Review of Plant Studies
2014 Vol. 1, No. 2, pp. 26-38
ISSN(e): 2410-2970
ISSN(p): 2412-365X
DOI: 10.18488/journal.69/2014.1.2/69.2.26.38

EFFECT OF SOWING DATE ON MAIZE SEED YIELD AND QUALITY: A REVIEW

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ABSTRACT

Various maize researchers have been conducting experiments to know the effect of sowing date on maize seed yield and quality, which explored a vast variation in the results. In some countries, early sowing of maize gave good yields besides quality seed and at the same time, in some countries late sowing yielded better and posses' high quality seed. Despite of all these differences in sowing period, many scientists and farmers opined that early and mid early sowings in India resulted good yields and high quality seed.

Keywords: Sowing date, Maize, Seed yield and seed quality.

Contribution/ Originality

This study is one of very few studies which have investigated on effect of sowing date on various aspects of maize mainly used in the context of climate change, which is a most important factor in global issues.

1. INTRODUCTION

The available literature on the effect of sowing date on maize seed yield and quality is limited and not much work has been reported on seed production of maize especially under Indian conditions. Many authors have reported from experiments carried out to determine the effect of sowing time on maize, but the results are often contradictory. Of all the management aspects (cultivar selection, plant density, amount and timing of fertilizers etc.) of growing a maize crop, planting date is an important aspect and is probably subject to variation due to differences in weather at planting time between seasons and within the range of climates [1]. The year-to-year variation in plant establishment, pest and disease incidence makes it difficult to predict optimum planting dates for maize crop [2]. In practice, recommended dates are normally drawn up from the results of long-running series of agronomic experiments, which can give mean planting dates

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for highest yield together with realistic estimates of expected yield penalties for each week of delay in planting [3]. However, in accepting such guidelines, several reservations must be appreciated in addition to the fact that use of the recommended date is not a guarantee of highest yield under growing season [2]. First, there can be very large differences in the pattern of response to planting date among cultivars. Secondly, the interactions between plant diseases and planting date are not fully understood.

The literature available on effect of sowing date on maize was reviewed and described as under by using various headings like phenology, growth, Seeds cob^{-1}, seed yield, seed weight, silking / tasseling and physiological maturity and seed quality.

1.1. Phenology

Phenology is a study of relationship between various physical factors of the environment and seasonal changes in growth and development during life cycle of plants and animals [4]. Temperature and light are the major factors regulating phenological response [5], thus most responses focus on the thermal time accumulation, day length and vernalization. The understanding of maize phenology will help to construct crop model and useful for prediction of growth in relation to environment and management. The growing degree days (GDDs) requirement of maize cultivars showed variation with sowing dates depending upon temperature during each growth phase and also the cultivar [6]. At Morris, Minnesota, when maize was sown on three dates *i.e.* 1st May, 21st May and 25th June, the time taken from sowing to silking ranged from 86-91, 71-78 and 57-77 days for three dates of sowing, respectively in three years 1983, 1984 and 1985 [7].

Wilson and Robson [8] noted that the time to flowering and the duration of growth was strongly influenced for climatic adaptation and yield potential of crop plants. Similarly, delayed sowing in kharif and summer season reduced days to tasseling, silking and duration of crop and also the grain yield [9]. Berzsenyi, et al. [10] found that delay in sowing reduced the number of days from sowing to seedling emergence from 6 to 5 days. The leaf emergence was found rapid in delayed sowing and occurred early up to 54 days after emergence as against 61 days after emergence in normal condition than with early planting. Silking and seed black layer formation occurred significantly in fewer GDDs as planting was delayed from early May to early June [11].

1.2. Growth

Rao, et al. [12] performed experiment on sunflower crop at Kanpur on 13 dates between November and August and observed that plant height increased when planting was extended from November to February. Thereafter with the exception of two planting dates (15th March and 1st March) which deviated from the normal trend, the plant height decreased and the minimum plant height was recorded with 16th August and 17th July sown crops. Consistent with these findings, Lepez [13] suggested that variation in plant height was due to different dates of planting. Chhabra, et al. [14] revealed maximum plant height with November planted sunflower crop when compared to July, September, October and January sowings. Planting date was reported to affect the growth and yield of maize significantly.

In maize planting date modifies the radiative and thermal conditions during growth. The amount of incident radiation and the proportion of this radiation that is intercepted by the crop directly determine crop growth rate. Delay in planting date determined important reductions in the amount of incident radiation accumulated from emergence to silking, because it hastened development. Low temperatures during grain filling in late plantings limited seed growth as well as crop photosynthesis. Thus, the ratio between final seed number and dry matter at silking dropped dramatically for the late plantings, indicating a predominance of vegetative growth over reproductive growth [15-18].

Planting maize too early and too late resulted in reduced leaf area index, leaf area, dry matter production and yield [19]. Berzsenyi, et al. [10] Persuaded that growth indices in the vegetative stage were greater with late savings as compared to early sowings. However, the values were greater in early sowings during reproductive growth stages. In general, late plantings will result in high crop growth rates during the vegetative period because of high radiation use efficiency (RUE) and high percentage radiation interception, but conversely result in low crop rates during grain filling because of low RUE and low incident radiation. The inverse holds true for early plantings [15]. In addition, Maddonni, et al. [20] found that in late plantings, both solar radiation and temperature decline during grain filling. Thus, lowered solar radiation resulted in grain growth in excess of biomass production, indicating a possible source limitation. On the other hand, low temperature may have a negative effect on seed weight through reductions in both radiation use efficiency and biomass partitioning to the grains [21-23].

The highest plant height (90.47 cm), branches plant^{-1} (5.20), capsules plant^{-1} (45.82), seeds capsule^{-1} (58.24), seed yield (251.30 kg ha^{-1}) and stover yield (1615.33 kg ha^{-1}) were obtained from the sesamum crop sown on 26th February. Most of these characters were statistically identical to 10th March sowing except plant height, branches plant^{-1} and capsules plant^{-1} but all of them were recorded significantly lowest in 22nd March sowing compared to first sowing. The highest seed yield (251.30 kg ha^{-1}) was obtained with 26th February sowing and thereafter reduced with delay in sowing [24]. Moosavi, et al. [25] reported that delay in sowing from July 4 to August 6 decreased significantly the plant height, stem diameter, leaf area index, total fresh and dry yield by 15.7, 20.9, 42.1, 24.7 and 25.9 %, respectively in maize.

1.2.1. Seeds Cob^{-1}

Although the acceleration in the rate of crop development associated with increased plant density or with delay in planting date means that the duration of the phase of spikelet initiation is reduced, the overall effects of these two management factors upon cob size are different [26]. In the case of plant density, the rate of spikelet initiation is relatively unaffected, with the result that cob size declines progressively with increasing seeding rate. In contrast, variation in planting date is commonly found to have an influence on the seeds cob^{-1} [27]. Cirilo and Andrade [15] found no effect of planting date on spikelet primordial counted at silking in the apical ears of two maize hybrids. They suggested that seed abortion rather than a morphogenetic process was the dominant factor determining the final seed set.

Otegui and Melon [28] reported that planting dates affected the seed set and flower synchrony within the cob of maize. Reduced seeds cob^{-1} is the most consistent, irreversible component of yield reduction under drought stress [29]. The number of florets that may become seeds cannot exceed exposed silk number and declines from this potential as silks lose receptivity and senesce with age [26]. Hybrids with faster silk growth rates may have more silks available for pollination at the beginning of flowering. However, when environmental conditions are below optimum, seed number may be limited by asynchrony (pollen is not shed when silks are exposed or receptive) [29], loss of silk receptivity (silk is no longer functional to support pollen tube growth [26] or developmental failure of the ovary. Such limitations to seed number may have drastic impacts on grain or seed production profitability and may be influenced by silk characteristics for a given hybrid or inbred [29].

1.2.2. Seed Yield Plant^{-1}

Maize planted earlier develops better and has a higher yield potential because the vegetative period of its development occurs in the cooler part of the season when moisture stress is less likely [30-35]. Generally, there are many benefits related to early planting date compared to late planting date and this include a long growth duration that allows a greater choice of hybrid maturities and wider window of opportunities for replant decisions. In addition, Sheperd, et al. [36] reported that early planting date could contribute significantly to higher maize yields. The authors also highlighted that higher yield is not the only advantage of early planting because other benefits can also be achieved from high plant density and high fertilizer rates. It also allows harvesting earlier in the season when conditions are usually better and field and time losses can be minimized [37]. In addition, very simply early planting increases net returns without adding production costs.

On the other hand, late planting or planting after the optimum period consistently resulted in lower yields. Delayed planting shortens the effective growing season for maize, increasing the risk of exposure to lethal cold temperatures late in the season before grain maturation. According to Aldrich, et al. [38], yield reduction in late plantings could be attributed to a short growth duration, insect and disease pressure, heat and moisture stress during pollination. These results were in agreement with those by Otegui and Melon [28] , who reported that delayed plantings are generally accompanied by increased temperatures during the growing season, which accelerate crop development and decrease accumulated solar radiation, resulting in less biomass production, seed set and grain yield.

However, the results of planting date experiments can be highly inconsistent between seasons and sites. For example, it is usual for a relatively late sown crop to out yield the control crop sown within the optimum period [39-41]. There are several reasons for such inconsistencies and unexpected results. First, the soil conditions at different planting dates will inevitably be different and unfavorable conditions (excess or deficiency of soil moisture, serious incidence of diseases, etc.) can occur at almost any point during the normal planting dates. Consequently, the observed differences in the performance of crops sown on different dates are commonly a reflection of differences in established plant density. Secondly, crops sown at different dates pass through each developmental stage at slightly different times and, therefore, under different environmental conditions (especially photoperiod and temperature); thus any one of the developmental stages which determine the components of yield could conceivably occur under more or less favorable conditions in late-sown crops. For these reasons, it is not easy to carry out a critical comparison of the grain yields and their components of the different crops in a sowing date experiment. Scarsbrook and Doss [42] reported that yield of maize is a function of many plant and environmental factors which are often interrelated. Miller, et al. [43] conducted experiments on the effect of planting dates on sunflower performance under sub-humid conditions of USA and concluded that planting in early June in Arlington and mid May at Spooner maximized seed yield (1008 and 1309 seeds head^{-1}, respectively), oil content (46.5 and 46.3 per cent, respectively) and test weight (9.4 and 9.9 g, respectively) and reported a decline in test weight with each successive delay in planting and lowest test weight (7.4 g 200 seeds^{-1}) was recorded in late June planting.

Silva and Sangoi [44] found higher seed and oil yields from sowings in August or September than from later sowings in sunflower. Gardner [45] in their trials to determine the optimum date of sowing in sunflower hybrids under the frequently cool, short growing season of North Dakota, reported that late May is the best time in terms of seed yield and also oil content. Environmental changes associated with different sowing dates (sunshine, temperature) have a modifying effect on the growth and development of maize plant. Each hybrid has an optimum sowing date, and greater the deviation from this optimum (early or late sowing), the greater the yield loss [46]. Rahman, et al. [47] observed that sowing date had a significant effect on yield and yield components of maize. October sowing (4097 kg ha^{-1}) out yielded November and December sowings by 36.5 and 53.0 per cent, respectively. The cultivars grown varied significantly in their yield potential. Hudeiba-1 and Hudeiba-2 gave similar yields but exceeded Mojtamaa-45 by 24.7 and 25.5 per cent, respectively. Grain yield of the crop was positively correlated with cob yield, 1000-seed weight and number of cobs m^{-2} (0.807, 0.732 and 0.468), respectively. The study indicated that substantial grain yield of maize can be obtained during the winter season in Northern Sudan in contrast to other findings in other parts of the country and concluded that maize could be an alternative winter cash crop for farmers in Northern Sudan. Ali, et al. [48] reported that higher grain yield in wheat (3826 kg ha^{-1}) was obtained from variety AS-2002 sown on November 10 followed by same variety sown on November 20 (3731 kg ha^{-1}). Each successive delay in sowing beyond November 20 progressively decreased the grain yield significantly. Yield was reduced by 27.24 per cent in sowing of December 30 as compared to November 10. Wheat variety AS-2002 proved better than SH-2002 and Uqab-2000. Experimental results conducted for three years concluded that regardless of the varieties November 10 to November 20 is the optimum sowing time for wheat under agro-ecological conditions of Vehari. Sowing of chickpea at second fortnight of October (1802 kg ha^{-1}) produced 56 % increased yield compared to sowing at second fortnight of November (1153 kg ha^{-1}). Higher seed yield (1918.65 kg ha^{-1}), net returns (Rs. 32000 ha^{-1}) and B:C ratio (2.80) were recorded with irrigation at 0.6 IW/CPE ratio applied to the crop grown during second fortnight of October [49].

Beiragi, et al. [50] evaluated 18 new corn varieties consisting of 15 foreign early and mid-mature single cross hybrids and three Iranian commercial hybrids at two sowing dates (5th and 20th June). This study showed that among all hybrids, EXP 1 (16.03 t ha^{-1}) and OSSK 617 (15.51 t ha^{-1}) had the highest yields in early planting (5 June) and EXP 1 (16.52 t ha^{-1}) and KDC 370 (16.22 t ha^{-1}) recorded the highest yields under late planting (20th June) conditions. Further, the results also indicated that yield components such as 300 kernel weight, kernels row^{-1}, kernel depth and ear length were adversely affected in delayed planting condition. Number of capitula, seeds capitula^{-1}, seed yield plant^{-1}, seed yield hectare^{-1} (kg) in niger were found to be higher in June first fortnight sowing as compared to other later sowings. The crop sown during second fortnight of February recorded the lower yield parameters like number of capitula, seeds capitula^{-1}, seed yield plant^{-1} and seed yield hectare^{-1} [51].

Planting date significantly affected all the growth and yield parameters including oil yield in sunflower. As planting was delayed, seed and oil yields declined (2513 kg ha^{-1} and 1077 l ha^{-1}, respectively) when planted on August 13 as against 1234 kg ha^{-1} and 528 l ha^{-1}, seed and oil yields respectively, at September 10th planting in 2004. Similar trend was observed in 2005; but there was a significant reduction in yield (815 kg ha^{-1} and 349 l ha^{-1}, respectively) when planted on July 21 as against 216 kg ha^{-1} and 92 l ha^{-1} of seed and oil yields, respectively, at September 1st planting due to change in rainfall distribution (climate) during growth period. The luxuriant growth of those planted late did not translate to seed yield because there was not enough water during the seed filling stage of growth. The two cultivars had similar agronomic qualities and consequently had no significant influence on all the yield parameters. Late July to mid August is the best planting time for optimum sunflower seed and oil yields in Ibadan [52]. Sowing of Ajowan (*Trachyspermum ammi* L.) at 1st September recorded higher yield (11.96 q ha^{-1}) followed by sowing on 10th September and 20th August. Reduction in yield by 86 per cent was observed with delay in sowing from 1st September to 10th October [53].

1.3. Seed Weight

There may be a tendency for later-planted crops to give lighter grains because of other aspects of the acceleration of development (in particular, lower crop dry mass at anthesis). Thus in most findings, grain mass is either unaffected or reduced by later planting by about 10 per cent [54-56]. These generally support the idea that the individual grain mass for a given cultivar is a relative stable character [20]. However, when delay in the start of grain filling by a few days coincides with a rapid deterioration in the environment, much larger effects can be anticipated. In summary, grain yield generally decreases with delay in sowing, principally as a consequence of decrease in ear number, but also in some cases because of small decrease in individual grain mass.

Maddonni, et al. [20] persuaded that seed mass is conditioned by post-silking crop growth, with more dependence on reserve mobilization in hybrids with small seeds and large seed number than in hybrids with fewer seeds of large size. Thus, decreased incident solar radiation reduced final seed mass through reduction in biomass production per seed, but low temperatures impair grain filling through reductions in biomass partitioning to seeds. Nasser [57] reported that the highest values of number of tillers and spikes m^{-2}, 1000- seed weight, grain yield fed^{-1} and grain NPK uptake was obtained when wheat was sown on mid-November. Early or delayed planting significantly reduced forenamed traits due to the environmental effects. Thousand seed weight in niger was found to be higher in June first fortnight sowing as compared to other later sowings. The crop sown during second fortnight of February recorded less seed weight [51].

1.4. Silking / Tasseling and Physiological Maturity

Estimates of thermal time required for grain filling (period between silking and maturity) vary considerably, however, with the GDD system frequently overestimating thermal time required for grain filling. A better understanding of the phenological response of maize to thermal time as planting is delayed is necessary to improve the accuracy of maturity time of hybrid for late planting situations [58]. Sutton and Stucker [59] opined that a thermal interval between plantings and black layer decreased as planting was delayed from early to late planting. Thus late plantings reduced cumulative intercepted photosynthetically active radiation (PAR) from silking to physiological maturity mainly because of their low values of daily incident radiation [60]. Krishnasamy and Ramaswamy [61] elucidated the correlations between weather elements (maximum and minimum temperature, relative humidity, hours to bright sunshine, amount of rainfall and number of rainy days) and number of days to panicle initiation and from panicle initiation to 50 per cent flowering in four different hybrids of sorghum. They reported negative correlation between minimum temperature and days to panicle initiation in MS 2077A and a positive correlation between maximum temperature and days to panicle initiation in CS 3541. Similarly, afternoon relative humidity exhibited negative correlation with panicle initiation in MS 2077A while positive relationship was noticed in CS 3541. From these reports they concluded that the extent of synchronization of flowering was dependent on the degree of level of interaction between the varieties and the environmental factors considered.

Tollenaar and Bruulsema [62] found that the time from silking to physiological maturity lengthened with delay in planting dates because cool temperatures prevailed late in the season of the late planted crops which prevented true maturity since grains never formed a true black layer. Daynard and Duncan [63] found that delayed planting increased the thermal time interval from planting to mid-silking but decreased the thermal interval between mid-silking and black layer formation. Stewart, et al. [64] reported that delayed planting increased growing degree days (GDDs) to black layers for three hybrids in a drought year but decreased GDDs to black layer for the same three hybrids in the following year under less stressful conditions. According to the Canadian studies, the GDDs system provides a reliable estimate of thermal time required for vegetative (interval between planting and silking) development. Early planting tends to place the tasseling and silking period ahead of the greatest risk of moisture stress and drought damage [28]. In addition, the period between emergence and anthesis of maize hybrids planted earlier in the season can be up to two weeks longer than when the same cultivar is planted later [65]. During this extra period, plants will uptake more solar radiation and store the energy because the lower temperatures limit their growth and consumption of this energy. As a result of this slower pattern of development, early-planted maize plants are smaller and less leafy at anthesis [66, 67].

1.5. Seed Quality

Good quality seed is a essential for higher productivity of crop and it plays an important role in seed production. It ensures genetical and physical purity, higher germination and seed vigour and thus better and healthy seed production. Freshly harvested seeds usually have maximum level of viability and vigour. Losses in seed viability and vigour do occur depending upon various factors *viz*., genetic makeup of the seed material, harvesting stage of seed, environmental conditions at harvesting time and seed size etc. Patil and Dighe [68] and Singh, et al. [69] in their study suggested that the seeds obtained from early set bolls in cotton had high seedling vigour index than the later set bolls. Adam, et al. [34] demonstrated that time of sowing influenced soybean seed quality and found that hotter environmental conditions were associated with lower quality of harvested seeds. In french dwarf beans, Greven, et al. [70] suggested that a lower air temperature during seed maturation increases the duration of seed growth, which enabled seeds to be better organized at the cellular level.

Significant increase in root and shoot length may be due to higher seed index which may have supplied adequate food reserves to resume embryo growth. The seedling vigour index and seedling dry weight was also more due to higher seedling length. It was observed a positive correlation between seed weight and seedling vigour and seedling dry weight *i.e.*, the heavier seeds were better in seedling vigour and seedling dry weight compared to higher ones [71]. Kumar, et al. [51] found lower seed quality parameters like germination percentage, root length, shoot length, field emergence and vigour index with the niger crop sown during second fortnight of February.

2. CONCLUSION

In total, early or mid early sowings can be recommended for the hybrid seed production of maize, because plants have longer growth period, their growth and development of plant coincides with favorable environmental conditions, thus produce vegetative development and reproductive parts and more assimilates.

REFERENCES

[1] M. E. Otegui, M. G. Nicolini, R. A. Ruiz, and P. A. Dodds, "Sowing date effects on grain yield components for different maize genotypes," *Agronomy Journal*, vol. 87, pp. 29-33, 1995.

[2] A. Oktem, "Determination of sowing dates of corn (Zea Mays L.) under dryland conditions," *Turkish Journal of Agriculture and Forestry*, vol. 21, pp. 65-71, 2000.

[3] J. G. Lauer, P. R. Carter, T. M. Wood, G. Diezel, D. W. Wiersma, R. E. Rand, and M. J. Mlynarek, "Corn hybrid response to planting date in the Northern Corn Belt," *Agronomy Journal*, vol. 91, pp. 834-839, 1999.

[4] J. E. Newman and J. B. Beard, "Phenological observations: The dependent variable in bioclimatic and agrometereological studies," *Agronomy Journal*, vol. 54, pp. 399-403, 1962.

[5] T. Hodges, *Modeling and programming philosophies. In: T. Hodges (ed.) Predicting crop phenology*. Boca Raton, Florida, USA: CRC Press, 1991.

[6] G. Singh, S. S. Narwal, V. U. M. Rao, and D. S. Dahiya, "Effect of sowing date on requirement of growing degree days, heliothermal units and photo thermal units and phenology of winter maize (Zea Mays)," *Indian Journal of Agricultural Sciences*, vol. 60, pp. 35-41, 1990.

[7] G. R. Benoit, A. Olness, and K. A. Van Sickle, "Day night temperature effects on leaf expansion and height of field grown corn," *Agronomy Journal*, vol. 852, pp. 690-695, 1990.

[8] D. R. Wilson and M. Robson, "Pea phenology responses to temperature and photoperiod," in *Proceedings of the 8th Australian Agronomy Conference*, Toowoomba, 1996, pp. 590-593.

[9] D. Lenka, *Climate weather and crops in India*. New Delhi: Kalyani Publishers, 1998.

[10] Z. Berzsenyi, A. Y. Ragab, and D. Q. Lap, "Effect of sowing time on the growth of maize (Zea Mays L.) hybrids asymptotic functions," *Crop Production*, vol. 47, pp. 525-545, 1998.

[11] R. L. Nielsen, P. R. Thomson, G. A. Brown, A. L. Halter, J. Wells, and K. L. Wuethrich, "Delayed planting effects on flowering and grain maturation of dent corn," *Agronomy Journal*, vol. 94, pp. 549–558, 2002.

[12] S. B. P. Rao, K. L. Inra, and A. B. Singh, "Performance of Russian sunflower varieties under Kanpur conditions," in *Proceedings of the Symposium on Techno-Economic Aspects of oil Based Industries in Seventies, Harcourt Butler Technological Institute*, Kanpur, 1972.

[13] M. L. Lepez, "Effect of date of planting and row spacing on sunflower crop in Andalucía," in *Proceedings of the 5th International Conference on Sunflower, 25-29, July Clermant-Ferrad*, Paris, France, 1972, pp. 133-136.

[14] M. L. Chhabra, T. P. Yadava, and S. C. Gupta, "Effect of season of sowing on productivity of sunflower," *Indian Journal of Agricultural Sciences*, vol. 52, pp. 107-112, 1982.

[15] A. G. Cirilo and F. H. Andrade, "Sowing date and maize productivity. I. Crop growth and dry matter partitioning," *Crop Science*, vol. 34, pp. 1039-1043, 1994.

[16] M. Ahsan, M. M. Hussain, J. Farooq, I. Khaliq, A. Farooq, Q. Ali, and M. Kashif, "Physio-genetic behavior of maize seedlings at water deficit conditions," *Cercetari Agronomice in Moldova*, vol. 146, pp. 41-49, 2011.

[17] M. Ahsan, A. Farooq, I. Khaliq, Q. Ali, M. Aslam, and M. Kashif, "Inheritance of various yield contributing traits in maize (Zea Mays L.) at low moisture condition," *African J. Agri. Res.*, vol. 8, pp. 413-420, 2013.

[18] Q. Ali, M. Elahi, M. Ahsan, M. H. N. Tahir, and S. M. A. Basra, "Genetic evaluation of maize (Zea Mays L.) genotypes at seedling stage under moisture stress," *IJAVMS*, vol. 5, pp. 184-193, 2011.

[19] P. S. Stephen and W. W. Wallace, "Planting date and residue rate effects on growth, partitioning and yield of corn," *Agronomy Journal*, vol. 88, pp. 205-210, 1996.

[20] G. A. Maddonni, M. E. Otegui, and R. Bonhomme, "Grain yield components in maize: II. Post silking growth and kernel weight," *Field Crops Research*, vol. 56, pp. 257-264, 1998.

[21] F. H. Andrade, S. A. Uhart, and A. Cirilo, "Temperature effects radiation efficiency in maize," *Field Crops Research*, vol. 32, pp. 17-25, 1993.

[22] Q. Ali, M. Ahsan, M. H. N. Tahir, and S. M. A. Basra, "Genetic evaluation of maize (Zea Mays L.) accessions for growth related seedling traits," *IJAVMS*, vol. 6, pp. 164-172, 2012.

[23] Q. Ali, M. Ahsan, H. S. B. Mustafa, and Ejaz-ul-Hasan, "Genetic variability and correlation among morphological traits of maize (Zea Mays L) seedling," *Alban. J. Agric. Sci.*, vol. 12, pp. 405-410, 2013d.

[24] S. M. N. Alam, M. Salim, N. Islam, and M. M. Rahman, "Effect of sowing date and time of harvesting on the yield and yield contributing characters of sesame (Sesamum Indicum L.) seed," *International Journal of Sustainable Crop Production*, vol. 2, pp. 31-35, 2007.

[25] S. G. Moosavi, M. J. Seghatoleslami, and M. Ali, "Effect of planting date and plant density on morphological traits, LAI and forage corn (Sc. 370) yield in second cultivation," *International Research Journal of Applied and Basic Sciences*, vol. 3, pp. 57-63, 2012.

[26] P. Bassetti and M. E. Westgate, "Emergence, elongation and senescence of maize silks," *Crop Science*, vol. 33, pp. 271-275, 1993.

[27] R. E. Harris, R. H. Moll, and C. W. Stuber, "Control and inheritance of prolificacy in maize," *Crop Science*, vol. 16, pp. 843-850, 1984.

[28] M. E. Otegui and S. Melon, "Kernel set and flower synchrony within the ear of maize. I. Sowing date effects," *Crop Science*, vol. 37, pp. 441-447, 1997.

[29] S. R. Anderson, M. J. Lauer, J. B. Schoper, and R. M. Shibles, "Pollination timing effects on kernel set and silk receptivity in four maize hybrids," *Crop Science*, vol. 44, pp. 464-473, 2004.

[30] Q. Ali, M. Ahsan, F. Ali, S. Muhammad, M. Manzoor, N. H. Khan, S. M. A. Basra, and H. S. B. Mustafa, "Genetic advance, heritability, correlation, heterosis and heterobeltiosis for morphological traits of maize (Zea Mays L) " *Alban. J. Agric. Sci.*, vol. 12, pp. 689-698, 2013b.

[31] S. R. Aldrich, W. O. Scott, and R. G. Hoeft, *Modern corn production*. Champaign: A and L Publications, 1986.

[32] Q. Ali, M. Ahsan, M. H. N. Tahir, and S. M. A. Basra, "Genetic studies of morpho-physiological traits of maize (Zea Mays L.) seedling," *African J. Agri. Res.*, vol. 8, pp. 3668-3678, 2013c.

[33] Q. Ali, A. Ali, M. Waseem, A. Muzaffar, S. Ahmad, S. Ali, M. Awan, and T. Samiullah, "Correlation analysis for morpho-physiological traits of maize (Zea Mays L.)," *Life Sci J.*, vol. 11, pp. 9-13, 2014b.

[34] N. M. Adam, M. B. McDonald, and P. R. Henderlong, "The influence of seed position, planting and harvesting dates on soybean seed quality," *Seed Science and Technology*, vol. 17, pp. 143-153, 1989.

[35] Q. Ali, M. Ahsan, F. Ali, M. Aslam, N. H. Khan, M. Manzoor, H. S. B. Mustafaa, and S. Muhammad, "Heritability, heterosis and heterobeltiosis studies for morphological traits of maize (Zea Mays L.) seedlings," *Adv. Life Sci.*, vol. 1, pp. 52-63, 2013a.

[36] L. N. Sheperd, D. R. Hicks, and W. H. Schmidth, *Maximizing the advantages of early corn planting. National corn handbook*. West Lafayette, Indiana, USA: Purdue University Cooperative Extension Service, 1991.

[37] D. R. Hicks, I. D. Harrington, and J. H. Mc Gahen, *Maximizing the advantages of early com planting. National corn handbook. crop management*. West Lafayette, Indiana, USA: Purdue University Cooperative Extension Service, 1993.

[38] S. R. Aldrich, W. O. Scott, and E. R. Leng, *Modern corn production*, 2nd ed. Champaign: A and L Publications, 1975.

[39] T. S. Green, M. Ender, and J. J. Mock, "Effect of sowing dates on maize yields," *Agricultural Sciences*, vol. 20, pp. 51-63, 1985.

[40] Q. Ali, A. Ali, M. Ahsan, S. Ali, N. Khan, S. Muhammad, H. Abbas, I. Nasir, and T. Husnain, "Line × tester analysis for morpho-physiological traits of Zea mays L. seedlings," *Adv. Life Sci.*, vol. 1, pp. 242-253, 2014a.

[41] Q. Ali, M. Ahsan, N. Khan, M. Waseem, and F. Ali, "An overview of zea mays for the improvement of yield and quality traits through conventional breeding," *Nat Sci.*, vol. 12, pp. 71-84, 2014d.

[42] C. E. Scarsbrook and B. D. Doss, "Leaf area index and radiation as related to com yield," *Agronomy Journal*, vol. 65, pp. 459-461, 1972.

[43] B. C. Miller, E. S. Oplinger, R. Rand, J. Peters, and G. Weis, "Effect of planting date and plant population on sunflower performance," *Agronomy Journal*, vol. 76, pp. 511-515, 1984.

[44] P. R. F. Silva and L. Sangoi, "Time of sowing sunflower. I. Effect on seed yield, yield components, oil content and yield," *Lavoura Arrozeira*, vol. 38, pp. 20-27, 1985.

[45] J. Gardner, *Substituting legumes for fallow in U.S.great plains wheat production: The first five years of research and demonstration 1988-1992*. USDA/SARE and North Dakota State Univ.,Michael Fields Agricultural Institute,Kansas State Univ. and Univ. of Nebraska. Carrington,N.D.: NDSU Carrington Research Extension Center, 1992.

[46] M. Sarvari and Z. Futo, "Correlation between the sowing date, yield and grain moisture content of maize hybrids on chernozem soil," *Debreceni Egyetem Agrartudomanyi Kozlemenyek Journal*, vol. 1, pp. 32-41, 2000.

[47] M. A. Rahman, E. L. Magboul, and E. N. Abdelatief, "Effects of sowing date and cultivar on the yield and yield components of maize in northern Sudan," presented at the Seventh Eastern and Southern Africa Regional Maize Conference, 2001.

[48] M. A. Ali, M. Ali, M. Sattar, and L. Ali, "Sowing date effect on yield of different wheat varieties," *Journal of Agricultural Research*, vol. 48, pp. 157-162, 2010.

[49] C. P. Mansur, Y. B. Palled, S. I. Halikatti, M. B. Chetti, and P. M. Salimath, "Effect of dates of sowing and irrigation levels on growth, yield parameters, yield and economics of Kabuli chickpea," *Karnataka Journal of Agricultural Sciences*, vol. 23, pp. 461-463, 2010.

[50] M. A. Beiragi, S. K. Khorasani, S. H. Shojaei, M. Dadresan, K. Mostafavi, and M. Golbashy, "A study on effects of planting dates on growth and yield of 18 corn hybrids (Zea Mays L.)," *American Journal of Experimental Agriculture*, vol. 1, pp. 110-120, 2011.

[51] B. N. M. Kumar, Basavegowda, B. S. Vyakaranahal, V. K. Deshpande, and P. V. Kenchanagoudar, "Influence of sowing dates on production of seed yield in Niger (Guizotia Abyssinica Cass.)," *Karnataka Journal of Agricultural Sciences*, vol. 24, pp. 289–293, 2011.

[52] B. A. Lawal, G. O. Obigbesan, W. B. Akanbi, and G. O. Kolawole, "Effect of planting time on sunflower (Helianthus Annuus L.) productivity in Ibadan, Nigeria," *African Journal of Agricultural Research*, vol. 6, pp. 3049-3054, 2011.

[53] T. Susila and M. Rajkumar, "Effect of date of sowing of ajowan (Trachyspermum Ammi L.) sprague on seed yield in Southern Telangana, Andhra Pradesh," *Madras Agricultural Journal*, vol. 98, pp. 39-40, 2011.

[54] H. M. Taylor and P. S. Blackett, "Soybean and maize yield as affected by row spacing, planting dates and seasonal water supply," *Agronomy Journal*, vol. 80, pp. 930-935, 1982.

[55] Q. Ali, A. Ali, M. Awan, M. Tariq, S. Ali, T. Samiullah, S. Azam, S. Din, M. Ahmad, N. Sharif, S. Muhammad, N. Khan, M. Ahsan, I. Nasir, and T. Hussain, "Combining ability analysis for various physiological, grain yield and quality traits of zea mays L," *Life Sci J.*, vol. 11, pp. 540-551, 2014c.

[56] Q. Ali, M. Ahsan, M. H. N. Tahir, and S. M. A. Basra, "Gene action and correlation studies for various grain and its contributing traits in maize (Zea Mays L)," *Bothalia*, vol. 44, pp. 80-91, 2014e.

[57] K. B. E. G. Nasser, "Effect of planting date and fertilizer application on yield of wheat under no till system," *World Journal of Agricultural Sciences*, vol. 5, pp. 777-783, 2009.

[58] J. Berger, "Maize production and the manuring of maize," *Journal of Agricultural Research*, vol. 1, pp. 293-302, 1969.

[59] L. M. Sutton and R. E. Stucker, "Growing degree days to black layer compared to relative maturity rating of corn hybrids," *Crop Science*, vol. 14, pp. 408-412, 1974.

[60] M. Tollenaar and A. Aguilera, "Radiation use efficiency of an old and a new maize hybrid," *Agronomy Journal*, vol. 84, pp. 536-541, 1992.

[61] V. Krishnasamy and K. R. Ramaswamy, "Studies on synchronization of flowering in the parental lines of sorghum hybrids. I. Variation in the duration of flowering as influenced by dates of sowing," *Madras Agricultural Journal*, vol. 74, pp. 346-350, 1987.

[62] M. Tollenaar and T. W. Bruulsema, "Effects of temperature on rate and duration of kernel dry matter accumulation of maize," *Canadian Journal of Plant Sciences*, vol. 68, pp. 935-940, 1998.

[63] D. T. Daynard and W. G. Duncan, "The black layer and grain maturity in corn," *Crop Science*, vol. 9, pp. 473-476, 1972.

[64] D. W. Stewart, L. M. Dwyer, C. J. Andrews, and J. A. Dugas, "Modeling carbohydrates production, storage and export in leafy and normal maize," *Crop Science*, vol. 37, pp. 1228-1236, 1997.

[65] L. Sangoi, "Suitability of the fields of lages (SC) for corn production in different growing seasons," *Brazilian Agricultural Research*, vol. 28, pp. 51-63, 1993.

[66] L. Sangoi and R. J. Salvador, "Influence of plant height and leaf number on maize production at high plant densities," *Brazilian Agricultural Research*, vol. 33, pp. 297-306, 1998.

[67] P. R. F. Silva, G. Argenta, and F. Rezera, "Response of irrigated corn hybrids to plant density in three sowing dates," *Brazilian Agricultural Research*, vol. 34, pp. 585-592, 1998.

[68] V. G. Patil and Dighe, "Cotton seed quality related to time of harvest and position of bolls," *Cotton Development*, vol. 14, pp. 29-32, 1985.

[69] I. P. Singh, D. P. Singh, and B. S. Chhabra, "Seed germination in relation to time of pickings in cotton," *Cotton Development*, vol. 17, pp. 37-38, 1987.

[70] M. M. Greven, B. A. McKenzie, and G. D. Hill, "The influence of stress on yield, abortion and seed size of French dwarf beans (Phaseolus Vulgaris L.)," *Proceedings of Agronomy Society, New Zealand*, vol. 27, pp. 101- 108, 1997.

[71] R. T. Kasul, N. R. Kadam, N. R. Pavithrakar, and R. P. Khedekar, "Improvement of seed quality in the marginal seed lots of cotton by using specific gravity separator," *Seed Research*, vol. 31, pp. 213-218, 2003.