

Review Article

Effects of planting time on growth, development and productivity of maize (*Zea mays* L.)

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ABSTRACT

Planting date plays important role in the growth, development and yield of maize. Optimum planting date has becomes a prime importance for higher crop production. The plant establishment as well as pest and disease incidence are affected by planting dates. Crop varieties respond differently to planting dates. Early or late planting dates on maize causes an array of morpho-anatomical, physiological and biochemical changes in plants, which affect plant growth and development and such changes may lead to a drastic reduction in yield. Maize growth and development involves numerous biochemical reactions which are sensitive to variance in weather parameters as affected by planting dates. Delayed planting dates affect traits namely anthesis silking interval, photosynthesis, physiological maturity and dry matter production due to reduction in cumulative interception of photosynthetically active radiation (PAR). Late planting dates cause higher non-structural carbohydrate concentration in stems at mid-grain filling stages due to low temperature exposure of crop limiting kernel growth and photosynthesis. The adverse effects of delayed planting dates can be mitigated by forecasting optimum planting dates through crop modeling experiments. This article summarizes various effects of planting dates on maize growth, development and yield parameters. This information may be useful for maize growers and researchers.

Keywords: Maize (*Zea mays* L.), planting date, grain yield

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Effect of planting time on growth of maize plant

As the result of changing planting date, maize crop receives different level of radiation as well as thermal temperature and period also vary. Cirilo and Andrade (1994) found that late planting of crop decreased its growth and development because less amount of solar radiation was captured by crop during emergence to silking stage. Likewise, if any crop are exposed to colder temperature as well as low solar radiation environment during grain filling stage then very low dry matter accumulation occurs as result of late planting date. During middle of grain filling stage, higher amount of non-structural carbohydrates are accumulated in stem as result of delaying planting date. These consequences concluded that photosynthetic process as well as kernel establishment are adversely effected by exposure to low temperature and radiation environment caused by late planting. Exposure of crop to higher radiation and temperature condition during its vegetative growth stages created higher radiation use efficiency (RUE) consuming more radiative energy in plant, increasing its vegetative growth but inversely decreased the optimum growth of reproductive stages due to exposure of crop to cold temperature and low solar radiation reducing RUE. As the ultimate result, ratio between kernel number and dry matter during silking stage decreased significantly due to delayed planting, Whole phenomenon gets inversed if early planting is practiced (Cirilo and Andrade, 1994). Reduction of filing grains caused after delaying of planting date which let plant to get exposed to low temperature and radiation condition (Maddonna *et al.*, 2004). Both dry matter accumulation and kernel weight decreases as the result of low temperature and radiation during grain filling stage as the detrimental impact of delaying planting date in crop plant (Andrade *et al.*, 1993).

Effect of planting time on silking, tasseling and physiological maturity

Late planting of maize caused elongation of silking to physiological maturity period due to adverse effect of low temperature on pace of maturity period as well as proper grain black layer filling was also affected (Tollenaar & Bruulsema, 1998). Daynard (1972) observed that time interval requirement of thermal condition during planting to mid – silking stage in maize crop was lengthen whereas requirement of thermal exposure interval by mid – silking to grain black layer formation stage was shorten as a result of late seed sowing. Sutton and Stucker (1974) confirmed that late sowing causes shortening of Growing Degree Days (GDDs) requirement during planting to physiological maturity stage as shifted from early sowing date. Therefore, due to reduced daily incident radiation, cumulative intercepted PAR was reduced during silking to physiological maturity in case of late planting was observed (Tollenaar & Aguilera, 1992). Whereas, late planting of maize caused reduction of Radiation Use Efficiency (RUE) in later growth stage but increased during earlier growth stage. If temperature remain at optimum required level for photosynthesis in maize, low RUE remains constant from emergence to grain filling period (Cirilo & Andrade, 1994). Sangoi (1993) found hybrid maize planted during earlier planting date elongated growth period of more than 2 weeks than planted in delayed date. (Sangoi *et al.*, 1998; Silva *et al.*, 1998) concluded that if there is exposure of maize crop to low temperature during its active growth stages then the speed of growth and development slows down due to which crop absorbs more solar radiation and consume less for metabolism which results the problem of less number of leaves formation, stunted growth of plant etc. Drought condition increased GDDs to complete up to physiological maturity level in hybrid maize varieties significantly compared to suitable

growing environment (Stewart *et al.*, 1997). Though thermal interval required for silking to maturity stage always vary, frequent estimation of thermal time interval required for this grain filling stage is essential to be done under GDD system of measurement. Barger (1969) suggested that to maximize the yield response of hybrid maize varieties requires clear study about interaction between maize yield response, late planting date and required thermal time interval.

Effect of planting time on leaf area index

Leaf area index (LAI) is the ratio of total area occupied by a plant leaves per unit total area of land (Watson, 1997). It is an important index to be measured to know rate of plant growth and development status (Steward & Dwyer, 1999). Plant growth activities like photosynthesis, transpiration and accumulation of dry matter mainly depends upon total area occupied by plant canopy and the distribution of leaves which regulate the interception of solar radiation, gaseous exchange and maintain temperature around plant canopy. Therefore, LAI can also be used as important plant growth parameter for doing any researches (Fortin *et al.*, 1994). Proper arrangement of leaves and good canopy required for better interception of sunlight promoting photosynthesis and other metabolic processes of crop (Morrison *et al.*, 1992). (Monteith, 1981) found that photosynthetically active radiation (PAR) utilized by crop belongs to only half proportion of total incident solar radiation and rest of proportion converts into heat energy. Higher utilization of PAR by maize crop during its vegetative stages declines the leaf growth and development (Thiagarajah & Hunt, 1982; Hesketh & Warrington, 1989). The temperatures encountered with early planting tend to reduce plant height (Al-Darby & Lowery, 1987) mainly by decreasing internode length and less so by reducing leaf numbers. Leaf area (LA) is also considerably lower.

Effect of planting time on kernel number per cob

Bassetti and Westgate (1993) found significant variation in ear growth of maize as the result of reduction in spikelet initiation stage interval due to extending planting date. Kernel number per cob as well as flower distribution in it also get adversely effected by delay in planting dates (Otegui & Melon, 1997). Derieux *et al.* (1985) also found kernel number per row and ovule number per row were significantly affected by delay in planting dates. On another hand, Cirilo and Andrade (1994) observed that there was no any distinct reduction of spikelet initiation in tested hybrid maize varieties due to delay of planting date and also considered kernel abortion as more potential factor for declining spikelet primordial growth. Anderson *et al.* (2004) found drought condition is also responsible for permanent declination of kernel number per row in maize. Bassetti and Westgate (1993) found that under stressful conditions, the regular process of pollen formation in tassel and silk formation from cob may alters due to which they don't get chance to pollinate properly. Pollen could not get attached to silk due to lack of receptivity which get non-functional because of overage or pollen still may not get matured enough to pollinate with already matured silk. This alteration in pollination process ultimately reduces grain yield of crop (Bassetti & Westgate, 1993; Anderson *et al.*, 2004). The effect of sowing dates on yield of maize during spring season was given in Table 1.

Table 1. Effect of sowing dates on yield of maize during spring at Kawasoti 5, Nawalparasi, Nepal

Sowing dates	Kernel rows/ear	Kernels/row	1000 kernel weight (g)	Grain yield (t/ha)	Stover yield (t/ha)	Harvest index
7 th April	12.89	27.97	232.0	5.126	14.35	0.347
22 nd April	12.47	24.47	231.3	4.104	14.26	0.289
7 th May	12.22	22.73	224.3	3.692	12.58	0.290
SEM	0.075	0.301	1.686	0.078	0.289	0.009
LSD(0.05)	0.219	0.883	4.946	0.227	0.849	0.027

(Source: Shrestha *et al.*, 2016)

Effect of planting time on kernel mass

Delay in planting date can reduce the total grain yield due to reduction of individual kernel mass during anthesis stage up to 10% (Taylor & Blackett, 1982). More distinct reduction in grain filling occurs if environmental stress intensifies at the same time. Therefore, though grain yield mainly depends upon total ear number formed, same effect could also occur due to kernel mass reduction as the result of late planting date (Maddonna *et al.*, 2004). After completion of silk stage in maize, if there is condition of low interception of solar radiation then mass filling of each kernel reduces and low temperature cause improper distribution of biomass in each kernel which ultimately result in reduction of kernel mass as consequence of late planting (Maddonna *et al.*, 2004).

Effect of planting time on grain yield

Different factors of production influences final grain yield of crops. Early plantation of crop can significantly improves grain yield but besides that other practices like maintaining higher plant population and higher dose of fertilizer also can improve grain yield (Sheperd *et al.*, 1991). Furthermore, early planting helps in early harvesting which helps to avoid possible unfavourable environmental conditions as well as save more labour and time also (Hicks *et al.*, 1972). Avoiding late planting date or early planting can avoid environmental stress like solar radiation, unbalanced growth period interval, low temperature that can harm plant growth and reduce grain yield. Likewise, early planting can reduce unnecessary cost of production increasing profit value. Aldrich *et al.* (1975) found late planting favoured plant exposure to short growth period, more pest and disease infection, drought, cold temperature, less radiation availability etc. finally reducing grain yield. Otegui and Melon (1997) supported that late planting cause crop exposure to more thermal condition during its active vegetative stage which leads to over vegetative development reducing dry matter accumulation in kernel that ultimately reduces the final grain yield. Only late planting could not be sole factor reducing grain yield in crops (Green *et al.*, 1985). When such practice is done then different growth stages of plant get exposure to different environmental conditions like low or high temperature, low or high thermal period, and more or less disease and pest incidence, fluctuation in soil fertility status etc. that can combinely effect the final grain yield of any crop plant. Likewise, alteration of growth period due to above factors also cause altered situation of crop vegetative and reproductive growth which results lower grain yield. Since all internal and external factors effecting grain yield of crop are interlinked with each

other, still there exist lack of clear understanding the mechanism of late planting date effecting grain yield in maize (Scarsbook & Doss, 1972).

Crop cultivars show distinctive variation in response pattern among them related to planting date. Likewise, the research about correlation between disease incidence in plant and its planting time observed in different season and climate range is still unclear (Otegui *et al.*, 1995). Determination of optimum planting time for maize crop is very difficult due to occurrence of continuous distinct variation in disease and pest incidence that effect plant growth and development observed every year (Oktem, 2000). Optimum planting date of any crop planted delaying one or more week interval are determined aiming maximum yield by analyzing the performance data recorded for multiple production year of same crop (Lauer *et al.*, 1999). The optimum planting time of maize varies with geographical location, weather condition and varieties. In Nepal, delayed planting particularly in late October to December, results poor yield due to low temperature induced delayed germination and slow vegetative growth Similarly, very early planting in late August or early September is not conducive to the maize growth and yields because of negative consequences of higher temperature and rainfall at the initial growth stages (NMRP, 2004; Amgain, 2015). September planting maize has been producing higher yield than the subsequent late plantings. The percentage reduction in yield was high for September versus (vs) October planting than the October vs November planting and the highest for Sept vs November planting (Table 2) in all the maize cultivars (Amgain, 2015).

Table 2. Grain yield (t/ha) and yield reduction due to delayed planting in maize

Maize varieties	Grain yield (t/ha)			Yield reduction (%) due to late sowing		
	Sept 1	Oct 1	Nov 1	Sept vs Oct	Oct vs Nov	Sept vs Nov
Rampur composite	5.10	4.00	3.43	21.52	14.25	32.75
Poshilo makai-1	5.50	4.27	3.64	22.36	14.75	33.82
Gaurav	5.86	4.45	3.83	24.06	13.93	34.46
Pool-12	3.45	2.42	2.02	29.86	16.53	41.45

(Source: Amgain, 2015)

In spring season, First week of April is optimum planting time for had higher growth rate, higher yield and its attributing characters as it was facilitated by relatively favorable temperature (Shrestha *et al.*, 2016). Longer maturity maize hybrids were more sensitive to late planting date than the short maturity hybrids. The reason for differential response to maize planting dates could be attributed to variation in the maturity periods.

CONCLUSION

Delay planting greatly affects the growth, development and productivity of maize plants. It brings changes in weather parameters such as temperature, solar radiation, humidity during crop season which responsible for changes in morphology, plant physiology and molecular level of plants. Thus planting date has prime importance for crop production due to its variation in weather. Plant cultivar response differently with different planting date. Optimum planting date recommended for highest yield for that crop season. The plant response to delay/early planting and mechanisms underlying the development of delay/early planting

need to be better understood for development of optimum planting time for cultivar for highest yield. The responses of plant to delay/early planting have been studied intensively in recent years. However, a complete understanding of predict optimum planting dates for maize crops elusive due to year-to-year variation in plant establishment, pest and disease incidence. Field experiment should be conducted to identify optimum/mean planting dates which are needed to investigate for highest yield and expected yield penalties for each week of delay in planting on crop.

Author Contributions

JS, MK and AC wrote this article.

Conflicts of Interest

The authors declare that there is no conflict of interest.

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