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Phenology and growth of different maize cultivars as influenced by graded Levels of nitrogen under temperate conditions

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Abstract
The field experiment entitled "Phenology and Growth of Maize (*Zea mays* L.) of different maize cultivars as influenced by graded levels of Nitrogen under temperate conditions was carried out at Agronomy farm, FOA Wadura campus of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during 2016 and 2017. Experiment was laid in Factorial RBD assigning four maize cultivars Composite-3 (C-3), Composite-4 (C-4) Composite-5 (C-5) and Composite-6 (C-6) and five nitrogen levels N_0: 0 kg N ha^{-1}, N_1: 60 kg N ha^{-1}, N_2: 90 kg N ha^{-1}, N_3: 120 kg N ha^{-1} and N_4: 150 kg N ha^{-1} and was replicated three times. The results revealed that growth characters like plant height (cm), and dry matter accumulation were recorded highest with composite-4 (C-4) maize cultivar as compared to other maize cultivars. To complete growth phases more days were taken by composite-4 (C-4) maize cultivar which was at par with composite-3 (C-3) maize cultivar and lowest days were taken by composite-5 (C-5). Among nitrogen levels, 150 kg N ha^{-1} recorded highest growth characters like plant height (cm) and dry matter accumulation however, remained statistically at par with 120 kg N ha^{-1} (N_3) nitrogen application while lowest growth charaters were recorded from N_0: 0 kg N ha^{-1}. More number of days to complete different phenological stages were taken by higher nitrogen application.

Keywords: Cultivar, dry matter accumulation, growth, nitrogen

1. Introduction
Maize (*Zea mays* L.) is emerging as an important cereal crop in the world after wheat and rice. It is now an important ingredient in food, feed, fodder and large number of industrial products. It has acquired dominant role in the farming sector and macro- economy of the Asian region. It has the highest potential of per day carbohydrate productivity. Thus, it is not without any basis that father of green revolution, the renowned Noble Laureate Norman E. Borlaug, believes that "As the last two decades saw the revolution of rice and wheat, the next few decades will be known as maize era." (Patil *et al.*, 2000) [20]. Maize is widely cultivated throughout the world, and produced greater than any other grain. The United States produces 40% of the world's harvest; other top producing countries include China, Brazil, Mexico, Indonesia, India, France and Argentina. Maize is cultivated on an area of 161.82 million hectares in the world with production of 844.36 million tonnes and productivity of 5.22 tonnes ha^{-1} (FAO, 2010) [4]. Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as the "Queen of Cereals" because it has the highest genetic yield potential among the cereals and is the third most important cereal crop in India after rice and wheat and is cultivated on 8.71 million (m) ha with production of 22.23 million tonnes with productivity of 2552 Kg ha^{-1}(Agricultural Research Data Book 2011) [1]. It is cultivated on nearly 150 mha in about 160 countries having wider diversity of soil, climate, biodiversity and management practices that contributes 36% (782 mt) in the global grain production. The USA has the highest productivity (> 9.6 t ha^{-1}) which is double than the global average (4.92 t ha-1), whereas, the average productivity in India is 2.43 t ha^{-1}. Being an important cereal, over 85% of its production in the country is consumed directly as food in various forms, the chapatis is the common preparation whereas, roasted cobs, pop corns and porridge are other important forms in which maize is consumed. Besides, it is also used for animal feeding, particularly for poultry and in starch industry.

Maize fodder contains relatively high concentration of soluble carbohydrates and yield, a high quality Biomass within a short period, making it attractive as hay and silage crop. Compared to other cereals forage crops maize was found to be a high forage yield with high protein content and low fiber content (Kambal, 1984) [7]. Maize crop is being an exhaustive crop requires a large quantity of nutrients during different growth periods. Nitrogen is a vital plant nutrient and a major yield determing factor required for maize production (Shanti *et al.* 1997) [17]. Nitrogen is an essential element for both fodder quantity and quality as it is a component of chlorophyll and amino acids, which are the building blocks of proteins and is also a part of the DNA molecule, so it plays a very important role in cell division and reproduction. The chlorophyll molecule also contains nitrogen. Nitrogen also mediates the utilization of phosphorus, potassium and other elements in plants (Brady, 1984) [3]. The optimal amounts of these elements in the soil cannot be utilized efficiently if nitrogen is deficient in plants. Therefore, nitrogen deficiency or excess can result in reduction of maize yield. Most of the nitrogen taken up by plants from the soil in the forms of NO_3^-. Amino acids and proteins can only be built from NH_4^+ so NO_3^- must be reduced with split application of ammonical form of nitrogen. Nitrogen is usually applied in splits in the field to avoid various nitrogen losses. Cultivars have a pronounced effect on the yield of maize. Cultivars differ in their response to nutrient supply when planted in different geographical environments. Optimizing the NPK fertilizer doses is necessary to achieve optimal potential of maize cultivars (Khan *et al*, 2014) [8].

Materials and Methods

The field experiment entitled,

Phenology and Growth of Maize (*Zea mays* L.) of different maize cultivars as influenced by graded levels of Nitrogen under temperate conditions

Was carried out at Agronomy farm, FOA wadura campus of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during 2016 and 2017. Experiment was laid in Factorial RBD assigning four maize cultivars Composite-3 (C-3), Composite-4 (C-4) Composite-5 (C-5) and Composite-6 (C-6) and five nitrogen levels N_0: 0 kg N ha^{-1}, N_1: 60 kg N ha^{-1}, N_2: 90 kg N ha^{-1}, N_3: 120 kg N ha^{-1} and N_4: 150 kg N ha^{-1} and was replicated three times.

Phenology

Number of days taken by Maize crop to reach various phenological stages till harvesting was observed throughout crop growth period.

Plant height

Plant height of five randomly selected plants in penultimate rows of each plot at 15 days interval DAS was recorded from ground surface to the tip of the plant with the help of meter scale and the average data was recorded as plant height (cm).

Dry matter accumulation

At 15 days interval after sowing three randomly selected plants from penultimate row of each plot were harvested and chopped into small pieces, mixed homogeneously and oven dried at 60-65 ^oC temperature to a constant weight. After recording dry weight with the help of electronic balance, it was averaged and recorded as g plant^{-1} and converted into q ha^{-1}.

Results and Discussion

The field experiment was conducted during year 2016 and 2017 at the Experimental Farm of the Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir. The detailed description of treatment effects on various growth characters of sweet corn was studied

Phenology

The number of calendar days taken to different phenological stages (knee high stage, tasseling, silking and maturity) was strongly influenced by the prevailing environmental conditions, particularly the maize cultivars and the nitrogen levels. Analysis of the data revealed that the maximum number of days taken to different phenological stages (germination, emergence, knee high stage, tasseling, silking and maturity) during both the years was by composite-4 (C4), followed by composite-3 (C3). While the minimum number of days taken to different phenological stages (germination, emergence, knee high stage, tasseling, silking and maturity) was by composite-5 (C5) in both the years (Table1). Difference in maize cultivars regarding phenology might be due to their variation in genetic constitution. Luque *et a1.* (2006) [11] and Gozubenli *et al.* (2001) [5] also reported that variation in tasseling, silking and maturity of maize cultivars is due to its genetic makeup. This might be due to variation in varietal characteristics that deviated in their expression from each other. These results are in agreement with Khan Shafi (2008) [9].

With respect to nitrogen levels maximum number of days to different phenological stages was taken with 150 kg ha^{-1} nitrogen application (N_4) and minimum number of days to different phenological stages was taken under nitrogen deficit conditions (N_0: 0 kg ha^{-1}) during both years of experimentation. The reason for the lesser number of days taken in the higher nitrogen deficit may be explained by the fact that nitrogen deficit creates a stress on the plant. The result is that the plant wants to complete its growing cycle as quickly as possible, with reduction in the duration of growth stages (Table 1). The results could be due to the fact that higher levels of nitrogen delayed the reproductive phase i.e. tasseling and silking. It was also found that both 150 kg ha^{-1} and 120 kg ha^{-1} nitrogen application increased days to harvest of maize cultivars compared to 60 kg ha^{-1} (N_1) and 0 kg N ha^{-1} (N_0) nitrogen application. The response of crop to nitrogen with respect to harvest was significant up to 150 kg ha^{-1} (N_4). The effects were reflected in the length of harvesting period which was more with 150 kg N ha^{-1} (N_4). Thakur *et al.* (1997) [19] also reported significant increase in harvesting period with nitrogen application up to 150 kg ha^{-1} nitrogen application.

Table 1: Days taken to different phenological stages of different maize cultivars as influenced by graded levels of Nitrogen

Treatments	Germination		Emergence		Knee high stage		Taselling		Silking		Harvesting	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Cultivars												
C- 3	6.7	7.0	12.13	12.73	34.93	36.93	65.20	68.20	72.60	76.13	129.41	130.81
C-4	7.0	7.2	12.73	12.93	35.33	37.33	66.00	69.00	73.33	76.31	130.52	131.92

C- 5	6.8	7.1	12.20	12.33	34.13	36.13	64.26	67.26	71.26	74.28	127.14	128.53
C- 6	6.6	7.2	12.06	12.46	34.60	36.60	64.46	67.46	73.13	75.54	128.94	130.33
SE(m)±	0.2	0.2	0.20	0.30	0.23	0.23	0.21	0.21	0.25	0.25	0.49	0.50
CD(P = 0.05)	NS	NS	NS	NS	0.67	0.67	0.61	0.61	0.72	0.72	1.41	1.41
Nitrogen levels												
N_0	6.4	7.0	12.08	12.42	33.66	35.66	63.92	66.91	70.33	73.25	126.99	128.39
N_1	6.7	7.1	12.08	12.50	34.08	36.08	64.20	67.20	71.75	74.75	127.65	129.05
N_2	6.8	7.1	12.25	12.58	34.58	36.58	65.03	67.83	73.08	76.08	129.01	130.41
N_3	7.2	7.2	12.33	12.66	35.33	37.33	66.00	68.92	73.41	76.42	130.08	131.48
N_4	7.2	7.3	12.66	12.92	36.08	38.08	66.08	69.08	74.33	77.33	131.25	132.65
SE(m)±	0.2	0.2	0.23	0.31	0.26	0.26	0.24	0.24	0.28	0.30	0.55	0.55
CD(P = 0.05)	NS	NS	NS	NS	0.75	0.75	0.72	0.68	0.80	0.82	1.57	1.57

Plant height

Plant height is a reliable index of plant growth and represents the infrastructure build up over a period of time. It was also found that the plant height at different crop growth stages were significantly higher in Composite-4(C4) compared to other cultivars (Table 2, Fig.1). It was also found that the magnitude of increase in the plant height was upto 75 DAS. Sukanya *et al.* (1999) [18] reported significant variation in plant height of maize cultivars at grand growth stage and at harvest. The differential growth with respect to plant height observed among the varieties may be attributed to differences in genetic characteristics of the individual varieties, including rapid growth rates, tallness or shortness of species. This is similar to the findings of Majambu *et al*., (1996) [12] and Ibrahim *et al*., (2000) [6] that attributed the differences in growth indices of crops to genetic constitution.

Nitrogen levels also influenced the plant height significantly. Plant height was significantly higher with 150 kg ha^{-1} nitrogen application (N_4)as compared to 0 kg ha^{-1} (N_0) and 60 kg ha^{-1} nitrogen application (N_1)at all growth stages of plant during both the years but remained statistically at par with 120 kg ha^{-1} nitrogen application (N_3). The higher plant height with the increase in nitrogen application may be due to higher net photosynthesis. Additionally, proper availability of nitrogen enhances photosynthetic rate and cell division and its multiplication, resulting in taller plants (Table. 2, Fig. 2). The increase in plant height with increase in nitrogen levels also been reported by Ramesh *et al*., 2005 [14] and Krupnik *et al*., 2004 [10]. The increase in the plant height at higher level of nitrogen could be attributed to the fact the nitrogen being an essential constituent of plant tissue, induced rapid cell division and cell elongation. Thakur *et al.* (1997) [19] also reported significant increase in the height of maize plant with nitrogen fertilization up to 150 kg ha^{-1} nitrogen application.

Table 2: Plant height (cm) of different maize cultivars as influenced by graded levels of Nitrogen

Treatments	15DAS		30 DAS		45 DAS		60 DAS		75 DAS		At maturity	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Cultivar												
C- 3	13.86	11.71	53.54	51.74	106.48	99.87	191.82	185.51	202.96	196.77	202.98	196.80
C-4	13.98	11.78	56.15	53.87	107.42	102.51	195.82	186.71	204.32	198.74	204.40	198.82
C- 5	13.37	11.30	51.30	48.98	100.96	96.45	182.32	177.44	191.48	186.10	191.53	186.16
C- 6	13.38	11.48	52.83	49.76	102.07	96.60	182.35	180.20	191.71	186.21	191.77	186.32
SE(m)±	0.20	0.16	1.04	0.67	1.30	1.39	2.82	2.05	3.05	3.94	3.32	2.31
CD(P = 0.05)	NS	NS	2.99	1.93	3.73	3.99	8.09	5.88	8.75	11.28	9.53	6.61
Nitrogen levels												
N_0	13.15	11.45	47.46	46.39	95.59	92.80	176.36	173.27	183.47	179.27	183.71	179.56
N_1	13.60	10.51	50.72	48.39	101.46	97.09	185.27	180.55	192.87	187.12	193.02	187.66
N_2	13.68	10.54	54.44	51.19	103.43	100.13	186.87	182.16	195.73	193.45	195.87	194.08
N_3	13.88	10.62	58.40	55.90	108.70	101.82	194.96	187.44	207.50	198.87	207.68	198.92
N_4	13.85	10.76	56.30	53.19	111.97	102.45	196.93	188.91	208.53	201.05	208.58	201.20
SE(m)±	0.22	0.18	1.16	0.75	1.45	1.59	3.15	2.29	3.42	4.40	3.72	2.58
CD(P = 0.05)	NS	NS	3.34	2.15	4.17	4.47	9.04	6.57	9.78	12.62	10.65	7.40

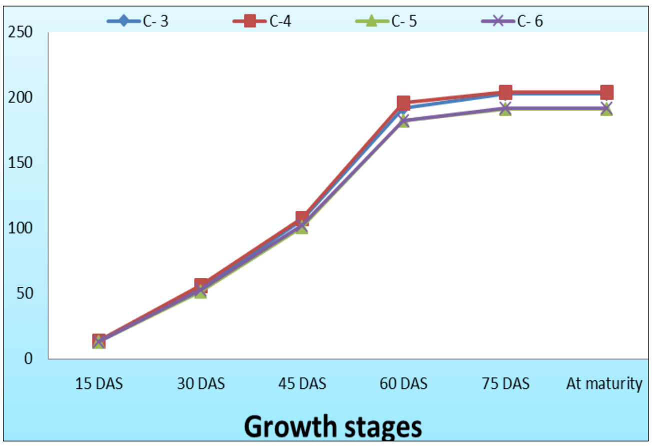

Fig 1: Plant Height

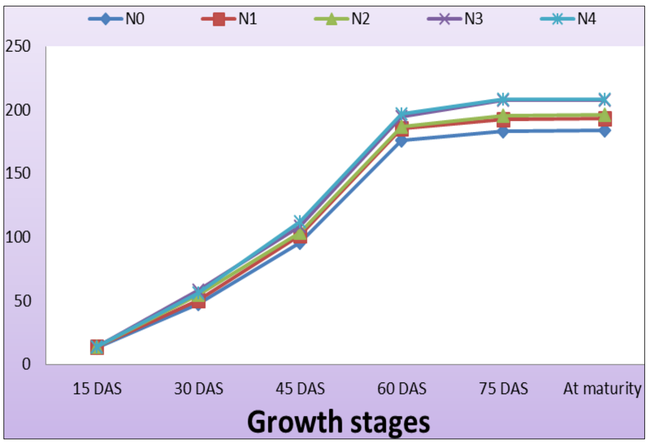

Fig 2: Plant Height

Dry matter accumulation

Dry matter accumulation (DMA) is one of the most important parameter reflecting crop growth. It is the final outcome of the interaction of various crop growth factors and reflects the growth and metabolic efficiency of the plant.

Data revealed that DMA at 15 days after sowing (DAS) was not influenced by cultivars and nitrogen levels. However, significantly higher dry matter accumulation (DMA) was recorded in composite-4 (C-4) and composite-5 (C-5) recorded significantly lower dry matter accumulation at all growth stages during both the years of experimentation (Table 3, Fig. 3). Similar findings were observed by Sukanya *et al.* (1999) [18] and Sajjan *et al*., (2002) [15] with respect to growth characters among different varieties. The variation in the growth characters of different maize cultivars could be due to the difference in their genetic potential.

The result of the study revealed that except at 15 DAS, dry matter accumulation at various crop growth stages increased significantly with nitrogen application up to 150 kg ha^{-1}(Table 3, Fig. 4). DMA was significantly higher with 150 kg ha^{-1}nitrogen application (N_4) as compared to N_0 (0 kg ha^{-1}N) and N_1 (60 kg ha^{-1} N) at all growth stages during both years of experimentation was at par with 120 kg ha^{-1} nitrogen application (N_3). The improvement in dry matter production at increased levels of nitrogen might be due to increased metabolic activities more cell growth and elongation. Increased dose of nitrogen thereby increased photosynthetic surface (LAI) which paved the way for more production of dry matter. The results are in agreement with the findings of Banga *et al.* (1994) [2] and Singh (2001) [16]. Further, it is well known that the reduction in nitrogen levels limits the net assimilation rate. The decrease in DMA with increase in nitrogen deficit has also been reported by Krupnik *et al.* (2004) [10].

Table 3: Average dry matter accumulation (g plant^{-1}) of different maize cultivars as influenced by graded levels of Nitrogen

Treatments	15DAS		30 DAS		45 DAS		60 DAS		75 DAS		90 DAS		105 DAS	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Cultivars														
C- 3	0.46	0.42	10.59	8.73	39.50	36.56	62.04	56.98	101.66	94.94	125.32	115.70	193.92	187.87
C-4	0.47	0.42	10.83	9.68	39.97	40.50	66.02	60.02	104.42	96.73	131.36	120.80	197.57	191.44
C- 5	0.46	0.41	9.86	7.69	37.37	34.78	58.47	52.50	93.25	84.23	115.14	111.04	181.79	176.30
C- 6	0.45	0.41	9.98	8.41	38.34	36.30	59.82	52.75	95.46	86.33	120.63	115.70	185.90	178.17
SE(m)±	0.01	0.01	0.18	0.11	0.65	0.94	1.59	0.81	2.66	1.34	2.64	1.78	4.06	2.60
CD(P = 0.05)	NS	NS	0.53	0.32	1.87	2.72	4.56	2.32	7.62	3.84	7.58	5.09	11.64	7.46
Nitrogen levels														
N_0	0.44	0.41	8.67	7.79	32.82	31.57	56.47	49.55	90.73	81.33	115.62	107.98	180.41	177.47
N_1	0.45	0.41	9.47	8.12	35.55	33.98	59.79	52.61	93.25	85.00	118.56	111.16	183.56	180.16
N_2	0.45	0.42	10.24	8.65	38.37	36.84	60.97	55.34	98.31	90.25	122.52	113.96	188.57	182.84
N_3	0.47	0.42	12.21	9.51	41.98	40.32	64.79	58.61	104.19	95.29	127.65	115.66	193.72	186.47
N_4	0.47	0.42	11.00	9.07	45.27	42.46	65.92	61.69	107.02	100.93	131.22	117.31	202.73	190.29
SE(m)±	0.01	0.01	0.21	0.12	0.73	1.06	1.78	0.98	2.97	1.50	2.96	1.99	4.54	2.91
CD(P = 0.05)	NS	NS	0.60	0.36	2.09	3.03	6.84	2.60	8.52	4.30	8.47	5.69	13.02	8.34

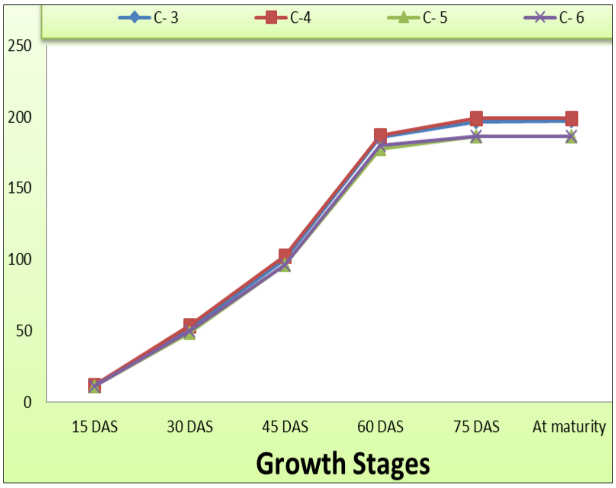

Fig 3: Dry Matter Accumulation

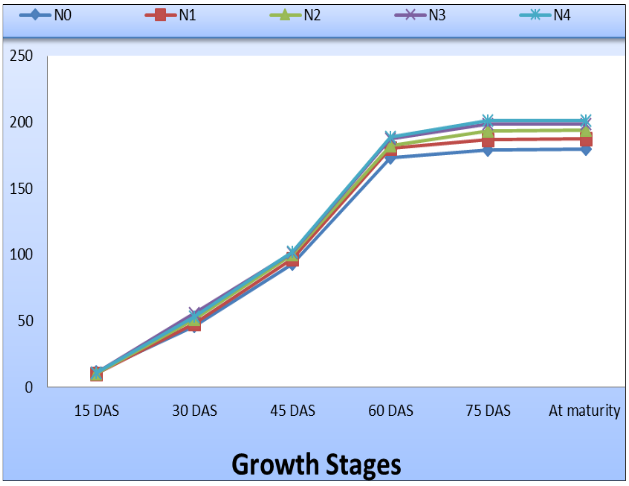

Fig 4: Dry Matter Accumulation

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