Original Research Article

Impact of varietal selection and plant spacing patterns on the growth of maize (*Zea mays L.)* In irrigated agro-eco-systems of Punjab

UNDER PEER REVIEW

Abstract: Maize (*Zea mays L*; 2n=20) is one among the major cereal crops grown in the humid tropics. It has high yield potential, there is no cereal on the earth which has so immense potentiality, and that is why it is also known as 'queen of cereals'. Though it is mainly used as a food crop in India by the rural population in the form of bread and gruel, it has vast industrial potentialities as well having many as 50 different uses. The world's corn production in 2020-2021 is 1216.87 million tons. The estimated production of maize in this year 2022-2023 is to reach 1,161.86 million tonnes in. The predicted global maize production for this year is 1,161.86 million tonnes, and decrease of 55.00 million tonnes or 4.52%. The total area of maize (for dry grain) in the world is 197 M hectares, with significant regions in Asia, Latin America, and Sub-Saharan Africa (SSA) (FAOStat, 2021). In India, Kharif maize accounts for about 83% of the country's total maize area, while Rabi maize accounts for 17%. The most widely used products made from maize are meal and flour, though there are many regional variations in how maize is processed and consumed.

Keywords: Maize, Spacing, Plant height, Number of leaves, leaf length, Stem diameter, Leaf area, Leaf area index

Introduction

Maize (*Zea mays L*; 2n=20) is one among the major cereal crops grown in the humid tropics. It is considered that maize was one of the first plants cultivated by farmers between 7000 and 10,000 years ago, with evidence of maize as food coming from some archaeological sites in Mexico. It has high yield potential, there is no cereal on the earth which has so immense potentiality, and that is why it is also known as **'queen of cereals'.** Maize has highest yield/ha among the cereal crops. It is now grown in all countries except Antarctica and under a more varied range of climates than any other cereal crops. The National Commission on Agriculture observed that maize can substantially contribute to the additional total food grain production by increasing its present contribution from 6-7% to 10%. Though it is mainly used as a food crop in India by the rural population in the form of bread and gruel, it has vast industrial potentialities as well having many as 50 different uses. It'**s** a versatile crop and ranks second following sugarcane in world production as reported by Food and Agriculture Organization (FAO, 2020). Maize crop may be a key source of food and livelihood for millions of people around the world. It's a short duration, quick growing and widely grown crop with high potential, there's no cereal on the earth which has so immense potentiality like maize, therefore it's also known as 'queen of cereals' (Begam et al., 2018).

The world corn production of the year 2020-2021 was 1129.5 million tonnes. The world's corn production in 2021-2022 was 1216.87 million tons. The estimated production of maize in this year 2022-2023 is to reach 1,161.86 million tonnes. The predicted global maize production for this year is 1,161.86 million tonnes, and decrease of 55.00 million tonnes or 4.52%. The United States produces the most maize in the world, 360,252,000 metric tonnes, followed by China with 260,670,000 metric tonnes and Brazil in third with 109,000,000 metric tonnes. India ranks fourth in area and seventh in production among nations that cultivate maize, accounting for around 4% of global maize area and 2% of total production. In India, the area planted to maize in 2018–19 was 9.2 million acres (DACNET, 2020). India produced 1.73 million MT of maize in 1950–1951, but by 2018–19, it had climbed to 27.8 million MT, an almost 16 times increase. While the globe increased by over three times, the average production during the period increased by 5.42 times, from 547 kg/ha to 2965 kg/ha. Even though India's

UNDER PEER REVIEW

production is almost half that of the rest of the globe, the average daily productivity of Indian maize is comparable to that of several other nations that also produce lead maize.

The total area of maize (for dry grain) in the world is 197 M hectares, with significant regions in Asia, Latin America, and Sub-Saharan Africa (SSA) (FAOStat, 2021). In many nations, particularly in SSA, Latin America, and a few countries in Asia, where maize is consumed as human food and accounts for approximately 20% of food calories, it is a well-established and significant crop for human food (Shiferaw et al., 2011). In comparison to wheat and rice, maize is a more adaptable crop with a wider range of uses. It has a variety of roles as an industrial and energy crop in the developed economies, where it is largely used as a crop for livestock feed. Asia is a good illustration of how the consumption of animal source foods is increasing along with economic development (including income growth and urbanisation) and driving demand for maize as feed (Erenstein, 2010). Hence, maize contributes to the diversity and dynamism of global agri-food systems and the security of food and nutrition (Grote et al., 2021; Poole et al., 2021; Ranum et al., 2014; Shiferaw et al., 2011). Throughout the past ten years, interest in agri-food systems has surged (Brouwer et al., 2020; Fanzo et al., 2021; HLPE, 2017; IFAD, 2021). This partly reflects worries about the recent global food crisis and how to sufficiently care for the expanding global population while preserving planetary boundaries, as well as concerns about climate change (Jones & Yosef, 2015). It also reflects a growing interest in the outcomes of agri-food systems, including the possibility to enhance them through the transformation of agri-food systems. These outcomes include food and nutrition, environmental sustainability and resilience, and livelihoods and inclusivity. Hence, agri-food systems are essential to achieving the 17 Sustainable Development Goals of the 2030 Agenda for Sustainable Development (SDGs, Fanzo et al., 2021; HLPE, 2017).

UNDER PEER REVIEW

Kharif (rainy) and winter are the two main seasons for maize cultivation in India (rabi). In India, Kharif maize accounts for about 83% of the country's total maize area, while Rabi maize accounts for 17%. More than 70% of the area used for growing kharif maize is rainfed, and numerous biotic and abiotic stressors are common. Lower productivity of kharif maize (2706 kg/ha) compared to rabi maize (4436 kg/ha), which is mostly grown under assured ecosystem, is a result of the strain-prone ecology. In the recent past, the spring maize area in the states of Punjab, Haryana, and Western Uttar Pradesh has also been expanding pretty quickly. Sadly, there is little information available about the globe and spring maize output. Yet, unofficial calculations place the world's size at 150 000 acres. In terms of area and productivity, maize has the highest rate of increase among cereals. Among food crops, maize production in India has increased at a rate of over 50 kg/ha/year since 2010.

The most widely used products made from maize are meal and flour, though there are many regional variations in how maize is processed and consumed. Due to waste, use in non-food products, and the removal of portion of the bran during milling, which is typically utilised as animal feed, the actual human consumption of these cereals is slightly lower than the estimates.

Methods and materials

The experiment was conducted in the year 2022-2023 at Agricultural Research Farm, LOVELY PROFESSIONAL UNIVERSITY, Phagwara (Punjab), which comes under Trans Gangatic Plains, located geographically at 31.2431519'N and 75.6962869'E longitude. Recommended dose of NPK was applied to all the treatments. The experiment was spread over 12 treatments in 3 replications with Split-plot design (SPD) with a plot size of 20m^2 and total gross cultivated area of 707.5m^2. This experiment consists of 3 hybrid maize varieties (AHC-2033, P1899 and NHM-589) with four different spacings (60cm x 25cm, 70cm x 20cm, 70cm x 30cm and 70cm x 25cm). The land was ploughed and harrowed using tractor. Three replicates consisting of 12 treatments (plots) each were laid out.

UNDER PEER REVIEW

Fig 1:- Lovely Professional University, agricultural field

Climatic conditions:-

Phagwara is a town and municipal corporation with a zone of 20 km approx., situated in Kapurthla region of Punjab, India. The city lies on the national highway 44 and found 124 km away from Chandigarh and 20 km away from Jalandhar. The temperature at night during summer falls to 25 to 30 ^{o}C and in the morning the temperature is around 35^{o}C.

Treatment Details:-

The genotype which were use in this experiment are AHC-2033, P1899 & NHM-589. We proceeds this experiment with four different spacings 60cm X 25cm, 70cm X 20cm, 70cm X 30cm and 70cm X 25cm.

Chart 1. Plot treatment and different varieties

A. Main plot treatment	Varieties
V1	AHC-2033
V2	P-1899
V3	NHM-589
B. Sub plot treatment	**Spacing**
S1	60cm X 25cm
S2	70cm X 20cm
S3	70cm X 30cm
S4	70cm X 25cm

Chart-2 List of treatments used for the study

Symbol	Treatment
T1	V1S1(AHC-233 X 60cm X 25cm)
T2	V1S2 (AHC-233 X 70cm X 20Cm)
T3	V2S1 (P1899 X 60cm X 25cm)
T4	V2S3 (P1899 X 70cm X 30cm)
T5	V1S3 (AHC-2033 X 70cm X 30cm)
T6	V1S1 (AHC-2033 X 60cm X 25cm)
T7	V1S4 (AHC-2033 X 70cm X 25cm)
T8	V1S2 (AHC- 2033 X 70cm X 20cm)
T9	V3S1 (NHM-589 X 60cm X 25cm)
T10	V3S4 (NHM-589 X 70cm X 25cm)
T11	V3S3 (NMH-589 X 70cm X 30cm)
T12	V3S2 (NHM-589 X 70cm X 20cm)

UNDER PEER REVIEW

Chart- 3 Soil chemical Properties:-

CHEMICAL PROPERTIES	DEPTH (0-15cm)	
EC (electrical conductivity ds/m)	0.34	By Zhu et al., 2000
pH	7.7	Estimated by pH 79 WP Milwaukee
ORGANIC CARBON (%)	0.45	By wet digestion method
NUTRIENT STATUS		
AVAILABLE N (kg/ha)	150	
AVAILABLE K (kg/ha)	250.5	
AVAILABLE P (kg/ha)	18.7	

UNDER PEER REVIEW

Observations to be Recorded:-

Plant Height (cm):

Plant height was measured at an interval of 30, 60 & at harvest (Days after Sowing). The height of the tagged plant was measured with a measurement scale from the ground to the node where the flag leaf of the plant is acquired.

Number of leaves:

Number of leaves was counted at an interval of 30. 60 & at harvest (Days after Sowing). The number of leaves of the tagged plant was counted using numerical order using hand.

Leaf length (cm):

Leaf length was measured at an interval of 30, 60 & at harvest (Days after Sowing). The length of the leaf of the tagged plant was measured with the help of a measuring scale from the tip of the entire leaf down to the base of the lowest leaflets where they meet the leaf stem.

Stem diameter (cm):

Stem diameter was measured at an interval of 30, 60 & at harvest (Days after Sowing). The diameter of the stem of the tagged plant are measured using a pair of vernier calipers.

Leaf area (cm^2):

Leaf area was measured at an interval of 30, 60 & at harvest (Days after Sowing). The leaf area of the tagged plant are measured using leaf area meter. The leaves are cut into pieces and put in the machine to get the accurate data.

Leaf area index:

Leaf area index was measured at an interval of 30, 60 & at harvest (Days after Sowing). The leaf area index are calculated using the formula:

LAI= leaf area / ground area, m^2/m^2

Result and Discussion:

Plant height (cm)

In this experiment we have observed the effect of spacing in terms of 3 different varieties of maize, the data was taken at 30 DAS, 60 DAS & at harvest. In main-plots minimum plant height in 30DAS was found in V1 (41.54cm). It increased to a maximum in V2 (45.49cm), which is an increase of 9.08%. And upon calculation V3 (43.65cm) increase by 4.96% in comparison to V1. In sub-plots the maximum plant height was obtained in S4 (48.6cm) and decrease by S1 (43.5cm) which is a decrease of 11.1%. The minimum plant height was found in V1S1 (29.92cm) and the maximum plant height was found in V2S4 (49.83cm) which is an

UNDER PEER REVIEW

increase of 49.93%. And in 60 DAS the minimum plant height in main plot was shown in V3 (132.85cm) and increase to a maximum plant height in V2 (139.5cm) which is 5.15%. And upon calculation V1 (133.45cm) increase by 0.75% compare to V3. In sub-plots the minimum plant height was found in S1 (121.14cm) and increased by S4 (143.2cm) which is an increase of 16.7%. The minimum plant height was obtained in V3S1 (112.33cm) and the maximum in V2S4 (147.56cm) which is an increase of 27.11%. Whereas the minimum plant height in 90DAS for main plot was obtained in V3 (158.4cm) and rise to a maximum of V2 (164.05cm) which is an increase of 3.5%. And upon calculation V1 (163.62cm) increase by 3.24% in comparison to V3. In sub-plots the minimum plant height was found in S1 (159cm) and increased by S4 (164.6cm) which is an increase of 3.5%. The maximum plant height is found in V2S4 (169.4cm) and the minimum in V3S2 (153.7cm) which is a decrease of 9.7%.

It was indicated by the experiment conducted by ***Enujeke E. C., 2013*** the plant height are more effective with hybrid variety 9022-13 with a specific spacing. ***Ful et al., 2020*** revealed that plant height with Pioneer variety are the tallest and it was observed that there is significant difference. The experiment was done by ***Kripa et al., 2021*** by taking hybrid variety as it was observed that plant height at 90 DAS was found statistically significant ($p<0.05$) due to various levels of N. So it is concluded that for effective plant height hybrid varieties can be further preferable as the results are very applicable.

UNDER PEER REVIEW

	Plant height		
Mainplot	30	60	harvest
V1	41.5	133.45	163.62
V2	45.5	139.49	164.05
V3	43.6	132.85	158.4
cv	1.42	4.5	1.2
Subplot			
S1	34.5	121.14	159
S2	47.7	140.10	161.55

S3	43.57	136.63	163
S4	48.6	143.9	164.6
cv	1.41	4.5	1.5
V X S cd@5%	1.05	NS	4.13

Table 1: Table for plant height

Number of leaves:

In main-plots minimum number of leaves in 30DAS was found in V1 (7.29). It increased to a maximum in V2 (7.70), which is an increase of 5.47%. And upon calculation V3 (43.65cm) increase by 3.5% in comparison to V1. In sub-plots the maximum number of leaves was obtained in S4 (8.64) and decrease by S1 (6.87) which is a decrease of 22.8%. The minimum number of leaves was found in V1S1 (6.8) and the maximum number of leaves was found in V2S4 (9.1) which is an increase of 28.93%. And in 60 DAS the minimum number of leaves in main plot was shown in V1 (14.98) and increase to a maximum number of leaves in V2 (15.38) which is 2.6%. And upon calculation V3 (15.01) increase by 0.2% compare to V1. In sub-plots the minimum number of leaves was found in S1 (14.23) and increased by S4 (16.29) which is an increase of 13.5%. The minimum number of leaves was obtained in V3S1 (14.02) and the maximum in V2S4 (16.85) which is an increase of 18.34%. Whereas the minimum number of leaves in 90DAS for main plot was obtained in V1 (16.53) and rise to a maximum of V2 (17.13) which is an increase of 3.5%. And upon calculation V3 (16.72) increase by 1.14% in comparison to V1. In sub-plots the minimum number of leaves was found in S1 (15.6) and increased by S4 (17.88) which is an increase of 13.6%. The maximum number of leaves is found in V2S4 (18.3) and the minimum in V1S1 (15.47) which is a decrease of 18.3%.

Enujeke E. C. **(2013)** shows in his experiment that there are significant different in the number of leaves of the hybrid varieties in which hybrid variety 9022-13 has the highest number of leaves with a specific spacing. Number of leaves per plant are ominously affected by spacings. Higher values for number of leaves at the widest spacing. This could be attributed to less competition between plants which resulted in taller plants and better growth. The interaction effect of variety and spacing was found significant ***Ful et al.,*** **(2020).** ***Devi et al.,*** **(2021)** reported in the experiment that number of leaves of the hybrid varieties are higher than the local varieties under Leaf Colour Chart (LCC).

	Number of leaves

UNDER PEER REVIEW

Mainplot	30	60	Harvest
V1	7.29	14.98	16.53
V2	7.7	15.38	17.13
V3	7.55	15.01	16.72
cv	7.6	2.56	3.7
Subplot			
S1	6.87	14.23	15.6
S2	7.42	15.20	17.04
S3	7.12	14.77	16.65
S4	8.64	16.29	17.88
cv	8.6	5.9	4.8
V X S cd@5%	NS	NS	NS

Table.2: Table for number of leaves

Leaf length (cm):

In main-plots minimum leaf length in 30DAS was found in V1 (48.02cm). It increased to a maximum in V2 (50.46cm), which is an increase of 4.96%. And upon calculation V3 (43.65cm) increase by 0.62% in comparison to V1. In sub-plots the maximum leaf length was obtained in S4 (56.74cm) and decrease by S1 (43.88cm) which is a decrease of 25.56%. The minimum leaf length was found in V1S1 (43.6) and the maximum leaf length was found in V2S4 (59.4cm) which is an increase of 30.67%. And in 60 DAS the minimum leaf length in main plot was shown in V3 (45.6cm) and increase to a maximum leaf length in V1 (54.66cm) which is 18.1%. And upon calculation V2 (54cm) increase by 16.86% compare to V3. In sub-plots the minimum leaf length was found in S2 (48.24cm) and increased by S4 (57.83cm) which is an increase of 18.1%. The minimum leaf length was obtained in V3S3 (44.4cm) and the maximum in V2S4 (67.93cm) which is an increase of 41.89%. Whereas the minimum leaf length in 90DAS for main plot was obtained in V1 (62.58cm) and rise to a maximum of V2 (66.46cm) which is an increase of 5.9%. And upon calculation V3 (62.9cm) increase by 0.4% in comparison to V1. In sub-plots the minimum leaf length was found in S1 (55.92cm) and increased by S4 (73.82cm) which is an increase of 27.6%. The maximum leaf length is found in V2S4 (78.8cm) and the minimum in V1S1 (55.2cm) which is a decrease of 35.2%.

***Amin et al.* (2015)** mentioned in his research that Plant density and cultivar had a substantial impact on leaf length. The 25 cm plant density treatment had the greatest leaf length

UNDER PEER REVIEW

and the 10 cm plant density treatment had the lowest leaf length, according to a comparison of the mean values for leaf length for plant density. But when the average leaf lengths for each cultivar treatment were compared, it became clear that BIARIS cultivar had the longest leaves and AS54 cultivar had the shortest. While the maximum width was virtually constant for Leaf positions 1 and 2 and increased linearly for higher leaf positions, the length increased with leaf position in a sigmoidal fashion. As a consequence, the area increased exponentially and linearly with leaf position were revealed in the experiment by ***Bos et al. (2000).***

	Leaf length		
Mainplot	30	60	Harvest
1	48.02	54.66	62.58
2	50.5	54	66.46
3	48.32	45.6	62.9
cv	11.5	8	5.9
Subplot			
1	43.9	48.93	55.92
2	46.2	48.24	61.04
3	48.92	50.67	65.14
4	56.74	57.83	73.82
cv	9.22	12.3	12.3
V X Scd@5%	NS	NS	NS

Table.3 : Table for leaf length

Stem diameter (cm):

In main-plots minimum stem diameter in 30DAS was found in V3 (0.92cm). It increased to a maximum in V2 (0.96cm), which is an increase of 4.3%. And upon calculation V1 (0.93cm) increase by 1.1% in comparison to V3. In sub-plots the maximum stem diameter was obtained in S4 (1.1cm) and decrease by S1 (0.82cm) which is a decrease of 29.2%. The minimum stem diameter was found in V1S1 (0.81cm) and the maximum stem diameter was found in V2S4 (1.11cm) which is an increase of 31.2%. And in 60 DAS the minimum stem diameter in main plot was shown in V1 (2.95cm) and increase to a maximum stem diameter in V3 (3.03cm) which is 2.7%. And upon calculation V2 (3.01cm) increase by 2% compare to V1. In sub-plots the minimum stem diameter was found in S3 (2.95cm) and increased by S2 (3.07cm) which is an increase of 3.99%. The minimum stem diameter was obtained in V1S3

UNDER PEER REVIEW

(2.67cm) and the maximum in V2S1 (3.1cm) which is an increase of 14.9%. Whereas the minimum stem diameter in 90DAS for main plot was obtained in V1 (2.64cm) and rise to a maximum of V2 (2.69cm) which is an increase of 1.9%. And upon calculation V3 (2.65cm) increase by 0.4% in comparison to V1. In sub-plots the minimum stem diameter was found in S1 (2.22cm) and increased by S4 (3.17cm) which is an increase of 35.3%. The maximum stem diameter is found in V3S1 (2.15cm) and the minimum in V2S4 (3.21cm) which is a decrease of 39.6%.

***Amin et al.* (2015)** states in his research that only cultivar and plant density had a discernible impact on stem width. In density treatments, the 25 cm plant spacing treatment had the greatest stem diameter and the lowest stem diameter, and the differences between the two were statistically significant. The AS54 cultivar had the largest and AS31 had the smallest stem diameters in the cultivar treatment. ***Karimuna et al.* (2020)** The study's findings regarding stem diameter indicated that the combination treatment of maize variety and different doses of bokashi plus fertiliser had substantial effects and reliable outcomes on maize stem diameter seen at 2, 4, 6, and 8 WAP in Pentiro village. The combination of hybrid corn bisi-2 and 9 t/ha of bokashi fertilizer plus produced the greatest stem diameter of maize growth, and local maize and without bokashi fertilizer produced the lowest. This indicates that hybrid maize bisi-2 applied by the doses of bokashi plus fertiliser 9 t h-1 responded better than other combinations. The study's findings also indicated that maize grown in an intercropping system with peanuts between rows of three-year-old teak trees based on an agroforestry system grew more quickly on stem diameter as more bokashi plus fertiliser was added to the soil.

	Stem Diameter		
Mainplot	30	60	Harvest
1	0.93	2.95	2.64
2	0.96	3.01	2.69
3	0.92	3.03	2.65
cv	22	75.32	15.45
Subplot			
1	0.82	2.98	2.22
2	0.98	3.07	2.78
3	0.89	2.95	2.46
4	1.1	2.99	3.17

UNDER PEER REVIEW

cv	27	7.96	25.9
V X Scd@5%	NS	NS	NS

Table. 4: Table for stem diameter

Leaf area (cm^2):

In main-plots minimum leaf area in 30DAS was found in V1 (107.44cm^2). It increased to a maximum in V2 (111.93cm^2), which is an increase of 4.1%. And upon calculation V3 (109.37cm^2) increase by 1.8% in comparison to V1. In sub-plots the maximum leaf area was obtained in S4 (115.62cm^2) and decrease by S1 (98.9cm^2) which is a decrease of 15.6%. The minimum leaf area was found in V1S1 (91.83cm^2) and the maximum leaf area was found in V2S4 (116cm^2) which is an increase of 23.3%. And in 60 DAS the minimum leaf area in main plot was shown in V1 (377.5cm^2) and increase to a maximum leaf area in V2 (383.61cm^2) which is 1.6%. And upon calculation V3 (378.33cm^2) increase by 0.22% compare to V1. In sub-plots the minimum leaf area was found in S1 (278.98cm^2) and increased by S4 (418.1cm^2) which is an increase of 39.92%. The minimum leaf area was obtained in V1S1 (274cm^2) and the maximum in V2S4 (419.57cm^2) which is an increase of 41.98%. Whereas the minimum leaf area in 90DAS for main plot was obtained in V1 (403.1cm^2) and rise to a maximum of V2 (407.83cm^2) which is an increase of 1.2%. And upon calculation V3 (403.48cm^2) increase by 0.1% in comparison to V1. In sub-plots the minimum leaf area was found in S1 (313.14cm^2) and increased by S4 (440.21cm^2) which is an increase of 33.73%. The maximum leaf area is found in V2S4 (442.04cm^2) and the minimum in V1S1 (311.81cm^2) which is a decrease of 34.6%.

Karimuna et al.* (2021)** The study's findings regarding leaf area indicated that the combination treatment of maize variety and different doses of bokashi plus fertiliser had substantial effects and reliable outcomes on maize leaf area seen at 2, 4, 6, and 8 WAP in Pentiro village. The combination of hybrid corn bisi-2 and 9 t/ha of bokashi fertilizer plus produced the greatest leaf area of maize growth, and local maize and without bokashi fertilizer produced the lowest. This indicates that hybrid maize bisi-2 applied by the doses of bokashi plus fertiliser 9 t h-1 responded better than other combinations. The study's findings also indicated that maize grown in an intercropping system with peanuts between rows of three-year-old teak trees based on an agroforestry system grew more quickly on leaf area as more bokashi plus fertiliser was added to the soil. ***Enujeke (2013) discovered in his study that from the fourth to the eighth week after sowing, maize's leaf area gradually increased. The hybrid

UNDER PEER REVIEW

maize types studied varied significantly in terms of leaf area. The foliage area was greatest for hybrid variety 9022-13. By the conclusion of the eighth week after sowing, the hybrid variety 9022-13's mean value in relation to leaf area showed that it was superior to other varieties tested.

	Leaf area		
Mainplot	30	60	Harvest
1	107.44	377.5	403.1
2	111.93	383.61	407.83
3	109.37	378.33	403.48
cv	2.6	0.31	0.7
Subplot			
1	98.9	278.98	313.14
2	110.66	407.15	429.83
3	113.14	415.05	436.02
4	115.62	418.08	440.21
cv	1.9	0.62	0.74
V X S cd@5%	3.6	4.04	NS

table.5: Table for leaf area

Leaf area index (LAI):

In main-plots minimum LAI in 30DAS was found in V1 (1.59). It increased to a maximum in V2 (1.66), which is an increase of 4.31%. And upon calculation V3 (1.62) increase by 1.87% in comparison to V1. In sub-plots the maximum LAI was obtained in S1 &S4 (1.65) and decrease by S2 (1.58) which is a decrease of 4.33%. The minimum LAI was found in V1S1 (1.53) and the maximum LAI was found in V2S1 (1.74) which is an increase of 12.84%. And in 60 DAS the minimum LAI in main plot was shown in V1 (5.56) and increase to a maximum LAI in V2 (5.65) which is 1.61%. And upon calculation V3 (5.57) increase by 0.2% compare to V1. In sub-plots the minimum LAI was found in S1 (4.65) and increased by S4 (5.97) which is an increase of 24.9%. The minimum LAI was obtained in V1S1 (4.57) and the maximum in

UNDER PEER REVIEW

V2S4 (5.99) which is an increase of 26.9%. Whereas the minimum LAI in 90DAS for main plot was obtained in V1 (5.94) and rise to a maximum of V2 (6.01) which is an increase of 1.2%. And upon calculation V3 (5.95) increase by 0.2% in comparison to V1. In sub-plots the minimum LAI was found in S1 (5.22) and increased by S4 (6.29) which is an increase of 18.6%. The maximum LAI is found in V2S4 (6.31) and the minimum in V1S1 & V3S1 (5.2) which is a decrease of 19.3%.

In an experiment by ***Pion et al. (2022)***, the results showed that the contribution of fertilization was maximum (23.85%), the second was intensive planting (16.05%), which promoted nitrogen accumulation and transport in leaves and stems via increased leaf area index and dry matter accumulation around the anthesis simultaneously, elevating the radiation utilization efficiency of the canopy and allowing a higher grain weight to be obtained. ***Sali et al. (2022)*** shows the result in his experiment, that leaf area index, number of cobs per plant, cob length, number of cobs harvested per hectare and above ground fresh biomass yield and their interactions were highly significantly ($P<0.01$) affected by inter and inter-row spacing while cob diameter was significantly ($P<0.05$) affected by inter and inter-row spacing.

	LAI		
Mainplot	30	60	Harvest
1	1.59	5.56	5.94
2	1.66	5.65	6.01
3	1.62	5.57	5.95
cv	2.63	0.3	0.7
Subplot			
1	1.65	4.65	5.22
2	1.58	5.82	6.14
3	1.62	5.93	6.23
4	1.65	5.97	6.29
cv	1.93	0.63	0.75
V X S cd@5%	0.05	0.06	NS

Table.6: Table for leaf area index

	Plant height	No of leaves	Stem diameter	Leaf length	Leaf area	LAI

UNDER PEER REVIEW

Plant height	1					
No. of leaves	0.69801911	1				
Stem diameter	0.86059581	0.891652048	1			
Leaf length	0.65510174	0.895941434	0.825200558	1		
Leaf area	0.91366776	0.638065908	0.75749174	0.733897154	1	
LAI	0.0512048	0.206824798	0.038775349	0.274062787	0.236182588	1

Table 7: Correlation Table for 30 DAS

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	Plant height	No of leaves	Stem diameter	Leaf length	Leaf area	LAI
Plant height	1					
No. of leaves	0.818695	1				
Stem diameter	0.191194	0.005934	1			
Leaf length	0.306516	0.521004	-0.3821	1		
Leaf area	0.878235	0.674301	0.051406	0.234664	1	
LAI	0.881393	0.689488	0.046903	0.245851	0.998685	1

Table 8: Correlation Table for 60 DAS

	Plant height	No of leaves	Stem diameter	Leaf length	Leaf area	LAI
Plant height	1					
No. of leaves	0.31843	1				

Stem diameter	0.403473	0.924037	1			
Leaf length	0.516739	0.884646	0.816458	1		
Leaf area	0.366188	0.824606	0.725074	0.719519	1	
LAI	0.391961	0.842471	0.740729	0.756439	0.997891	1

Table 9: Correlation Table for harvest

Conclusion:

The variety and plant spacing are the two most significant agronomic measures that demand attention. The appropriate plant type and spacing typically depend on the environmental circumstances and the available resources for plant growth (nutrients, water, sunlight, and carbon dioxide). The tallest variety of maize crop may be able to tolerate restricted spacing better than the shortest variety due to its capacity to convert collected sun radiation into grain yield. The yield of maize per plant falls with closer or narrower spacing. On the other hand, it appears that reducing the spacing is a viable alternative to intensifying crop yield per unit of land area. Number of leaves, number of leaves, leaf length, stem diameter, leaf area and leaf area index are greatly influenced by variety. Variety that is suited for a place can boost its economy tremendously. According to the above discussion it can be concluded that there is a significant difference in result which is visible in graph, as it was observed that there is certain effect of spacing and variety in maize plant. This experiment was basically conducted to observe the effect of spacing along with 3 chosen variety, and by this we can see the variations in all the treatments individually too. By combining variety with spacing made a huge difference as they interact with environment and enhance the plant growth and development, like increasing the spacing will directly affect the plant ground area and the leaves of plant can easily absorb more sunlight as compared to others but on the other hand decreasing the area the plant population will be increased thus, it will directly enhance the crop yield as mentioned above. Therefore, this trial was seen to be effective and can be recommended to farmers. The results highlight that treatment effects vary over time. While significant differences were observed in the 60 DAS measurements, the earlier (30 DAS) and later (90 DAS) measurements did not consistently show significance. Across all time points, sub treatments consistently showed significant effects. This suggests that specific conditions or treatments applied at the sub-level are critical to the overall effectiveness. The differences in means, particularly at 60

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DAS, suggest that adjustments in treatment protocols may be necessary depending on the timing of application to achieve desired outcomes.

Compliance with ethical standards

Ethical issues: None

Reference:

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Fig 2 Maize productivity

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