_1MSS}{EMSS}$		
Plant Density	t_2-1	Tr_2SS	$\frac{Tr_2SS}{(t_2-1)}$	$\frac{Tr_2MSS}{EMSS}$		
Variety×Plant Density	(t_1-1)(t_2-1)	Tr_1SS ×Tr_2SS	$\frac{Tr_1SS\times Tr2SS}{(t_1-1)(t_2-1)}$	$\frac{Tr_1MSS\times Tr_2MSS}{EMSS}$		
Error	(r-1) (t_1×t_2-1)	ESS	$\frac{ESS}{(r-1)(t_1\times t_2-1)}$			
Total	(rt_1t_2-1)	TSS				

3. Results and Discussion

3.1 Phenological Observation

3.1.1 Emergence

A significant difference on emergence percentage among the varieties, emergence percentage of varieties MM1107 (81.97%), JKMH502 (80.44%) and C1415 (79.15%) were found significantly similar. Emergence percentage of CP808 (61.64%) was statistically similar to that of RH-10 (63.29%). Emergence percentage was not significantly influenced by plant density, however higher emergence percentage was found at 66,666 plants/ha. Interaction of varieties and plant density had insignificant result. A group researchers also found significant result on emergence percentage among the varieties DKC-5783, Prestige and ADA-9510 (Malaslı et al., 2017). They also found statistically significant result on emergence percentage at different intra-row seed spacing of 10, 15, 20 cm which is contradicting with our result.

3.1.2 Days to Tasseling

A significant difference was observed among varieties in days to tasseling. Variety MM1107 took longest days to tassel (65DAS) followed by RH-10(60.56DAS), JKMH502 (61DAS), C1415 (59.78DAS) and CP808 (59.78DAS). However, plant density did not affect days to tasseling. Interaction between varieties and days to tasseling was not found. Significant difference in days to tasseling among varieties under similar condition might be due to phenology being genetically controlled trait.

3.1.3 Days to Silking

A significant difference was observed among varieties on days to silking. Variety MM1107 took longest days to silk (70.22DAS) which was significant over other varieties C1415 (66.44DAS), RH-10 (66.11DAS), JKMH502 (67DAS) and CP808 (66.33DAS). However, plant density did not affect significantly on days to silking. Interaction between varieties and days to silking was not found. Significant difference in days to silking among varieties under similar condition might be due to phenology being genetically controlled trait.

3.1.4 Days to Maturity

A significant difference was observed on days to maturity. Variety MM1107 took longest days to mature (86.67DAS) which was significant over other varieties C1415 (82.67DAS), RH-10(84.67DAS), JKMH502 (85.67DAS) and CP808 (83.67DAS). However, plant density did not significantly affect days to maturity. Interaction between varieties and days to maturity was not found. Significant difference in days to maturity among varieties under similar condition might be due to phenology being genetically controlled trait.

3.1.5 Plant Height

Significant differences were observed on varietal height at 30DAS and at harvest at 5% and 1% level of significance respectively. However, Variety × plant density showed insignificant result at all days of observation. At 30DAS, maximum height observed was 39.5cm (JKMH502) which was statistically similar to height of C1415 (38.65cm) and MM1107 (37.50cm). Minimum height observed of CP808 (32.85cm) which was statistically similar to height of RH10 (33.72cm). Similarly, at harvest, plant height of MM1107 (256.9cm) was found significant over the other varietal heights. Plant heights of C1415 (236.6cm), RH-10 (231.9cm), JKMH-502 (221.9cm) and CP-808 (224.5cm) were found similar. Tested varieties had the height range of 221.9-256.9cm. Some researchers also found the six silage maize varieties heights ranging from 234.3-294.3cm (Alagöz and Türk, 2019). Plant height was not significantly influenced by density however slightly higher plant height was observed at 47,619plants/ha during harvest. No interaction effect was found between variety and plant density on plant height. A group researchers also found plant height insignificant at plant density ranging from 60,000-220,000 plants/ha (Çarpıcı et al., 2010).

3.1.6 Stem Diameter

Significant differences on stem diameter among varieties and at different plant density were found. Variety × plant density had insignificant result. At 30 DAS, highest stem diameter was found of variety JKMH-502 (1.67cm) significant over the other varieties at 1% level of significance. Stem diameters of C1415 (1.49cm), MM-1107 (1.51cm) and RH-10 (1.49cm) were found similar. Lowest stem diameter was found of variety CP-808 (1.31cm). At harvest, diameter of varieties of RH (3.31cm), CP-808 (3.21cm) and JKMH-502 (3.16cm) were found statistically similar. Stem diameter of C1415 (3.09cm) was statistically similar to JKMH-502 (3.16cm) and MM1107 (2.94cm) which had lowest diameter.

Stem diameter was found significant at different plant density at 60DAS and at harvest at 1% level of significance. At 60DAS, highest diameter (3.25cm) was found at 47,619 plants/ha statistically similar to diameter at 66,666 plants/ha (3.12cm). Diameter at 66,666 plants /ha and 47,619 plants/ha were found significant over diameter at 111,111 plants/ha (2.94cm). Similar result was obtained at harvest. Stem diameter at 47,619 plants/ha (3.27cm) and at 66,666 plants/ha (3.18cm) were found statistically significant over diameter at 111,111 plants/ha(2.98cm). Diameter of tested varieties was found in the range of 2.94-3.31 cm. Highest diameter was observed at lowest plant density (47,619plants/ha). This result was found consistent with the study conducted on silage maize (Karaşahin, 2014).

3.1.7 Leaf Number

Significant difference on varietal leaf number at different plant density was observed. Variety × plant density had insignificant result on leaf number. At 30DAS, JKMH-502 had highest leaf number (5.78) significant to variety C1415. However, leaf number of MM1107, RH-10 and CP808 was found statistically similar to JKMH-502 and C1415. At 45DAS, highest leaf number was found of JKMH502 (8.16), being statistically similar to RH-10. Leaf number of C1415 and CP808 were found to be similar. MM1107 had the lowest leaf number. At 60DAS, highest leaf number was found of JKMH502 (12.11), being statistically similar to varieties C1415 and RH-10. MM1107 had lowest leaf number. CP-808 had leaf number similar to MM1107 and RH-10. Highest leaf number was found at 47,619 plants/ha i.e. 12.17 followed by 66,666 plants/ha (11.49) which were found statistically similar. Leaf number was found lowest at 111,111 plants/ha (11.24). At harvest, highest leaf number was found of JKMH-502 (14.22) which was statistically significant to varieties C1415 (12.22), MM1107 (12), RH-10 (12.22) and CP-808 (12.33). Highest leaf number was found at 47,619 plants/ha followed by 111,111 plants/ha and 66,666 plants/ha. Some researchers also found that leaf number per plant significantly decreased with increasing plant density and the highest value was found at 60,000 plants/ha (Çarpıcı et al., 2010).

3.1.8 Leaf Area

A significant difference on varietal leaf area and leaf area at different plant densities was found. Variety × plant density had insignificant result on leaf area. At 45DAS, highest leaf area was observed of JKMH502 (333.9cm²) which was significant over other varieties. Leaf area of C1415 (258cm²), MM1107 (265.2cm²), RH-10 (247.5cm²) and CP808 (232.5cm²) are found significantly similar. Plant density had insignificant result on leaf area.

At 60DAS, highest leaf area was observed of MM1107 (574cm²) which was significant over other varieties. Leaf area of C1415 (449.7cm²), RH-10 (421.3cm²), JKMH-502 (546.1cm²) and CP-808 (445.1cm²) are found significantly similar. Highest leaf area was found at 66,666 plants/ha (478.2cm²) followed by 47,619 plants/ha (474cm²) which were significant over leaf area at 111,111 plants/ha (438.8cm²).

Similarly, at harvest, highest leaf area was observed of MM1107 (603.2cm²) which was significant over other varieties. Leaf area of C1415 (481.2cm²), RH-10 (466cm²), JKMH502 (488.8cm²) and CP808 (453.8cm²) are found significantly similar. Highest leaf area was found at 66,666 plants/ha (536.1cm²) followed by 47,619 plants/ha (511cm²) which were significant over leaf area at 111,111 plants/ha (448.8cm²). In other study also found leaf area of the individual plant decreased significantly as the plant population density increased to 75,000 and 90,000 plants/ha (Subedi et al., 2006).

3.1.9 Leaf Area Index

A significant effect of variety and plant density on leaf area index was observed. However, variety × plant density had insignificant result on leaf area index. At 30DAS, highest leaf area index was found of JKMH-502 (0.3375) followed by MM1107 (0.2732). Leaf area index of C1415 (0.2473), RH-10 (0.2629) and CP-808 (0.2273) were found similar. Leaf area index was higher of JKMH-502 as it had larger number of leaf and leaf area at 30DAS. At 45DAS, highest leaf area index was found of JKMH-502 (2.0390) significant over other varieties supported by its higher leaf area and leaf number. Leaf area index of C1415 (0.335), MM1107 (0.319), RH-10(1.457) and CP-808(1.253) were found similar.

However, at 60DAS, leaf area index was found insignificant over the varieties. Variety having higher leaf area MM1107 had lower leaf number while variety having higher leaf number JKMH-502 had lower leaf area. At harvest, leaf area index of MM1107 (5.338) was found higher followed by JKMH-502(5.071) which were found significantly similar. Leaf area index of RH-10(4.283), C1415 (4.205) and CP-808(3.95) were found significantly similar. At 30DAS, 45DAS, 60 DAS and at harvest, leaf area index was found higher at 111,111 plants/ha. It was found that LAI increased linearly from 47,619 plants/ha to 111,111 plans/ha. Some researchers also found that high PPD had larger LAI. A positive linear relationship between LAI and plant density was also found by (Subedi et al., 2006; Pieper, 2018).

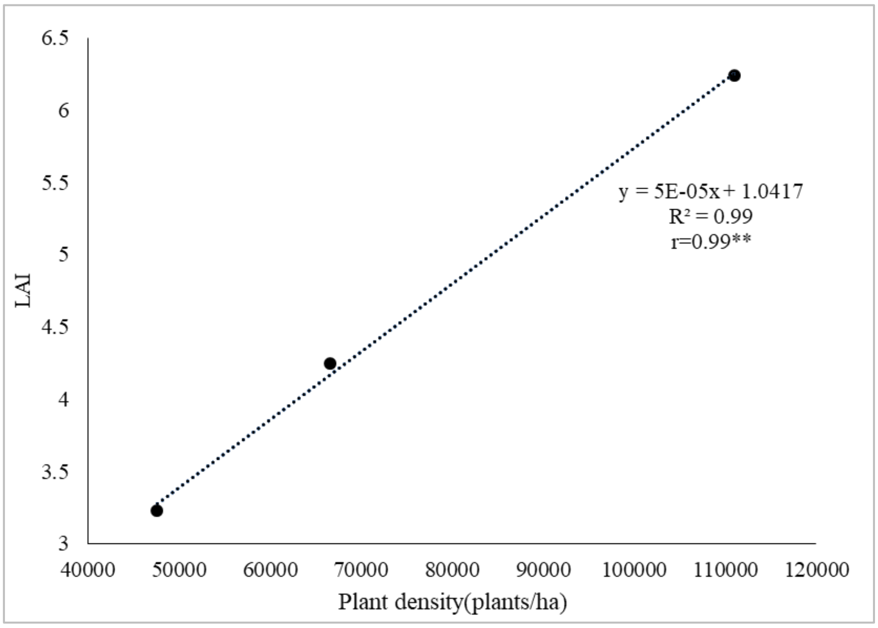

Figure 3: Relationship between LAI and plant density

3.1.10 Fresh Weight

Significant differences on varietal fresh weight and significant effect of plant density on fresh weight was obtained. However, variety× plant density had insignificant result on fresh weight. At 30DAS, highest fresh weight was found of JKMH-502 (45.44gm) followed by RH-10 (42.5gm) which were statistically similar. Fresh weight of MM1107 (32.78gm) was found significantly similar to RH-10 and C1415 (27.43gm). Lowest fresh weight was found of CP-808 (24.44), statistically similar to C1415 and MM1107. At 45DAS, highest fresh weight was found of JKMH-502 (264.4gm) followed by C1415 (187.4gm) and then MM1107 (180.1gm) which were statistically similar. Lowest fresh weight was found of RH-10(123.8gm) which was statistically similar to CP-808 (157.4gm), C1415 and MM1107. At 60DAS, highest fresh weight was found of MM1107 (751.5gm) followed by JKMH-502 (669.1gm) which were statistically similar. Fresh weight of RH-10 (584.9gm) and C1415 (581.4gm) were found statistically similar. Lowest fresh weight was found of CP-808 (560.6gm) which was statistically similar to C1415 and RH-10. Fresh weight was found highest at S3 plant density (723.7gm).

At harvest, highest fresh weight was found of MM1107 (972.5gm) followed by JKMH-502 (872.4gm) which were statistically similar. Fresh weight of RH-10 (771gm), CP-808 (756.5) and C1415 (743.3gm) were found statistically similar. Fresh weight was found highest at 47,619 plants/ha (852.9gm) which was statistically similar to fresh weight at 66,666 plants/ha (858.5gm). Higher fresh weight per plant higher is the biomass yield. Variety MM1107 had highest fresh weight as it contained higher plant height, leaf area and moisture content. Highest fresh weight per plant was found at lowest plant density as plant can utilize more nutrients and space in low plant population.

3.1.11 Moisture Content

Significant differences on moisture content among varieties and non-significant relation between moisture content and plant density were found. However, variety × plant density had insignificant result on fresh weight. At 30DAS, highest moisture content was found of JKMH-502 (80.16%) followed by RH-10(79.76%) which were statistically similar. However, at 60DAS and at harvest, highest moisture content was observed on MM1107 significant over other varieties. Moisture content was found at the range of 58.30-70.50% among the varieties which was found within acceptable range 60-70% for silage production.

3.1.12 Biomasss Yield and Dry Matter Yield

Significant differences on biomass yield among the varieties and at different plant densities was observed. However, dry matter yield was found insignificant among varieties and significant at different plant densities. Variety × plant density had insignificant result on biomass yield and on dry matter yield. Highest biomass yield was obtained of MM1107 (89.2t/ha) which was found significant over other varieties C1415 (69.96t/ha), RH-10 (66.29t/ha), JKMH502 (70.82t/ha) and CP808 (69.70t/ha). Highest biomass yield was obtained at 111,111 plants/ha (91.68t/ha) significant over 66,666 plants/ha and 47,619 plants/ha.

Dry matter yield was found highest at 111,111plants/ha (38.31t/ha) which was significant over dry matter yield at 66,666 plants/ha (21.31t/ha) and at 47,619 plants/ha (17.31t/ha). Dry matter yield of all the varieties was found significantly similar, higher dry matter yield was found of JKMH502 (28.13t/ha). Brad and Frederick also found that for each additional 15,000 plants/ha, weight of individual plant decreased by 10-11% but when expressed on an area basis, planting more plants increased shoot biomass, maximizing at 124,000/ha (Brad and Frederick, 2020). A group researcher found dry matter content per plant in the range of 242.7-314.2 gm/plant of maize silage hybrids, and non-significant differences on plant density ranging from 60,000 to 90,000 plants per ha (Ferreira et al., 2014). A group researchers found that silage yield increased linearly with the increase in PPD from 60 000 to 90 000 plants per ha, the silage yield tended to increase beyond the tested PPD range for both the leafy and non- leafy hybrids which was found consistent with our result (Subedi et al., 2006).

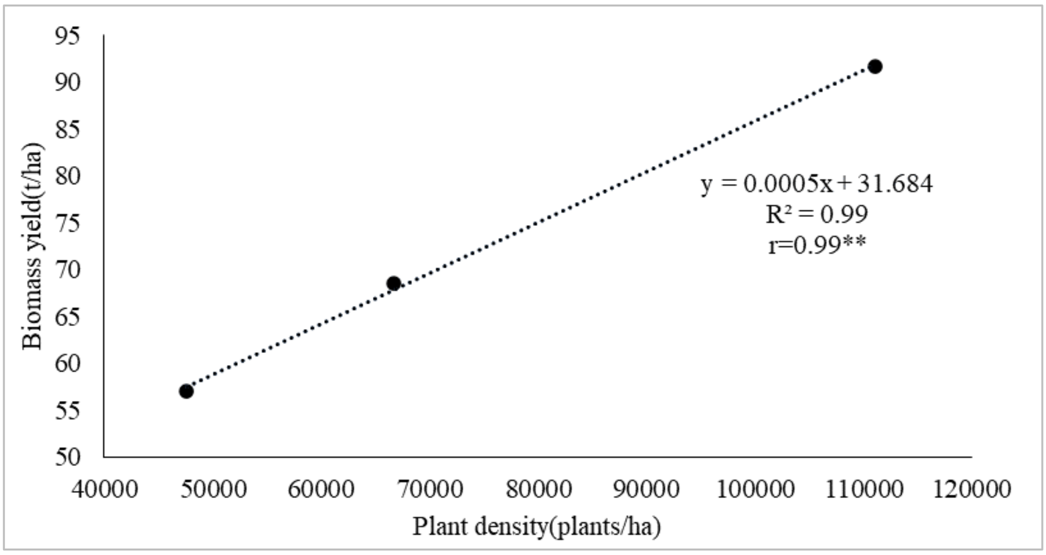

Figure 4: Relationship between biomass yield and plant density

4. Summary

A field experiment was conducted at Narayanpur, Dang in 2021 to assess the hybrid maize varieties performance under different planting density for silage production. The experiment consisted of fifteen treatment replicated thrice under two factorial Randomized Complete Block Design. There were five different maize hybrid varieties (C1415, MM1107, RH-10, JKMH502, and CP808) and three different plant densities (111,111plants/ha, 66,666 plants/ha and 47,619plants/ha). Result showed significant differences on phenological observation among the varieties but insignificant different at different plant densities. Emergence percentage of varieties MM1107 (81.97%), JKMH502 (80.44%) and C1415 (79.15%) were found significantly similar. Emergence percentage of CP808 (61.64%) was statistically similar to that of RH-10 (63.29%). Days to tasseling (65DAS), silking (70.22DAS), and maturity (86.67DAS) was found longest of variety MM1107 significant over other varieties.

Significant differences were observed on varietal height at 30 DAS and at harvest but plant density had insignificant effect on plant height. Plant height of variety MM1107 (256.50cm) was found highest among the tested varieties. Significant differences on stem diameter among varieties and at different plant density were found. Stem diameter of varieties of RH (3.31cm), CP-808 (3.21cm) and JKMH-502(3.16cm) were found statistically similar. Stem diameter of C1415 (3.09cm) was statistically similar to JKMH-502(3.16cm) and MM1107 (2.94cm) which had lowest diameter. Stem diameter at 47,619 plants/ha (3.27cm) and at 66,666plants/ha (3.18cm) were found statistically significant over diameter at 111,111 plants/ha (2.98cm). Leaf number was found significant among varieties and at different plant densities. Highest leaf number was found of JKMH-502(14.22) which was statistically significant to varieties C1415 (12.22), MM1107(12), RH-10(12.22) and CP-808(12.33). Highest leaf number was found at 47,619plants/ha followed by 111,111plamts/ha and 66,666plants/ha.

A significant difference on varietal leaf area and leaf area at different plant densities was found. Highest leaf area was observed of MM1107 (603.2cm^2) which was significant over other varieties. Highest leaf area was found at 66,666 plants/ha (536.1cm^2) followed by 47,619 plants/ha (511cm^2) which were significant over leaf area at 111,111plants/ha (448.8cm^2). A significant effect of variety and plant density on leaf area index was observed. Leaf area index of MM1107 (5.338) was found higher followed by JKMH-502(5.071) which were found significantly similar. Leaf area index was found higher at 111,111plants/ha, LAI increased linearly from 47,619plants/ha to 111,111plans/ha.

Significant differences on varietal fresh weight and significant effect of plant density on fresh weight was obtained. Highest fresh weight was found of MM1107 (972.5gm) followed by JKMH-502(872.4gm) which were statistically similar. Significant differences on moisture content among varieties and non-significant relation between moisture content and plant density were found. Moisture content was found at the range of 58.30-70.50% among the varieties which was found within acceptable range 60-70%. Varietal biomass yield at different plant densities had significant result. However, dry matter yield was found insignificant among varieties and significant at different plant densities.

Highest biomass yield was obtained of MM1107 (89.2t/ha) which was found significant over other varieties C1415(69.96t/ha), RH-10(66.29t/ha), JKMH502(70.82t/ha) and CP808(69.70t/ha). Highest biomass yield was obtained at 111,111plants/ha (91.68t/ha) significant over 66,666plants/ha and 47,619plants/ha. Dry matter yield was found highest at 111,111plants/ha (38.31t/ha) which was significant over dry matter yield at 66,666plants/ha (21.31t/ha) and at 47,619plants/ha (17.31t/ha). Dry matter yield of all the varieties was found significantly similar, higher dry matter yield was found of JKMH502 (28.13t/ha). Biomass yield was found to increase linearly within tested range of 47,619-111,111plants/ha.

5. Conclusion

Varying performance of maize hybrid varieties is observed at different plant density. Parameters like plant height, leaf area, leaf area index, fresh weight per plant and moisture content and biomass yield (ton/ha) are found higher of variety MM1107 than C1415, RH-10, JKMH502 and CP808. However, higher diameter is found in variety RH-10 at the plant density of 66,666 plants/ha. Plant density of 111,111 plants/ha gives better result in terms of biomass yield and dry matter yield. Silage biomass yield is found linearly increased within plant density of 47,619 – 111,111 plants. Thus, variety with higher plant height, leaf area, fresh weight with moisture content within acceptable range 60-70% and higher plant density maximizes the silage biomass yield.

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