Effect of Planting Dates on Agronomic Crop Production

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Abstract

The influence of planting dates on productivity of agronomic crops assumes pivotal significance. Optimum planting date has remained unambiguously one of the most imperative agronomic factors to achieve higher production and is believed to be important under changes in climatic circumstances in the present and future scenario. Planting date is determined through occurrence of weeds, diseases and pests attacks, and temperature of soil and environment weather parameters, circumstances to which young seedlings and agronomic crop plants are exposed to during various phenological stages and phases. Appropriate planting date is a main factor to enhance resources use efficiency. Additionally, an appropriate planting date in a specific ecological setting makes possible the accumulation of required thermal time essential for appropriate growth and development of agronomic crops. An appropriate planting time is different in various agroecological conditions. Under the warming climatic trend where crop-growing season is usually short and quick, an increase in temperature is observed at the end of the growing season which is unfavorable for growth and development of crop, and sowing date assumes a higher significance. The adaptation of an optimum planting date under changing climatic conditions is necessary as stress under thermal trend will shrink in critical developmental phases and ultimately results in decreased productivity of agronomic crops. Optimum sowing date enhanced yield components and yield to ensure food security worldwide.

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M. Hasanuzzaman (ed.), *Agronomic Crops*,
https://doi.org/10.1007/978-981-32-9151-5_8

Keywords
Sowing date · Productivity · Adaptation · Climate change · Yield · Optimum growing conditions

8.1 Introduction

Food security is an imperative global challenge with respect to the continuously growing population. At world level, arable land consists of almost 12% of the terrestrial land area (Humphreys et al. 2016; Muluneh et al. 2017). The productivity of agricultural lands is significantly influenced by the application of crop management practices like sowing date (Dai et al. 2017; Srivastava et al. 2017). Sustainability of various agronomic crops productivity is very important in providing food and fiber for the population at a global level and to feed the farm and domestic animals, which might be potentially supported by suitable adaptive crop husbandry practices like optimum sowing date, etc. (Baghdadi et al. 2014; Khan et al. 2017). Appropriate sowing date causes the enhancement of resources use efficiencies (Bonelli et al. 2016; Luo et al. 2018).

Sowing date is an important determinant of crop yield. Sowing date is a very essential crop management practice to increase the productivity of different agronomic crops (Joshi and Heitholt 2017; Wani et al. 2018). The most advantageous planting date is not a fixed time but changes with respect to region, season, and cultivar. Recommendation of optimal planting date depends on the combination of several factors including plant variety, temperature suitability, and water availability (Balalic et al. 2012). It has a significant influence on the economic yield due to the variations in weather conditions like timing and quantity of rainfall, humidity, dry and wet durations, minimum and maximum temperature changes, and solar radiations variability that sturdily affects phenological stages and phases and ultimately grain yield (Dharmarathna et al. 2014; Abbas et al. 2017; Mahajan et al. 2018). Environmental factors seriously influence plant growth and yield components; thus sowing date plays a decisive role for sustainable grain yield and quality of several crops (Buddhaboon et al. 2011; Pal et al. 2017). Reduction of crop yields in delayed or early sowing time has been indicated by various studies all over the world. Source and sink relationship is also affected by sowing date (Zhang et al. 2016). Dry matter assimilation and nutrients uptake under inappropriate sowing date can limit the source and sink size.

8.2 Sowing Date and Adaptation Strategy

Adapting shifting planting date against thermal trend is very important for the enhancement of agricultural productivity. Reason is that climate warming accelerates crop development and shortens growth duration. Physiological processes like photosynthesis rate, starch conversion rate, and nutrients metabolism are negatively affected by heat stress. The adaptation of newly evolved climate smart genotypes and optimum change in planting date can reduce the harmful impacts of warming trend (Baloch et al. 2010; Humphreys et al. 2016). Well-established crops depend on numerous reasons like soil water contents, soil temperature, and presence of pests and diseases at the time of planting. Well growing conditions can be obtained by adaptation of an optimum planting date (Fayed et al. 2015; Luo et al. 2018). Hence, the decision on seed rate, planting density, spatial arrangement of plants, and other crop management practices like irrigation, fertilization, and application of pesticide set are affected by the planting date (Andarzian et al. 2015). Planting date should coincide with the growing cycle with the possible environmental circumstances (Wajid et al. 2004). Earlier planting during spring growing season had improved productivity of agronomic crops by the enhancement of water use efficiency in Mediterranean regions (Kaur 2017). Increasing temperature will influence negatively crop production in local, regional, and global levels (Faraji et al. 2009). While direct effects are associated with increasing trend in minimum and maximum temperature, indirect effects like water availability, changing soil moisture status, and pests and disease occurrence are expected to be felt due to climate change (Muluneh et al. 2017). The main significant influences are likely to be borne through small-holder rainfed farming community that comprises the majority of the whole farming community in the region and has a lower economic and technological capability to adapt strategies against climate change and variability. Therefore shifting planting date increased significantly yield of various crops (Ozer 2003). Climate is the largest individual factor for variability in agricultural production that accounts for one-third to two-thirds of yearly worldwide in consistency in economic productivity (Morrison and Stewart 2002; Rahimi-Moghaddam et al. 2018). Planting date adaptation under climate change is imperative because heat stress reduces productivity of agronomic crops. Crops production will be decreased under future climate changes because it will not only bring modification to the average climatic parameters but also to climate variability and extremes (IPCC 2014; Abbas et al. 2017; Adamson et al. 2018).

The adaptation of an optimum planting date can reduce the harmful influence of climate change on the productivity of agronomic crops by avoiding the heat stress from anthesis to physiological maturity (Ding et al. 2016; Van Oort and Zwart 2018). Only 3% in the Northern region of South Africa and 5% in the Nile Basin of Ethiopia (Gbetibouo 2009; Deressa et al. 2009) of the surveyed farmers shifted their sowing dates to match with the most favorable weather conditions like temperature, rainfall, and sunshine hours. Hassan and Nhemachena (2008) determined that almost 16% of more than 8000 households in 11 African states changed sowing dates as response to apparent variations in minimum and maximum air temperature and rainfall distribution. Simulation results showed that productions of maize and peanut with the best possible planting time are generally high as compared to productions gained with conventional sowing dates under climate warming trend (Laux et al. 2010). Adapting shifting planting dates at the start of the rainfall season ensures optimum growing environment and reduces danger of water shortage at imperative crop developmental stages, thus allowing the good use of rainfall water and potentially enhancing production (Van Duivenbooden et al. 2000).

8.3 Sowing Date and Crop Productivity

8.3.1 Effect of Sowing Date on Wheat Productivity

Late sowing time not only influences grain production, it also negatively impacts the yield attributes and phenological stages and phases of wheat. Delayed sowing caused the reduction of grain weight due to high temperature stress (Table 8.1). Achievable grain production was powerfully influenced by early or delayed planting date and seasonal weather circumstances. For instance, with a planting date of 10 November, the maximum attainable grain yield ranges from 3.01 to 8.50 t ha^{-1} for a period of 40 years. In the middle areas of Punjab, India, the maximum attainable grain yield was generally at the highest with a sowing date of 20 November

Table 8.1 Yield reduction in primary cereals at early and late sowing

Crop	Country/Continent	Yield losses (%)	References
Wheat	Pakistan/Asia	38	Wajid et al. (2004)
	Pakistan/Asia	25	Shahzad et al. (2007)
	Italy/Europe	30	Bassu et al. (2009)
	Pakistan/Asia	24	Baloch et al. (2010)
	Pakistan/Asia	19	Khokhar et al. (2010)
	Iran/Asia	47	Andarzian et al. (2015)
	Egypt/Africa	45	Fayed et al. (2015)
	China/Asia	13	Ding et al. (2016)
	India/Asia	32	Humphreys et al. (2016)
	China/Asia	11	Dai et al. (2017)
	India/Asia	08	Kaur et al. (2017)
	Australia	16	Luo et al. (2018)
Rice	India/Asia	28	Chopra and Chopra (2004)
	India/Asia	57	Hussain et al. (2009)
	Thailand/Asia	09	Buddhaboon et al. (2011)
	India/Asia	25	Jalota et al. (2012)
	Sri Lanka/Asia	37	Dharmarathna et al. (2014)
	India/Asia	21	Pal et al. (2017)
	India/Asia	16	Wani et al. (2018)
Maize	Pakistan/Asia	19	Aziz et al. (2007)
	China/Asia	08	Sun et al. (2007)
	Iran/Asia	74	Dahmardeh and Dahmardeh (2010)
	Iran/Asia	03	Beiragi et al. (2011)
	Argentina/South America	88	Bonelli et al. (2016)
	India/Asia	16	Srivastava et al. (2017)
	China/Asia	28	Zhou et al. (2017)
	Argentina/South America	14	Abdala et al. (2018)

(average 6.40 t ha^{-1}), narrowly followed by a sowing date of 10 November (average 6.31 t ha^{-1}) (Humphreys et al. 2016). Baloch et al. (2010) indicated that wheat planted on 10 November in Dera Ismail Khan, Pakistan produced the maximum yield attributes, and ultimately grain production, but was consequently reduced on succeeding sowing dates. In Egypt, the maximum values of the number of grains and grain weight were gained when various varieties were planted at the optimum sowing date of 15 November (Fayed et al. 2015). In Shandong, China, lodging resistance can be enhanced at a sowing date of 15 October, and resulted to a maximum seed yield (9.81 t ha^{-1}) (Dai et al. 2017). In the Moree areas, the maximum grain yield was attained at a sowing date of 15 April for baseline (2452 kg ha^{-1}) and future climatic conditions (2306 kg ha^{-1}). Nevertheless, future grain production is lesser as compared to the present grain yield in Sydney, Australia (Luo et al. 2018). The highest mean seed yield (5.09 t ha^{-1}) of wheat was obtained at a sowing date of 15 November. Earlier sowing produces maximum grain yield as compared to delayed sowing, mostly because of longer period of growth and development. The daily delay in sowing date from 20 November onward reduces grain production by 39 kg day^{-1} ha^{-1} in Punjab areas of Pakistan (Shahzad et al. 2007). The highest grain production can be obtained with a sowing window of 1 to 10 of November (6250 kg ha^{-1}), and any delay of sowing date might decrease grain yield (Khokhar et al. 2010). The most advantageous sowing window varies among regions. An optimum sowing window was obtained on 5 November to 5 December in the Ahvaz region, 5 November to 15 December for Behbehan region, and 1 November to 15 December for Izeh province in Iran (Andarzian et al. 2015). According to the common observations in particular regions, the optimum sowing of crop at an earlier sowing date in the month of November or at the end of October, as soon as the rainfall season begins, could provide higher grain yield as compared to a sowing window in the month of December (if frost factor is not a risk for the anthesis stage), as soon as water logging is not present in Italy (Bassu et al. 2009). Delayed sowing date resulted in less photo-assimilates and plant height and the low leaf area index becomes less because of temperature stress. In delayed sowing, the wheat cultivar might be of less duration that can escape from stress of heat during anthesis to maturity phase (Kaur 2017). The earlier planting date of 10 November produced maximum grain production of 60.59% as compared to delayed sowing date of 10 December in Punjab areas of Pakistan (Wajid et al. 2004).

8.3.2 Effect of Sowing Date on Rice Productivity

An appropriate planting time in a specific environmental situation makes possible the accumulation of desirable thermal time essential for suitable growth and phenological stages to obtain the highest achievable grain yield of rice crop. The most favorable transplanting date varies with various agroecological setting. Under the temperate growing circumstances in which rice-growing season is usually short and sharp, reduction in minimum and maximum air temperature is observed later in the growing season which is injurious to the reproductive stage; thus transplanting time assumes a lot of significance. Appropriate sowing and transplanting time is imperative to achieve maximum grain yield. An optimum sowing time of the rice crop is essential due to the following reasons. First, it ensures that sowing to anthesis phase comes under a period of suitable average air temperature and higher quantity of solar radiations. Second, the most favorable planting date for every variety ensures that the cold susceptible developmental stage happens when the night lower temperatures are traditionally the hottest. Last, transplanting on a date which gives an assurance that grain filling stage takes place when moderate autumn temperatures are well possible, the highest grain weight and good quality traits are obtained (Wani et al. 2018). Too early or too delayed transplanting resulted in the reduction of grain production because of crop infertility and lesser quantity of productive tillers per hill, respectively (Jalota et al. 2012). Rice plant is thermophilic, so it is susceptible to heat stress for the period of particular stages of development. Optimum sowing date comprises optimum temperature. Temperature is the major driving factor for development in photoperiod unsensitive cultivars and accumulation of growing degree days, and therefore crop life cycle depends on the cultivar cardinal temperature like sum of temperature and base and appropriate temperatures during various phenological stages (Mahajan et al. 2018). Also productivity of rice under any specified environmental condition is due to yield attributes that emerged in various phenological phases and growth stages during crop duration. The maximum achievable grain production is determined by a number of productive tillers produced in the duration of the planting to anthesis phase, quantity of fertile panicles produced at the end of the vegetative stage, number of spikelets produced in every panicle during the formation of panicles, the number of productive spikelets determined through the booting and anthesis stage, and the grain weight determined for the duration of the affective seed filling phase. Every yield component is strappingly affected by the climate circumstances the plants experience in the respective phases the yield components are produced in. Sowing date synchronizes the appropriate climate situations to the requirements of various stages and phases of phenology (Dharmarathna et al. 2014). Nahar et al. (2009) reported a significant reduction in yield components and yield due to late transplanting of rice nursery. Spikelet's infertility was enhanced by the delayed transplanting due to stress of low temperature at panicles appearance stage. Grain yield diminution of cultivar dhan-46 due to delayed transplanting in 10 September, 20 September, and 30 September were 4.41%, 8.86%, and 15.53%, respectively, as compared to 1 September transplanting date. Mohammed et al. (2001) found out that late planting in 30 August decreased grain yield by 41% as compared to an optimum planting date of 15 July. Chopra and Chopra (2004) reported that delayed transplanting date of 28 July and 4 August produced less grain yield. Transplanting date at mid-July was appropriate for high grain production. The maximum grain yield (6.88 t ha^{-1}) was gained at a planting date of 7 July compared to delayed planting dates. When rice is planted late, the imperative growth phases particularly the seed filling stage can coincide with low temperature stress, resulting in higher sterility percentage, thus the decline in grain yield (Hussain et al. 2009). Grain yield was decreased for late sowing (20 June) as compared to early sowing (1 June)

(9.4 t ha^{-1}) in Northwest India (Pal et al. 2017). For flooded rice production during the dry season, grain yield was negatively influenced via the interaction between delayed planting date and cultivar. The highest grain yield (3661 kg ha^{-1}) was achieved at planting date 9 November during the dry season in the eastern plain of Thailand (Buddhaboon et al. 2011).

8.3.3 Effect of Sowing Date on Maize Productivity

Good growth and development of maize crop occurs and results in higher grain yield if it is sown earlier as compared to delayed sowing during the spring season. Sowing to anthesis and anthesis to maturity phase of maize happens in optimum environmental conditions (Sun et al. 2007; Dahmardeh and Dahmardeh 2010; Beiragi et al. 2011). Maximum yield components are obtained in earlier planting date (Aziz et al. 2007; Ali et al. 2013). Usually, there are a lot of benefits which are related to earlier sowing time, and this includes a longer period of gain filling phase that provides a good opportunity for cultivars to achieve higher grain yield. Additionally, earlier sowing time can contribute considerably to higher resources use efficiency. Earlier sowing also allows harvesting earlier in the spring growing season when circumstances are generally well and field and time losses could be reduced (Bonelli et al. 2016). Earlier sowing date also enhances net returns without additional production cost. Conversely, delayed sowing or sowing after the appropriate sowing window constantly resulted in reduction of number of grains and grain weight. Late sowing reduces the efficient growing period for maize, enhancing the danger of exposure to fatal temperature stress in delay in the season prior to maturation of grains (Zhou et al. 2017). Reduced productivity of maize in delayed sowing could result in reduction of sowing to maturity phase, pests and disease attack, and high temperature and drought stress for the duration of pollination and fertilization process. Late sowing is usually accompanied by enhanced minimum and maximum air temperatures for the period of growth duration, which speed up crop growth and development and reduced accumulation of solar radiations that resulted in the reduction of total dry matter production, grain set, and number of grains. Higher grain production was gained in 1 July sowing date. Then it was reduced to 25 and 50 kg ha^{-1}, with a per-day delay in planting date from 1 July to 16 July and 16 July to 1 August, respectively (Aziz et al. 2007). When planting date is delayed, the delivery of photo-assimilates to seeds (source strength) becomes more limited than the requirement for assimilates via seeds (sink capacity) during the period of effective grain filling (Abdala et al. 2018). Production of grain was influenced by planting date and was diverse from 1680 g m^{-2} (early plantings) to 203 g m^{-2} (delayed planting) (Bonelli et al. 2016). The planting time obviously showed 16.14% and 15.98% reduction of average grain production of rainfed maize for the first and second, respectively. An average of 9.79% and 11.98% grain production reduction from irrigated and rainfed maize was obtained under a delayed sowing situation (25 June) as compared to optimum planting date (10 June), respectively (Srivastava et al. 2017). Maize grain productivity enhanced firstly before (early sowing dates) and after that (late sowing dates) reduced of sowing date 12 June, ranging from 8117 to 11,364 kg ha^{-1} in first year and 7955 to 11,272 kg ha^{-1} in second year of study. The maximum grain yield was gained during the 12 June planting date in Henan province in China (Zhou et al. 2017).

8.3.4 Effect of Planting Date on Canola Productivity

Delayed planting date and heat stress decreased the number of flowers and pods and increased pollen sterility throughout the reproductive growth phase. Delayed sowing negatively affected the pollination and pollen tube formation (Morrison and Stewart 2002; Kirkegaard et al. 2016). Usually, either advance or delayed sowing date was an unfavorable influence in attaining higher grain yield. Advance sowing generally resulted in more vegetative growth. Harvest index is reduced in early sowing (Zhang et al. 2016). Too delay planting can reduce grain yield and quality traits in many growing regions of canola due to heat stress affect during grain filling period. Reduction of seed yield in canola was mainly linked with a decrease in the number of grains and siliques. The appropriate planting time for very early-maturing canola cultivars is the first week of October as both earlier and delayed sowing dates can reduce the number of flowers. Nevertheless, the early-, middle-, and late-flowering canola cultivars had the utmost potential for production of higher number of flowers at early planting date (Hua et al. 2014). The most excellent planting date in the evaluation of three planting dates was determined to be 11 October as it yielded the highest grain yield of 2111.05 kg ha^{-1} as compared to the other planting dates 21 and 31 October which produced lower grain yield of 1914.17 and 1806.46 kg ha^{-1}, respectively in Pakistan (Yousaf et al. 2002). The maximum grain yield of 4.20 tha^{-1} was obtained through variety RGS-003 at planting date 17 November as compared to 28 December in canola-growing areas of Iran (Safikhani et al. 2015). The advance sowing on 1 November resulted in a maximum grain production which in turn is a result of enhancing specific leaf area, primary and secondary branches, number of pods plant^{-1}, and a thousand grain weight. A maximum grain yield of 3352.35 kg ha^{-1} was produced through early sowing date 1 November, whereas the late sowing date 1 December produced the lowest 2602.84 kg ha^{-1} seed yield (Ahmadi et al. 2015). The higher grain yield of 2634 kg ha^{-1} was gained by sowing on mid-September as compared to sowing at the end of September (2174 kg ha^{-1}) and first week of October (1944 kg ha^{-1}) in the southwestern USA (Begna and Angadi 2016). The highest grain yield (3543 kg ha^{-1}) was obtained in the early sowing date 6 November in Golestan, Iran. Delay in sowing led to a higher speedy growth of canola and reduced biomass, leaf area index, harvest index, and grain yield (Faraji et al. 2009). Optimum sowing window starting from 29 April to 9 May (average 1166.7 kg ha^{-1}) as compared to 18 May (average 917.7 kg ha^{-1}) provides a larger assurance of obtaining higher grain yield in Turkey (Ozer 2003). Maximum seed yield was gained (386 g m^{-2}) at early sowing date 30 March as compared to late sowing (Robertson et al. 2004).

8.3.5 Effect of Sowing Date on Cotton Productivity

Potential cultivars for maximum attain a blessed cotton yield and quality characters might be evaluated through planting dates at various dates (Table 8.2). Both delayed and earlier sowing harmfully influence seed cotton quality and yield. Earlier sowing of cotton contributes more toward vegetative growth as compared to seed cotton yield (Iqbal et al. 2012). Furthermore, advance sowing of cotton reaches anthesis stage in the hotter month of the growing season which causes serious reduction of seed cotton yield (Rahman et al. 2007). Delayed sowing of cotton causes anthesis and physiological maturity at a time when temperature is most favorable. As a result, seed cotton production and quality traits are influenced by adverse environmental circumstances and shrink of growth phase (Elayan et al. 2015). Karavina et al. (2012) revealed that changes in planting dates not only influence seed cotton yields and quality traits but also influence the occurrence and management of pests, diseases, and weeds. Consequently, optimum sowing time is very important to increase cotton productivity against heat stress at anthesis stage. An appropriate planting date gives adequate time for the completion of phenological stages and phases of cotton in a well-timed and proficient way. Optimum sowing date also permits the farming community to picking of cotton in optimum period and saves from risk of delay season by pests damage mainly from those pests which damage to flowers and bolls causing almost 70% harm to cotton crop (Poonia 2002). The planning of sowing a cotton crop at an appropriate time prevents the risk of advance and delayed sowing either because of unfavorable weather circumstances or diseases and pest damage; both can be causing of enhancing rates of buds and bolls loss and abortion. Advance sowing provided higher vegetative expansion as compared to lint yield, whereas delayed sowing produced more and bigger bolls. In delayed sowing of Bt cotton, too high temperature stress harmfully influenced seed cotton production and quality features. The best sowing date in Dera Ismail Khan, Pakistan, was 19 April; because of the maximum leaf area index, interception of solar radiation was higher for maximum economic yield of Bt cotton (Usman and Ayatullah 2016). The highest seed cotton production of non-Bt cotton was gained when the crop was planted on 10 April as compared to 25 April and 10 May during both years of study in Punjab India (Buttar and Sudeep 2007). As compared to the usual sowing time, delayed sowing time reduced boll weight, number of bolls per plant, strength of fiber, cellulose concentration, and sucrose conversion rate and photosynthesis rate. In an optimum sowing time, cotton bolls in the center of positional fruit-bearing branch had the maximum cellulose quantity, sucrose conversion speed, number of bolls, boll biomass, and vigor of fiber. Enhancing the cellulose concentration and sucrose conversion rate could increase seed cotton yield and fiber traits in delayed sowing (Zhao et al. 2012a, b). The seed cotton production was 2831 kg ha^{-1} on early sowing date (25 April) as compared to minimum seed cotton yield of 2569 kg ha^{-1} produced on delay sowing time (25 May) in Pakistan (Awan et al. 2011). The highest average seed cotton production (1649 kg ha^{-1}) was gained at sowing date 20 April in India (Jalota et al. 2008). Sowing too early can result in reduced plant growth that causes lower seed cotton yield. Late planting dates

Table 8.2 Yield reduction in oilseed and sugar crops at early and late sowing

Crop	Country/Continent	Yield losses (%)	References
Canola	Canada/North America	21	Morrison and Stewart (2002)
	Pakistan/Asia	15	Yousaf et al. (2002)
	Turkey/Asia	22	Ozer (2003)
	Australia/Australia	35	Robertson et al. (2004)
	Iran/Asia	54	Faraji et al. (2009)
	China/Asia	30	Hua et al. (2014)
	Iran/Asia	23	Ahmadi et al. (2015)
	USA/North America	27	Begna and Angadi (2016)
	Iran/Asia	16	Safikhani et al. (2015)
	Australia	47	Kirkegaard et al. (2016)
	China/Asia	21	Zhang et al. (2016)
Cotton	India/Asia	29	Poonia (2002)
	Pakistan/Asia	14	Rahman et al. (2007)
	India/Asia	23	Jalota et al. (2008)
	Pakistan/Asia	34	Ali et al. (2009)
	Pakistan/Asia	09	Awan et al. (2011)
	Pakistan/Asia	29	Iqbal et al. (2012)
	China/Asia	15	Zhao et al. (2012a, b)
	China/Asia	26	Chen et al. (2014)
	Egypt/Africa	38	Elayan et al. (2015)
	Pakistan/Asia	27	Usman et al. (2016)
	China/Asia	42	Khan et al. (2017)
Sunflower	Portugal/Europe	45	Barros et al. (2004)
	Pakistan/Asia	39	Yousaf et al. (2007)
	Pakistan/Asia	28	Saleem et al. (2008)
	Italy/Europe	18	Flagella et al. (2002)
	Nigeria/Africa	51	Lawal et al., 2011
	Serbia/Europe	39	Balalic et al. (2016)
	Egypt/Africa	34	El-Mohsen (2012)
	Malaysia/Asia	54	Baghdadi et al. (2014)
	India/Asia	25	Sheoran et al. (2014)
	USA/North America	26	Joshi et al. (2017)
	Turkey/Asia	10	Ozturk et al. (2017)
	Italy/Europe	40	Patane et al. (2017)
Sugarcane	USA/North America	26	Garrison et al. (2000)
	Australia/Australia	24	McDonald and Lisson (2001)
	USA/North America	36	Viator et al. (2005)
	Kenya/Africa	61	Amolo et al. (2006)
	India/Asia	19	Kumar et al. (2008)
	Ethopia/Africa	32	Wolde and Adane (2015)

experience lesser average temperature and solar radiation that resulted in reduced sucrose supply in cotton leaves (Chen et al. 2014). Advance sowing of Bt cotton resulted in plant height, higher number of bolls, boll weight, and seed cotton production as compared to late sowing time (Khan et al. 2017). On the other hand, delayed sowing increased vegetative growth, and therefore shrunk phenological phases (Ali et al. 2009). Late in sowing decreases the number of bolls per plant, fiber strength, and dry matter partition (Bange and Milory 2004). In addition, sowing cotton too late results in low-temperature environment stress, which resulted in very poor opening of bolls (Zhao et al. 2012a, b).

8.3.6 Effect of Sowing Date on Sunflower Productivity

The appropriate sowing date of sunflower can vary in various regions with various climatic circumstances. The highest plant height, number of grains, grain weight, and grain yield were achieved in sowing during August as compared to September and October during the autumn season. The optimum planting window of sunflower from the third week of August to the end of August produced oil yield as compared to earlier August sowing dates (Saleem et al. 2008). In Egypt, the maximum average of grain yield and attributes were achieved at a sowing date of 6 June, while a sowing date study in Nigeria showed that the planting date from end of July to mid-August had a significant influence on phenological stages and phases and ultimately yield parameters of sunflower (Lawal et al. 2011). Various researchers had indicated that growing degree days and achene yield in sunflower were reduced when standard spring season sowing date was late. The results in Pakistan (Yousaf et al. 2007), Egypt (El-Mohsen 2012), and South Italy (Flagella et al. 2002) showed considerably decreased grain production of sunflower with a delay in planting time because of the decline in number of grains per capitulum and grain weight. Planting time exerted a greatly significant influence on pollination and grain filling stage. The earlier planting date of 25 April was shown to give a good seed yield of 2489.60 kg ha^{-1} as compared to delayed planting date of 15 May (Baghdadi et al. 2014). The highest attainable achene yield of 2.17 t ha^{-1} was attained when sunflower was planted in mid-January. Advancing sowing date to 20 December did not produce any benefit not only for the grain filling but also for the yield attributes; nevertheless, delaying sowing dates from 5 to 20 February generally resulted in diminution in sowing to physiological maturity phase, very poor pollination and fertilization, and acceleration of phenological stages, which eventually reduced achene yield in Ludhiana, India (Sheoran et al. 2014). Sowing dates also significantly affected capitulum diameter, with delaying sowing date, head diameter increased, so that the highest value was achieved in sowing date 20 May (11.82 cm at the anthesis stage and 22.60 cm at the stage of physiological maturity) (Balalic et al. 2016). The maximum grain production was obtained on a sowing date of 28 April (3033 kg ha^{-1}), and the lowest grain yield was gained on a sowing date of 12 May (2459 kg ha^{-1}). Lessening of grain yield in delayed sowing dates was due to reduction in capitulum diameter, number of grains, and thousand grain weight (Ozturk et al. 2017). An advance sowing time (18 January) enhanced leaf area duration and water uptake during the critical phase of bud appearance in anthesis. The early planting dates also augmented the number of grains m^{-2} with no reduction in grain biomass, resulting in the highest grain of 2197.42 kg ha^{-1} and oil yield in South of Portugal (Barros et al. 2004). The maximum production of overall and large grains was achieved from the delayed sowing at the end of May with mean values of 3777 and 3379 kg ha^{-1}, respectively. The capitulum diameter of sunflower planted from end of May to the first week of June was higher by ≥18% than sowing in the first week of May, which partially explains the 24% enhancement in the number of grains per capitulum in the end of May and first week of June sowing in Powell, USA (Joshi and Heitholt 2017). An optimum sowing date of 7 April during spring season resulted in high grain and oil yields and less oil unsaturation. Consequently, delayed planting date of early June reduced growing and decreased oil quantity in South Italy (Patane et al. 2017). Optimum sowing date can be vary with respect to various hybrids of sunflower (Balalic et al. 2012).

8.3.7 Effect of Planting Date on Sugarcane Productivity

The timing of planting influences significantly the productivity of sugarcane. The optimum weather conditions for sugarcane is full-grown, in which rain fall/irrigation is better distribution for the period of growing season, however, where before harvesting ripening phase is under comparatively dry condition, and the solar radiations are abundant all over. The highest cane yield (120 t ha^{-1}) was obtained at planting sugarcane during March as compared to April and May. The earlier the planting period could be done, the higher the millable cane yield obtained. Earlier planting has and advantage due to the reason that emerged cane has a longer growth period and is better to attain full tillering and leaf canopy, prior to the beginning of quick elongation of stalks with the commencement of optimum environment circumstances (Wolde and Adane 2015). Sugarcane planting date significantly affected cane yield, total recoverable sugar, and sugar yield due to effects of temperature and solar radiation. Highest cane yield, sugar yield, and total recoverable sugar were gained 43.12, 5.9 tons/acre and 274 lb./ton at planting date during August in the USA (Viator et al. 2005). There were considerable and positive relations with cane length, number of tillers ha^{-1}, number of millable canes ha^{-1}, number of nodes cane^{-1}, weight of millable cane, and sugar recovery of sugarcane planted during March and April in India. Insect pests, diseases, and weeds occurred with delayed planting and ultimately negative quality traits (Kumar et al. 2008). Cane yield and its components and attributes were affected negatively by delayed planting during September and October. The optimum planting month was August, in which maximum cane (117.21 t ha^{-1}) and sugar yield (45.86 t h^{-1}) were obtained in Louisiana (Garrison et al. 2000). Changes in months of planting influenced millable cane production; but quality traits were not affected significantly in Kenya. Planting of sugarcane in April produced significantly the highest cane yield of 148.91 t ha^{-1}, followed by May-planted crop (100.32 t ha^{-1}) and June-planted crop (93.80 t ha^{-1}) which were alike in millable cane yield even though July-planted crop had the significantly lowest millable cane yield of 58.54 t ha^{-1} at Chemelil site. Planting of sugarcane during the month of July should be prevented due to the significantly lowest millable cane yield and very poor quality traits due to more drought stress in growing sugarcane crop (Amolo et al. 2006). The 10 January-planted sugarcane produced the highest sucrose yield (2895 g m^{-2}) as compared to those planted in August (2197 g m^{-2}) in Queensland, Australia (McDonald and Lisson 2001).

8.4 Conclusion

Planting date is the most crucial factor that affects the agronomic crops productivity to foremost extents. Planting date influenced significantly components and yield of agronomic crops. Nevertheless, the appropriate planting date varies in the various agroecological zones due to variations of topography and weather determinants. There is a consensus in the research studies that the synchronization of the critical phenological stages and phases with favorable weather circumstances ensures promising crops productivity that is merely probable through adjusting the planting dates. Planting date can enhance both qualitative and quantitative traits of agronomic crops when determined accurately. Optimum planting time has optimistic impact on resources uses efficiencies. Hence, it is very important to substantiate appropriate planting date to synchronize with optimum growing conditions for agronomic crops under various agroecological regions of the globe to obtain the highest achievable yield levels and to ensure food security under climate change.

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