EFFECT OF SEEDLING AGE AND TRANSPLANTING DATES ON ESTABLISHMENT AND YIELD OF SUNFLOWER (*Helianthus annuus* L.) IN COASTAL REGION OF SOUTHWESTERN BANGLADESH

A Thesis

By

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ABSTRACT

In the southwestern (SW) coastal region timely sowing/planting of winter crop is not possible due to late harvest of aman rice and excess wetness of the soil. Sowing and dibbling of winter crop's seed including sunflower in wet soil under zero tillage have been possible recently and it was observed that late established sunflower gives poor yield. Transplanting of sunflower seedling might be one of the potential techniques to establish the crop in wet soil of this region. Thus a field experiment was conducted in the farmer's field of Pankhali, Dacope, Khulna (AEZ-13) during winter (2018-2019) to evaluate the effect of seedling age and transplanting date on establishment and yield of sunflower. The experiment was laid out in a factorial randomized complete blocks design (RCBD) with three replications. The experiment comprised of two seedling age (*viz,* 14 days and 21 days) and three transplanting dates (*viz,* 25th December, 5th January and 15th January). The result of the experiment indicated that individually 14-day-old seedling performed better than 21 day old seedling and early transplant 25 December crop gave the best yield performance. The combined effect of seedling age and transplanting date showed that younger seedling with early transplanting realized the maximum seed yield followed by younger seedling with 2nd planting (5th January). Among the transplanting dates and seedling age earlier transplanting and younger seedling produced ~ 54%, and ~ 25%, more seed yield, respectively, over later transplanting and older seedling. The results of the present study revealed that transplanting of 14 day old seedling on 15 December to 5 January will give the best yield and thus late harvesting of aman rice would not be a problem in sunflower cultivation.

Keywords: *Helianthus annuus, Transplanting, seedling age, southwestern coastal soil and seed yield.*

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December, 2019 ***The Author***

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CHAPTER I

INTRODUCTION

Sunflower is an annual herb of Asteraceae, the largest family of plant kingdom. It is an important edible oil crop ranking next to soybean. It is one of the most important oil crops in the world because of its oil quality (Ahmad et al., 2014; Dalchiavon et al., 2016; Papatheohari et al., 2016), high protein content (Ahmad et al., 2014) and use of the different parts of the plant (Skoric, 1992). It is cultivated in temperate region as a food and ornamental plant. Sunflower is a crop which offers tremendous adaptive plasticity to contrasting environmental conditions and cropping systems because of its higher per day productivity, photo-insensitivity, and quality edible oil. Sunflower oil is the fourth most important vegetable oil in world trade, with an annual production of around 9 million tones and a cultivated acreage of over 22 million hectares (Fernandez-Martinez et al., 2010). It has the potential to reduce the existing gap between production and consumption of edible oil because it contains almost 40-50% of oil and is rich in protein which is about 23%.

The cultivated sunflower probably originated in Mexico. It was first introduced as a garden plant in Bangladesh, but in the 1980s some dwarf varieties were introduced to cultivate as oil seed crop. Being a thermo and photo -neutral crop, sunflower is cultivated as *Rabi* and *Kharif* 1 crop in some central and northern districts of the country and still not considered a crop in any cropping pattern (FRG 2018). In the coastal area of Bangladesh, winter cropping is mainly constraint by excess soil moisture after harvesting of single transplanted *(T) aman* rice and salinity in irrigation water and in soil. Although the salinity problem particularly in the southwestern Bangladesh has got substantial attention for fitting crop after *T. aman* harvest, still the success of bringing winter crops timely was still nearly impossible until recently. This is because not only salinity is the responsible but excess soil wetness during the optimum sowing time of winter crops is identified as a first constraint to fit winter crops in the southwestern coastal Bangladesh (Kabir et al. 2019; Bell et al. 2019, Paul et al. 2019). All of these recent research works showed that early planting of some winter crops (e.g., maize, wheat, sunflower) is possible (through some field management and proper planning from *T. aman* season) which realized the maximum yield, approximately equal or even more than the national average of those crops, while late planting produced poor yield which is usual. As the topography of the arable land of this area is low to medium high (FRG 2018), sowing or seed dibbling is still difficult particularly in the medium low to low land due to high soil moisture. Moreover, farmers are unwilling to cultivate short duration *T. aman* rice as it is the only one crop in a year of this region. In this context, if other crop establishment methods is explored, e.g., transplanting of sunflower seedling, in these types of land and for the land where the farmers transplant *T. aman* very late, sunflower might be established during the optimum sowing time in winter and be harvested before the irrigation water reach to the constraint level of salinity. Transplanting sunflower seedling from early to late winter will show the possibility of transplanting, yield difference between transplanting time and also differing the seedling age of sunflower (as it is a new type of experiment of its type, the optimum seedling age also need to be identified). Thus the experiment was conducted with sunflower using seedlings of different ages and varying the dates of transplanting in a typical coastal soil of Bangladesh.

Objectives

- To examine the performance of transplanted sunflower in the wet soil of southwestern coastal soil of Bangladesh.
- To investigate the effect of seedling age and transplanting dates on seedling establishment and yield of sunflower in the coastal wet soil of southwestern Bangladesh.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this chapter is to review the past studies conducted by different researchers related to present study. Transplanting of sunflower was rare practiced before so literature on transplanted sunflower was not available. As far as possible the researcher tried to review the available literature from different countries related to effect of transplanting date and seedling age on yield of sunflower.

Effect of seedling age

Agbaje et al. (2002) carried out an experiment to study the effects of transplanting age on growth and grain yield of three varieties of Sorghum bicolor, 'Ilorin local', SK 5912, and SSV10. Seedlings from each variety transplanted at 2, 4 and 6 weeks after planting (WAP) were compared with directly seeded plants used as control. Results show that at 8 WAP with seedlings transplanted at 2 WAP were taller than the other transplants, but shorter than directly seeded plants. Transplanting caused delay in flowering, but at this stage, height of transplants was comparable to directly seeded plants in SK 5912 and SSV10, while in 'Ilorin local' the transplants were significantly shorter at $P< 0.05$. Dry matter accumulation and grain yield was comparable among transplants but lower than those of directly seeded plants. However, grain yield of seedlings that were transplanted at 2 WAP was statistically comparable with directly seeded plants at $P< 0.05$.

Jellani et al. (2016) conducted field experiments to determine the growth and yield of bitter gourd in response to seedling age during the years 2011 and 2012. Minimum days to 1st picking, maximum availability period, yield and net profit were observed in 40 days old seedlings and 100% survival rate was observed in all three (40, 50 and 60 days) ages of seedlings. Seedlings of varying ages did not fluctuate greatly in yield and yield components in the field, although, all

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seedlings had higher early yields than the directly seeded controls. Maximum gross margin was achieved in 40 days old seedling as compared to direct seeded crop. Results from these experiments suggest that 40 days may be reasonable target age for transplanting bitter gourd seedlings.

Mohammad R.H et al. (2010) investigated the effects of seedling age on agro-morphological characteristics, essential oil content and composition of German chamomile grown in Belgium. Five seedling ages (30, 45, 60, 75 and 90 days) was replicated thrice in a randomized complete block design. For 30-days-old seedlings, (*E*)-β-farnesene, α-bisabolol oxide A, α-bisabolone oxide and spathulenol were the compounds which were significantly influenced by planting date. Plant height and plant spread were the only agro-morphological characteristics which were significantly influenced by age of seedling at transplanting. Seedling age significantly increased DAS to flowering whereas the effect was age-dependent. For the first date of planting, spathulenol was the only compound which was significantly influenced by seedling age at transplanting whereas the highest amount was obtained for 90-days-old seedlings.

Oswald A. et al. (2001) conducted field experiments in 1996 and 1997 in western Kenya to assess the effect of transplanting maize and sorghum, under rain-fed field conditions, on grain yield and Striga parasitism. Transplanting maize in all experiments significantly increased grain yield compared to direct seeding. The improved productivity was largely associated with less Striga attachment. Striga densities were considerably lower if maize seedlings were more than 17 days old at transplanting, with decreasing levels of Striga with increasing age of the maize seedlings. Seedlings transplanted before they were 15 days old did not reduce Striga attachment. Transplanting maize under rain-fed conditions is probably only suitable for small areas. Under these conditions, crop yield can be more than doubled.

Ren et al. (2014) noticed that seed yield in canola is affected by many factors, including seedling age. Two field experiments were conducted to compare canola seedling quality and seed yield on 30-, 35-, 40-, 45-, 50-, 55-, and 60-d-old seedlings in 2011 and 2012. Results revealed that the highest seed yield obtained from 40-d-old seedlings was attributed to more branches and siliques per plant. The negative effect of young seedlings (30-d-old) on seed yield was greater than that of old seedlings (60-d-old). The reduction rates in seed yield on the 30- and 60-d-old seedlings were 25.7 and 18.2%, respectively, compared with the 40-d-old seedlings. The increase was larger in the old seedlings than in the young seedlings. However, correlation analysis revealed that the seedlings with the highest shoot and root dry matter did not necessarily obtain the highest seed yield.

Thakar et al. (2006) conducted a field experiment during the winter (rabi) seasons of 2001–02 and 2002–03 at Ludhiana, to evaluate the performance of transplanted African mustard (Brassica carinata A. Braun). They concluded that transplanting of 45 days old seedlings resulted in 34.5% higher seed yield than direct seeding. Transplanting of seedlings of 30 and 60 days age also gave 27.8 and 33.5% respectively higher seed yield than direct seeding. Leaf-area index, number of primary and secondary branches/plant, siliquae/plant, oil yield, protein yield and net returns were significantly higher in transplanted crop than direct-seeded ones.

Effect of transplanting date

Abdullahi et al. (2013) conducted an experiment to observe the influence of planting date of sunflower. The result showed that percentage prevalence of infestation was highly significant on sunflower sown the 5th July than other planting date except that of 26th July. Significantly lower damage was recorded on sunflower sown on 19th July than those of the 5th and grain yield loss was also significantly higher on 26th July planting date than all other dates. The result denotes that 19th

July is the best planting date to reduce infestations, damage and yield loss from *P. interrupta* in Maiduguri.

Ahmed et al. (2015) carried out an experiment to find out optimum planting date of sunflower during rabi season 2012-13. The sunflower variety BARI Surjomukhi-2 was used. Five sowing dates; 10^{th} November, 20^{th} November, 30^{th} November, 10^{th} December and 20^{th} December were tested. It was revealed that yield and yield attributes of sunflower were significantly influenced by planting dates. The maximum plant height (172.13 cm), head diameter (18.33), weight of seed/per head (66 g), 1000- seed weight (68 g) and yield (2.5 t ha^{-1}) were obtained from 20^{th} November planting. The lowest yield (1.83 t ha^{-1}) was obtained from 20^{th} December planting. The 20^{th} November planting received the higher duration for maturity (127 days), first flowering (57 days) and seed formation (20 days) while 20^{th} December planting showed shorter duration for maturity, first flowering and seed formation of 119, 54 and 14 days respectively. It was concluded that the 20 November planting would be the optimum time of planting for achieving maximum yield of sunflower

Akhtar et al. (2005) carried out an experiment, i.e. effect of different dates (16, 30 January and February 13, 27) on the yield of spring planted sunflower in the Agronomy Department, University of Agriculture, Faisalabad, during 2001-2002. Two years average data showed that crop sown on 13^{th} February produced significantly higher yield (4179.54 kg ha^{-1}).

Alessi et al. (1981) conducted a study for 4 years (1974–1977) to obtain information on safflower (*Curthamus tinctoris* L.) seed yield, oil concentration, and water use efficiency as affected by seeding date and plant population. Safflower was seeded on previously cropped or fallow land on three dates: early (16 May), midseason (6 June), or late (25 June) on Temvik silt loam. Results showed that the average water-use efficiency for mid-May, early June, and late June seeding was

34, 33, and 15 kg seed/cm water used, respectively. Seed and oil yields were highest for early and lowest for late seeding. In all years, planting date affected seed yield and oil concentration. The results showed that for best results safflower should be planted between 20 April and 10 May.

Balalic et al. (2012) inspected the effect of planting date using three hybrids (Miro, Rimi, Pobednik). They were cultivated during three growing seasons (2005, 2006, 2007) and sown at four different planting dates (PD1 - 20th of March, PD2 - 10th of April, PD3 - 30th of April, PD4 - 20th of May). Planting date had significant influence on head diameter in the stage of flowering and physiological maturity in sunflower. With later planting head diameter increased, so that significantly highest head diameter across planting dates was found in PD4 (11.8 cm in flowering stage, and 22.6 cm at the stage of physiological maturity).

Bange et al. (1997) investigated the effect of planting date on sunflower yield performance and found changes in yield reduction with date of planting. Correct time of planting, not only influences yield but also the kernel husk ratio. Seed weight tends to decrease with delayed sowing and greatest loss in the kernel. However, sowing outside the optimum time may be necessary to have a particular grade of oil (Weiss, 2000).

Barros et al. (2004) conducted an experiment on the effect of the planting date over 4 years and comprised four cultivars and four planting dates with the last one corresponding to the traditional planting date. An early planting date led to a simultaneous increase of leaf area duration (LAD) and water uptake during the critical period between flower bud appearance and flowering. The earlier planting dates also increased the number of seeds per area without decreasing its weight which resulted in higher crop yields.

Demir (2019) conducted a study at research farm in Kırşehir Province of Turkey in 2012 and 2013 to determine effects of planting date on yield and agronomic characteristics of sunflower hybrid cultivars in rainfed conditions. Five planting dates 10 days apart set on 10th April, 20th April, 1st May, 10th May and 20th May and 6 hybrid sunflower cultivars (LG-5580, SanayMr, SanbroMr, Sirena, Tarsan and Transol) were used. The result showed that planting date was delayed, seed and oil yields declined. The highest plant height (151.18 cm), 1000-seed weight (51.72g), crude oil content (46.18%), seed yield (2.55 t ha^{-1}) and oil yield (1.18 t ha^{-1}) were obtained on the second planting date (20th of April) while the highest ratio of dehulled/hulled seed weight (70.04%) and head diameter (20.49 cm) were obtained on the first planting date (10th of April) in 2012.

Dutta (2011) carried out an experiment in 2008-09 showing the influence of planting date on yield and yield component of hybrid sunflower. In his research five different planting dates were used November 15, November 30, December 15, December 30 and January 15. Plant height of three hybrids showed that November 15 had highest plant height followed by that planted on November 30.The analysis revealed that head diameter showed a decreasing trend with delayed date of planting. Planting on November 30 exhibited maximum head diameter (16.8 cm). Earlier plantation showed maximum seed filling percentage and 100 seed weight. The maximum seed filling percentage (92.7) and 100 seed weight (5.5 g) was in the case of November 30 planting date followed by November 15 date of planting (89.0% and 5g, respectively). The lowest value was observed in case of January 15 date of planting. The maximum seed yield was November 30 planting date followed by November 15 planting date.

Momoh et al. (2001) carried out an experiment on growth and yield responses to plant density and stage of transplanting (30, 35 and 40 days after sowing) of winter oilseed rape cultivar HO 605 were investigated in two trials in the 1996/97 and 1997/98 growing seasons at Zhejiang University

Farm, Huajiachi Campus, China. Results showed a progressive decrease in leaf area per plant in response to increasing plant density and delayed transplanting. Number of effective branches and pod per branch decreased with increasing plant density and delayed transplanting. There were no significant differences in the mean seed weight among treatments. Although the average number of seeds per pod was significantly lower for high-density plants and delayed transplanting. Seed oil content was negatively affected by increasing plant density, but no significant differences were observed with delayed transplanting. The highest seed yields of 1730.7 and 1748.1 kg ha^{-1} with no significant differences were observed for plant densities of 9.75 ′ 104 and 12.75 ′ 104 plants ha^{-1}, respectively, transplanted at 35 and 30 days after sowing.

Ozturk et al. (2017) investigated the effects of planting date and nitrogen fertilizer forms on the yield and agronomic characteristics of two cultivars of oil sunflower (early, Sirena and late, Teknosol) in Erzurum, Eastern Anatolia of Turkey, in 2013 and 2015. Three planting dates were established at about 10-day intervals from late-April to early and mid-May (22 April, 2 May and 12 May 2013; and 28 April, 8 May and 18 May 2015). Three nitrogen fertilizer forms ammonium sulfate, ammonium nitrate, and urea were used. The results of this study showed that sunflower seeding from 28 April to 8 May gives more assurance for higher yields. The yield differences measured for three planting dates and nitrogen fertilizer forms were primarily related to the changes in head diameter and 1000 seed weights. According to the results of this study, early sunflower cultivars, having the highest yield and agronomic characteristics can be recommended for the similar ecological condition of our study region a short growing season and high altitude.

Pavlista et al. (2011) conducted field trials on Brassica, Canola and camelina in 2005 and 2006 at planting dates of 24 February, 24 March, 7 April, 21 April and 5 May, and 3 March, 3 April, 10 April, 27 April, 11 May, and 2 Jun, respectively. Flowering date was later with later planting but occurred within a range of degree days (P-days). Fruiting was affected by date and P-days, but seed maturity was not affected by planting date and was unrelated to P-days. Planting in April gave the best yields, and canola could yield over 2200 kg ha−1. Oil content of the Brassica was highest when planted from late March and later. For camelina, planting date had no effect. In brown mustard and canola, 60–65% of oil was C18:1, in camelina, about 15%. Later planting increased C18:1 content for the three crops. The major fatty acid in camelina was C18:3 at 32–37%; earlier planting increased the content of C18:3. In Camelina, C20:1 comprised about 12% of the oil and was highest with April planting.

Rashid et al. (2014) led a field trial in 2012 to compare the planting date of early dibbled sunflowers in zero tilled soil with traditional tilled one after T. aman rice. Sunflower was planted on four dates, 14 January (zero tillage in moist soil), 22 and 29 February and 5 March (tilled field at field capacity). It showed that dibbled on 14 January produced the tallest plant (1.59 m) which was significantly higher than plants of all other planting dates. The first planting (14 January) had the largest head diameter (16.14 cm) while the crop planted on last sowing (March 05) produced the heads of smallest size (12.75 cm). The highest seed yield was produced from 14 January planting (3.06 t ha^{-1}) significantly followed by 22 February planting (2.68 t ha^{-1}) and 29 February planting (2.59 t ha^{-1}). The lowest seed yield (2.54 t ha^{-1}) was recorded in 5 March planting which was at par with 29 February planting. Results indicated that dibbling on 14 January produced significantly taller plant, larger head and higher seed yield (3.06 t ha^{-1}) than those of other planting dates (2.54 to 2.68 t ha^{-1}).

Saghayesh et al. (2014) conducted an experiment showing the effect of different planting dates on growth, development, morphological characteristics, yield, oil content and fatty acid composition of *Linum usitatissimum* L. Six planting dates including (March 3, March 19, April 1, April 17, May 2, May 18) were used in this work. The findings showed that planting dates had significant effect on all morphological characteristics except thousand seed weight and oil percentage. An earlier planting date led to better results. Delaying in planting decreased the linoleic and linolenic acid content but increased the palmitic and oleic acids. For the best production and fatty acid contents, it is postulated that the planting date offers a high economic yield and oil quality. It was resulted that plants sown at March 3 come across favorable environmental conditions resulting in significantly high economic yield compared to other planting dates.

Sheoran et al. (2015) carried out an experiment to evaluate the changes in seed yield and oil quality of sunflower in response to changing environmental conditions across different planting dates and genotypic variability, during spring 2005-2008 at PAU, Ludhiana. Planting dates affected seed yields more than any of the other characteristics measured with significant yield reduction under delayed planting conditions. There was a consistent and significant reduction in number of calendar days to reach a particular phenophase with each successive delay in planting time. The highest seed yield of 2249 kg/ha was recorded when the crop was planted on 20 January though it was statistically at par with 20 December.

Urbaniak et al. (2008) conducted an experiment on seeding date and rate in 2005 and 2006 in Nova Scotia and Prince Edwards Island. Seeding date did not affect camelina emergence, plant height, seed yield and oil content. But the earlier seeding date increased the concentration of stearic acid in the oil compared with the later seeding date.

Zheljazkov et al. (2011) set two years (2006 and 2007) of experiments using five locations in Mississippi to evaluate the effect of planting date (April 20, May 20, and June 20), and hybrid (DKF3875, DKF2990, DKF3510, DKF3901, PR63M80, PR62A91, PR63A21, PR63M91, and

PR64H41) on seed yield, oil content, and oil composition of sunflower. Planting date nested within location and hybrid had significant effects on oil content, whereas the planting date by hybrid interaction nested within location had significant effect on the five responses but not on oil content. Seed yields within the five locations and depending on the treatments ranged between 217 and 2889 kg ha^{-1}. In most instances, average yields from the first and second planting dates were within the range of sunflower hybrids in various locations. The result showed that early planting of sunflower may produce higher yields. Mean seed oil content decreased from the first to the second planting date but decreased in the third planting date. The third planting provided higher oil content than the first planting.

Effect of water stress and salinity on sunflower

Hafeez et al. (2017) designed an experiment to study the effects of four different naturally salt affected soils having electrical conductivity (EC) of 1.15, 8.33, 15.48 and 20.23 dSm^{-1}, respectively on seed germination and growth parameters of five sunflower hybrids. Certified seeds of 5 diverse varieties of sunflower hybrids namely HU-777, CRN-1435, DK-3915, Super-25 and Hysun 33 were used in this study. Growth study was conducted in plastic pots using randomized complete block design for 30 days. After that, a set of seedlings was uprooted carefully from each treatment for the measurement of growth parameters i.e. number of leaves $plant^{-1}$, leaf length (cm), leaf width (cm), number of burnt leaves, plant length (cm) and stem girth (cm). Germination and growth of all sunflower hybrids were significantly reduced with increase in salinity. Among all sunflower genotypes, Super-25 and Hysun-33 showed better tolerance to salinity and performed well even under high salinity level (20.23 dS m^{-1}).

Katerji et al. (1994) carried out an experiment to observe the effect of salinity on the emergence and early seedling growth of sunflower and maize. Experiments were conducted in pots filled with sandy clay and sandy loam. The experiments consisted of a control and four saline water qualifies with chloride concentrations of 15, 30, 45, and 60 meq/l. The emergence of sunflower and maize were affected by salinity. Soil texture did not affect the emergence. During early seedling growth, salinity and soil texture affected the development of the seedlings that showed symptoms of water stress in the form of lower leaf water potential, stomatal conductance, and evapotranspiration. The higher the salinity, the lower the leaf area and the dry matter production. Leaf, stem, and root showed an almost similar growth reduction due to salinity. Seedlings on sandy loam were more affected by water stress than those on sandy clay.

Khatoon et al. (2000) conducted a greenhouse study during spring 1998-99 to evaluate the effect of salinity on growth, yield, protein and oil contents of two sunflower genotypes viz FH-1 and FH-6. The EC levels were 1.5 (control), 3.0, 4.5 and 6.0 dS m^{-1}. The salinity levels were created with the addition of NaCl in the soil. Salinity adversely affected yield and yield components of sunflower. Protein contents of seed decreased with increasing salinity levels, but oil contents were not affected by salinity. The cultivar FH-6 was found relatively more salt tolerant as compared with FH-1.

Wu et al. (2015) carried out a study to investigate the effects of saline stress on seed germination, ion distribution, and organic solutes changes of sunflower (Helianthus annuus L.). In this study, seeds and 3-week-old seedlings were subjected to a series of external NaCl concentrations (5–200 mmol). The results showed that high salinity (200 mmol) remarkably inhibited the germination of seed and delayed germination time in sunflower. It was concluded that sunflower plants adapt to saline stress to some extent through regulating distribution of Na+ and K+, maintaining higher selective absorption capacity for K+ over Na+, and accumulating more osmoprotectants, such as soluble sugar and proline.

Zeng et al. (2014) conducted an experiment to evaluate the effects of interactions between soil salinity and nitrogen (N) application rate on sunflower photosynthesis and growth and to determine the optimum N application rate for sunflower growth in the district. Four levels of soil salinity expressed as electrical conductivity (0.33–0.60, 0.60–1.22, 1.2–2.44, and 2.44–3.95 dS m^{-1}) and three application rates of N fertilization (90, 135, and 180 kg ha^{-1}) were applied to 36 micro-plots. Soil salinity inhibited the photosynthetic rate, stomatal conductance, transpiration rate, plant height, leaf area, and aboveground dry matter of sunflowers. The intercellular CO2 concentration first decreased and then increased with increasing soil salinity in the seedling stage, and the instantaneous leaf water-use efficiency fluctuated with soil salinity. The stomatal and non-stomatal limitations of sunflowers alternated in the seedling stage; however, in the bud, blooming, and mature stages, the stomatal limitation was prevalent when the salinity level was lower than 2.44 dS m^{-1}, whereas the non-stomatal limitation was predominant above the salinity level.

From the above review of literature it is clear that sunflower can be cultivated in all three seasons. The yield potentialities of sunflower is better in winter season compared to other seasons. In winter, earlier planting always gives better yield and subsequent growth and development. As the winter in southwestern coastal region is shorter than the northern part of the country. So, obviously earlier planting can provide better results. In case of seedlings age some experiment was conducted by different researchers in pot but field experiment using transplanting of seedling has not yet been done. Sunflower has the capacity to tolerate salinity to some extent. To fit the crop in optimum time just after harvesting of aman rice using different ages seedling at different transplanting I thus a new intervention for the maximization of cropping intensity in the costal soil of southwestern Bangladesh.

CHAPTER III

MATERIALS AND METHODS

The study was conducted at the farmer's field in the village of Pankhali, Dacope, Khulna which located at 26 km southwest from Khulna university campus. The main objectives of this study was to establish sunflower as a *Rabi* crop by transplanting timely after harvest of *T. aman* rice with the suitable age of seedling in the southwestern coastal region to ensure maximum yield return to the farmer. A brief description of the experimental procedures is given below:

3.1 Location and soil of the experimental site

The experiment was conducted in Pankhali, Dacope, Khulna situated in the Agro-ecological Zone (AEZ) 13 during winter December 2018 to April 2019. The site is located in between 22°24' north latitudes and 89° 24' and 89° 35' east longitudes. Dacope is surrounded by Batiaghata upazila, Pasur river on the north, Rampal and Mongla is in the east, Paikgacha and Koyra upazila on the west and Sundarbans is on the southern part of this upazila. The soil texture ranged from silty clay at 0-30 cm depth to clay at 30-60 cm and the soil was almost neutral with pH-7.3.

Table 1: Physical and chemical properties of the soil (experimental plot soil) of Pankhali, Dacope, Khulna

	Salinity (dSm^{-1})	OM (%)	N (%)	P (µg/g soil)	K (meq/100 g soil)	Cu (µg/g soil)	Zn (µg/g soil)	B (µg/g soil)
Soil test value	7.4	2.4	0.124	31.34	0.35	107.42	1.51	1.16
Condition	Medium	Medium	Low	High	High	Very high	High	Very high

3.2 Weather parameter

The experimental site was characterized by sub-tropical climate with moderately high temperature and heavy rainfall during the Kharif season (April to October) and low rainfall with moderately low temperature during the Rabi season (November to March). The daily meteorological data (temperature, relative humidity, and rainfall) for the period of December 2018 to April 2019 recorded from the weather station, Khulna graphically represented below:

Temperature: The temperature during the growing period (2018-19) ranging from 8-37.2° C (Fig. 1). The average monthly maximum temperature of December 2018, January 2019, February 2019, March 2019 and April 2019 was 29.0° C, 31.2° C, 33.5° C, 34.5° C and 37.2° C respectively while the minimum monthly average temperature was 8.0° C, 9.5°C, 11.4° C, 4.4° C, 19.8° C respectively. Gradually temperature (maximum and minimum) increased with the progress of time.

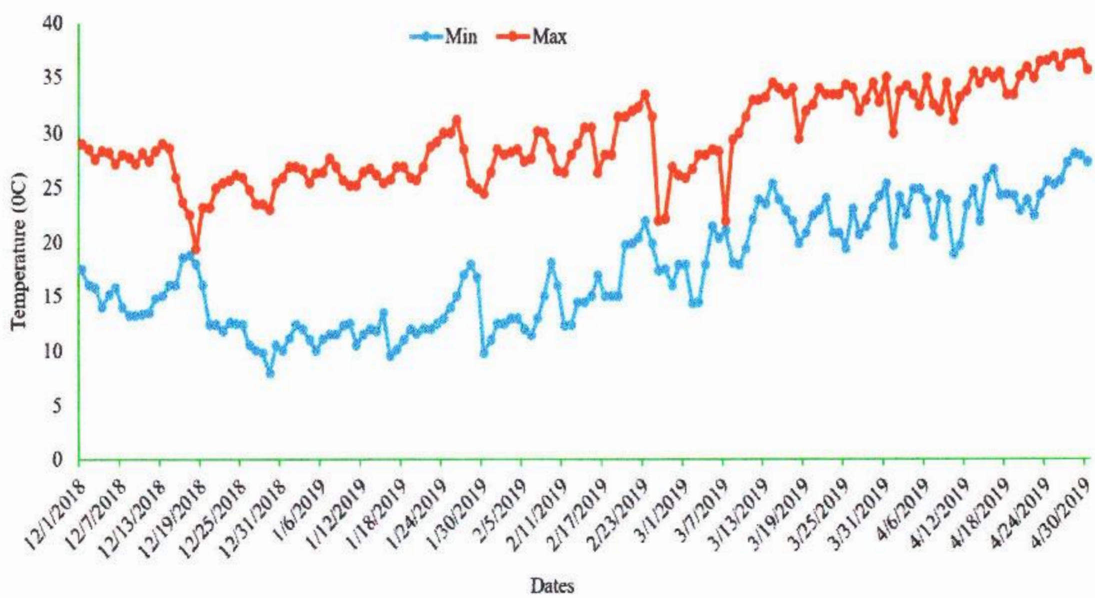

Figure 1: Maximum and minimum temperature pattern during the growing period (Dec '18-Apr '19) in the experimental area.

Relative humidity: The average relative humidity of December 2018, January 2019, February 2019, March 2019 and April 2019 was 79.5%, 76%, and 68.5%, 70% and 72% respectively. Initially the relative humidity was high then decreased gradually up to March again increased (Fig. 2).

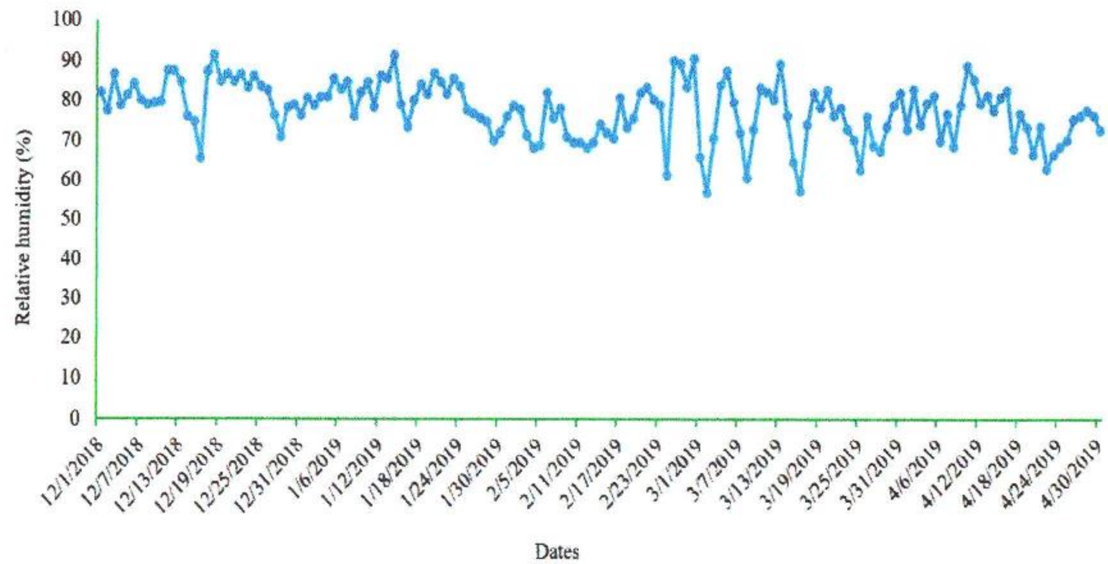

Figure 2: Relative humidity pattern during the growing period (Dec '18-Apr '19) in the experimental area.

Rainfall:

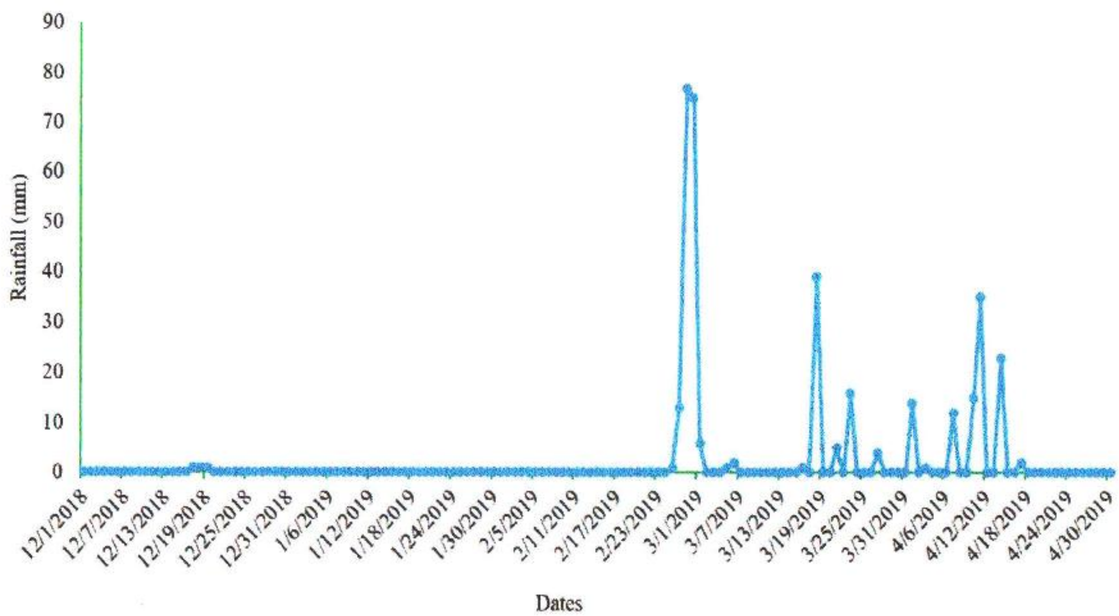

Figure 3: Rainfall pattern during the growing period (Dec '18-Apr '19) in the experimental area.

3.3 Water salinity

The salinity level of the river, canal, pond and tube-well water have been presented in figure 4. The salinity levels of the river water gradually increased with the progress of dry season. The water salinity in the river, canal and pond are more or less similar but after the heavy rainfall in the last week of February the salinity level decreased and then increased but not beyond the limit. In the experimental plot canal was used as the source of irrigation. The canal was managed by disconnected it from the river during the middle of December.

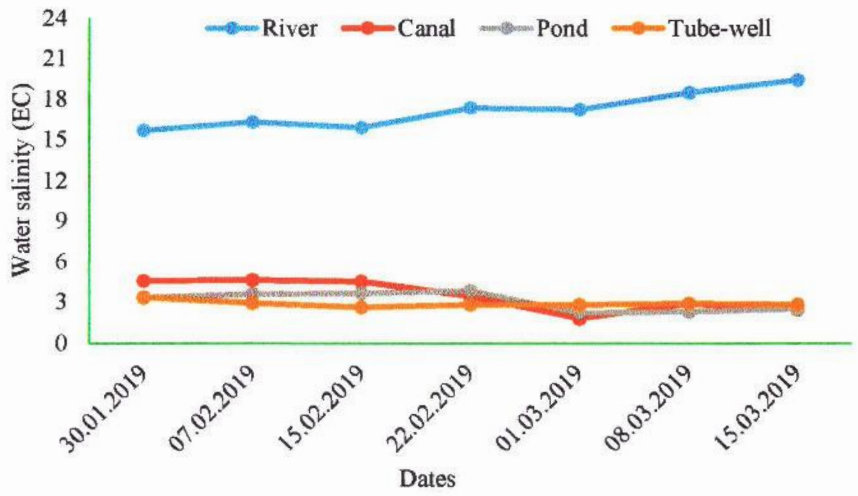

Figure 4: Salinity level of water at different sources with the progress of time

3.4 Experimental design and treatments

The experiment was carried out in factorial randomized complete block design (RCBD) with three replications. Treatments were three transplanting dates and two seedling age that means six different treatments combinations were replicated three times. The total experimental plots were 18 and the size was $12m^2$ (4 m× 3 m). Replication to replication distance was 1.5 m and plot to plot distance was maintained 1.0 m.

Factor-A (Seedling age) | **Factor-B** (Transplanting dates)

S_1 = 14 days | T_1 = 25th December

S_2 = 21 days | T_2= 5th January

T_3 = 15th January

Thus the treatment combinations were: T_1S_1, T_1S_2, T_2S_1, T_2S_2, T_3S_1 and T_3S_2. Seeds were sown in the poly bag before 14 or 21 days of each transplanting date, i.e., for each transplanting date, there were two sowings in the poly bag maintaining the depth of 2 inch. The seeds required four to five days for emergence.

3.5 Experimental details and crop management

The previous crop was BR23, a long duration HYV rice, harvested during mid-December 2018. After rice harvest the field was with ~2-3 cm standing water. The variety of sunflower was Hysun 33 (Hybrid). The seedling was raised in polythene bags (perforation at the bottom) in Khulna University campus. The media of the seedling was 50% of each soil and compost mixture. Two seeds were sown in each poly bag. After emergence of seedlings one seedling was removed carefully leaving the healthy one. No additional fertilizer was added to the polybag soil. Frequent irrigation was applied to the polybag when necessary depending on the soil moisture status.

Seed sown in the polybag: Seeds were sown in polybag at every 10 days interval:

***First Transplanting*: (25th December 2018)**

14 days old seedling was sown on 11 December 2018

21 days old seedling was sown on 04 December 2018

huge rainfall and the field was completely waterlogged. Water from the field was drained out using shallow pump and it was taken around 3 days for the removal of standing water. After that internal drain was prepared for the drain out of excess water from the field.

3.6 Harvesting and postharvest operations

The crop was harvested when the plants were dried and feathery like appendages about to fall down from the disk. Then plants of first transplanting (25^{th} December 2018) were harvested on 2^{nd} April 2019, plants of second transplanting (5^{th} January 2019) were harvested on 12^{th} April 2019 and the plants of third transplanting (15^{th} January 2019) were harvested on 20^{th} April 2019. Seven heads were selected randomly from each plot and tagged properly. Seeds from the disks were separated manually. The grains were cleaned, sun dried and calculated to ton on a hectare basis. Finally, straw yields of each treatment was determined on dry weight basis and converted to t ha^{-1}.

3.6.1 Physiological maturity and harvest of crop

Physiological maturity was recorded when more than 85% of the heads turn yellow and their bracts started turning brownish in color. 7 days after physiological maturity, 10 plants randomly selected from the inner line in each plot and then cut the selected plants. After that the disk was separated from the plant and kept on the clean net (2-3 days) for sun drying. The remaining parts of the plants after separation of disk was also kept on the field (2-3 days) for sun drying. Finally the seeds from the disk separated manually.

3.7 Data collection and calculation

3.7.1 Plant height (cm)

The height of plant was recorded in centimeter (cm) at the time of 25, 35, 45, 55, 65 and 75 days after transplanting (DAT) and at harvest. Five plants were selected randomly from the each plot avoiding the side line for data collection. Data were recorded from the five individual plant of each plot carefully. The plants were tagged in white rope in order to detect them for future data collection. A large scale was used in measuring the height of the plant. The height was measured from the ground level to the tip of the plant leaf. Finally the average plant height was calculated from the collected data.

3.7.2 Number of leaf

The number of leaf was counted and recorded from five randomly selected plants at the time of 25, 35, 45, 55, 65 and 75 DAT. Data were recorded carefully by counting all leaf number from the five plants of each plot and then calculate the mean value for analysis.

3.7.3 Stem diameter (cm)

The stem diameter was measured by measuring tape from five plants at the time of 25, 35, 45, 55, 65and 75 DAT and at harvest. Data were recorded carefully from the five plants of each plot and finally measured the average value of stem diameter.

3.7.4 First heading

Heading was visually observed and recorded from the five plants and noted the date of first heading.

3.7.5 First flowering

Flowering was visually observed and recorded from the three plant and noted the date of first flowering.

3.7.6 Head diameter (cm)

Head diameter was measured from the ten randomly selected head by measuring tape and recorded them carefully and finally calculated the mean value.

3.7.7 Head circumference (cm)

Head circumference was measured from the randomly selected ten head and recorded. Finally the average value of the head circumference was calculated.

3.7.8 Filled seed head^{-1}

The numbers of total filled seed from the ten selected plants were counted and their mean was calculated.

3.7.9 Unfilled seed head^{-1}

The total number of total unfilled seed from the selected ten plants were counted and their mean was calculated.

3.7.10 1000-seed weight (g)

Thousand seeds were randomly counted from the harvested seed of the different treatment. Then weight of 1000 seeds was taken with the help of electric balance.

3.7.11 Seed yield (t ha^{-1})

The seeds from the selected ten plant was measured and the seed yield of sunflower can be calculated by number of plants per plot and then calculated in 12 m^2 and then converted in hectare.

3.7.12 Stover yield (t ha^{-1})

Stover yield was measured and recorded for the selected plants using a balance. Then it converted into t ha^{-1}.

3.7.13 Biological yield (t ha^{-1})

Seed yield and stover yield were together considered as biological yield. Biological yield was calculated by following formula:

Biological yield (t/ha) = Seed yield (t/ha) + Stover yield (t/ha)

3.7.14 Harvest index (%)

Harvest index (%) is the ratio of the seed yield to biological yield and was calculated using the following formula:

Harvest index (%) = (Seed yield/ Biological yield) × 100

For the calculation of biological yield and harvest index the grain and stover was dried in oven at 70° C for 72 hours.

3.8 Statistical analysis

The collected, calculated and recorded data on different parameters were compiled and statistically analyzed following the analysis of variance techniques (two-way ANOVA) by using 'Statistix 10' a statistical software. The significant differences among the treatment means were compared following all pair wise comparison by least significant different (LSD).

CHAPTER IV

RESULTS

4.1. Effect of transplanting dates and seedling age on growth parameters of sunflower

4.1.1. Plant height (cm)

Transplanting date

Plant height showed significant difference (*$p \leq 0.05$* and *$p \leq 0.01$*) among the transplanting dates at different dates after transplanting (DAT) and at harvest (Table 2) except at 25 DAT.

At 25 DAT numerically the tallest plant (24.74 cm) was recorded from 25th December transplanting (T_1) while the shortest (21.55 cm) was found in 15th January transplanting (T_3). At 35 DAT, the highest plant height (45.66 cm) was found in 25th December transplanting (T_1) which was statistically similar to 5th January transplanting (T_2) and the shortest (37.61 cm) was found in 15th January transplanting (T_3).

At 45 DAT, the plant height varied from 59.35 cm to 69.15 cm. The maximum plant height (69.15 cm) was recorded from 25th December transplanting which was statistically at par with 5th January transplanting (T_2) whereas, the minimum (59.35 cm) was found from 15th January transplanting (T_3). At 55 DAT 25th December transplanting (T_1) produced the tallest plant (92.24 cm) which was statistically identical to 5th January transplanting (T_2) while the shortest (78.38 cm) was found in 15th January transplanting (T_3).

At 65 DAT, the tallest plant (99.43 cm) was found in the transplanting date of 25th December (T_1) which was statistically at par 5th January (T_2) transplanting and the shortest (87.53 cm) was found in of 15th January transplanting (T_3). At 75 DAT the highest plant (102.77 cm) height was observed in the planting date of 25th December (T_1) which was statistically identical to 5th January transplanting (T_2) while the lowest plant height (91.36 cm) was recorded from the transplanting on 15th January (T_3).

At harvest the uppermost plant height (108.66 cm) was observed from 25th December transplanting which was statistically similar to 5th January transplanting (T_2) whereas the lowermost (88.53 cm) was recorded from 15th January transplanting (T_3).

Table 2. Effect of different transplanting dates on plant height of sunflower.

Transplanting dates	Plant height (cm)						
	25 DAT	35 DAT	45 DAT	55 DAT	65 DAT	75 DAT	Harvest
25 December	24.74	45.66a	69.15a	92.24a	99.43a	102.77a	108.66a
05 January	24.15	42.51a	66.23ab	88.52a	96.77a	99.83a	99.28ab
15 January	21.55	37.61b	59.35b	78.38b	87.53b	91.36b	88.53b
(Mean ±SE)	*23.48±1.49*	*41.92±1.58*	*64.91±3.30*	*86.38±2.75*	*94.58±3.90*	*97.98±3.19*	*98.81±5.03*
LS	*ns*	**	*	**	*	*	**
CV (%)	*11.02*	*6.56*	*8.82*	*5.53*	*7.16*	*6.53*	*8.83*

**= $p \le 0.05$, **= $p \le 0.01$, ns= non-significant, LS= level of significance and CV= Co-efficient of variation; Data in each column of the table followed similar letter are not significantly different at $p \le 0.05$ significant level according to LSD test.*

Seedlings age

Seedling age had significant influence ($p \le 0.05$ and $p \le 0.01$) on plant height at different DAT and at harvest except at 25 DAT (Table 3). At 25 DAT numerically the taller plant (24.16 cm) was observed in the 14 days seedling (S_1) while the lower one (22.79 cm) was recorded from 21 days seedling (S_2). At 35 DAT, the higher plant height was (44.03 cm) which found in S_1 (seedling age of 14 days) whereas, the lower (39.82 cm) was found in 21 days seedling (S_2).

At 45 DAT, the taller plant (67.93 cm) which was observed in the transplanting age of 14 days seedling (S_1) and the shorter plant was (61.88 cm) found in 14 days seedling (S_2). In 55 DAT, the higher plant (90.58 cm) was observed in the transplanting age of 14 days seedling (S_1) and the lower plant height was (82.17cm) seen in 21 days seedling (S_2). At 65 DAT the taller plant (98.22 cm) was observed in the 14 days seedling (S_1) and the lower plant height (90.94 cm) was recorded in 21 days seedling (S_2).

At 75 DAT, the maximum plant height was (101.77 cm) which recorded from S_1 (transplanting age of 14 days) whereas, the minimum height was (94.20 cm) found in 21 days seedling (S_2). At harvest the taller plant (103.79 cm) was found in 14 days seedling age and the shorter (93.85 cm) was recorded from 21 days seedling (S_2).

Table 3. Effect of different seedling age on plant height of sunflower

Seedling age	Plant height (cm)						
	25 DAT	**35 DAT**	**45DAT**	**55 DAT**	**65 DAT**	**75 DAT**	**Harvest**
14 days	24.16	44.03a	67.93a	90.58a	98.22a	101.77a	103.79a
21 days	22.79	39.82b	61.88b	82.17b	90.94b	94.20b	93.85b
(Mean±SE)	*23.48±1.22*	*41.92±1.29*	*64.91±2.70*	*86.38±2.25*	*94.58±3.19*	*97.98±3.01*	*98.81±7.12*
LS	*Ns*	**	*	**	*	*	*
CV (%)	*11.02*	*6.56*	*8.82*	*5.53*	*7.16*	*6.53*	*8.83*

**= $p \leq 0.05$, **= $p \leq 0.01$, ns= non-significant, LS= level of significance and CV= Co-efficient of variation; Data in each column of the table followed similar letter are not significantly different at $p \leq 0.05$ significant level according to LSD test.*

Interaction of transplanting dates and seedling age

Interaction of transplanting dates and seedling age was not significant effect on plant height at different DAT and at harvest (Table 4).

At 25 DAT the tallest (25.23 cm) plant was observed from the interaction of 25th December transplanting with 21 days seedling age (T_1S_2) while the shortest (20.22 cm) was found from 15th January transplanting with 14 days seedling (T_3S_1). At 35 DAT the tallest plant height (48.81 cm) was seen in the combine effect of transplanting date of 25th December and transplanting age with 14 days seedling (T_1S_1) whereas, the lowest (36.81 cm) was found in the combination of 15th January transplanting with 21 days seedling (T_3S_2).

At 45 DAT the maximum plant height (71.36 cm) was recorded from 25th December transplanting with 14 days seedling (T_1S_1) while the minimum (53.48 cm) was found in 15th January transplanting with 21 days seedling (T_3S_2). At 55 DAT the tallest (96.52 cm) plant was observed from the interaction of 25th December transplanting with 14 days seedling age (T_1S_1) whereas, the smallest plant height (72.00 cm) was recorded from the interaction of 15th January transplanting and 21 days seedling (T_3S_2). At 65 DAT the tallest plant (102.76 cm) was recorded from 25th December transplanting with 14 days seedling (T_1S_1) while the smallest plant (81.95 cm) was found in 15th January transplanting with 21 days seedling (T_3S_2).

At 75 DAT the tallest plant (106.93 cm) was recorded from 25th December transplanting with 14 days seedling (T_1S_1) while the minimum plant height (86.63 cm) was observed from 15th January transplanting with 21 days seedling (T_3S_2). At harvest the maximum plant height (116.86 cm) was recorded from 25th December transplanting with 14 days seedling (T_1S_1) while the minimum (85.43cm) was found in 15th January transplanting with 21 days seedling (T_3S_2). Though the interaction effect had no significant influence on plant height but numerically 25th December transplanting with 14 days seedling produced the tallest plant.

The finding of the experiment regarding plant height revealed that earlier transplanting and younger seedlings performed better over later transplanting and older seedling. In the earlier date the moisture level in the soil facilitate better establishment. Usually in the early age of seedling after emergence (10-15 days after sowing) sunflower requires nitrogen that might be the reason for poor growth of 21 days seedling compared to 14 days seedling.

Table 4. Interaction effect of different transplanting date and seedling age of transplanting on plant height of sunflower

Interaction	Plant height (cm)						
	25 DAT	**35 DAT**	**45 DAT**	**55 DAT**	**65 DAT**	**75 DAT**	**Harvest**
T_1S_1	24.25	48.81	71.36	96.52	102.76	106.93	116.86
T_1S_2	25.23	42.51	66.93	87.97	96.12	98.61	100.46
T_2S_1	23.92	44.87	67.22	90.48	98.78	102.31	102.89
T_2S_2	24.38	40.14	65.24	86.55	94.77	97.35	95.67
T_3S_1	20.22	38.41	65.22	84.74	93.13	96.08	91.62
T_3S_2	22.88	36.81	53.48	72.00	81.95	86.63	85.43
(Mean±SE)	*23.48±2.11*	*41.92±2.24*	*64.91±4.67*	*86.38±3.90*	*94.58±5.52*	*97.98±5.2*	*98.81±7.12*
LS	*Ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
CV (%)	*11.02*	*6.56*	*8.82*	*5.53*	*7.16*	*6.53*	*8.83*

ns= non-significant, LS= level of significance and CV= Co-efficient of variation;

T_1S_1= 25th December transplanting with 14 days seedling, T_1S_2= 25th December transplanting with 21 days seedling
T_2S_1=5th January transplanting with 14 days seedling, T_2S_2=5th January transplanting with 21 days seedling
T_3S_1= 15th January transplanting with 14 days seedling, T_3S_2=15th January transplanting with 21 days seedling

4.1.2. Leaf number

Transplanting date

Transplanting dates had significant influence (*$p \leq 0.05$* and *$p \leq 0.01$*) on leaf number of sunflower at different DAT and at harvest except at 25 DAT (Table 5).

At 25 DAT numerically the maximum leaf number (12) was recorded from 25th December planting (T_1) while the minimum (11.16) was found in 15th January transplanting (T_3). In 35 DAT, the highest leaf number (17.83) was recorded in T_1 (transplanting date of 25th December) which was statistically similar to 5th January transplanting (T_2) and the lowest (14.66) was found in transplanting date of 15th January (T_3).

In case of 45 DAT, the maximum number of leaf (23.33) was recorded in the transplanting date of 25th December (T_1) which was statistically similar with transplanted in 5th January (T_2) while the minimum (20.83) was found in transplanting date of 15th January (T_3). At 55 DAT the highest leaf number (25.00) was recorded from 25th December transplanting (T_1) which was statistically at par with transplanted in 5th January (T_2) whereas the lowest leaf number (21.83) was found in 15th January transplanting (T_3).

In 65 DAT, the maximum number of leaf (23.66) was recorded transplanting date of 25th December (T_1) which was statistically similar to 5th January transplanting (T_2) whereas the lowest (19.16) was recorded in transplanting date of 15th January (T_3). At 75 DAT the highest number of leaf (22.50) was observed in the transplanting date of 25th December (T_1) while the lowest (16.83) was recorded from the transplanting date of 15th January (T_3).

Table 5. Effect of different transplanting dates on leaf number of sunflower

Transplanting date	Leaf Number					
	25DAT	**35 DAT**	**45DAT**	**55 DAT**	**65 DAT**	**75 DAT**
25 December	12.00	17.83a	23.33a	25.00a	23.66a	22.50a
5 January	11.50	17.00ab	22.16ab	23.16ab	22.00a	19.50b
15 January	11.16	14.66b	20.83b	21.83b	19.16b	16.83c
(Mean±SE)	*11.55±0.51*	*16.50±1.10*	*22.11±0.68*	*23.33±0.95*	*21.61±0.89*	*19.61±1.17*
LS	*ns*	*	*	*	**	**
CV (%)	*7.69*	*11.55*	*5.33*	*7.09*	*7.20*	*10.35*

*= $p \leq 0.05$, **= $p \leq 0.01$, *ns= non-significant, LS= level of significance and CV= Co-efficient of variation; Data in each column of the table followed similar letter are not significantly different at* $p \leq 0.05$ *significant level according to LSD test.*

Seedlings age

The results of study showed that seedling age had significant ($p \leq 0.05$ and $p \leq 0.01$) effect on leaf number plant^{-1} at different DAT and at harvest (Table 6).

At 25 DAT the maximum leaf number (12.11) was recorded in the 14 days seedling (S_1) while the minimum (11.00) was found in 21 days seedling (S_2). At 35 DAT, the highest leaf number (17.77) which found in transplanting age of 14 days (S_1) and the lowest leaf number was (15.22) observed in 21 days seedling (S_2).

In case of 45 DAT, the highest leaf number (22.77) was found from 14 days old seedling (S_1) and the lowest (21.44) was recorded from 21 days seedling (S_2). At 55 DAT the highest leaf number (24.44) was recorded in the 14 days seedling (S_1) while the lowest (22.22) was noticed in 21 days seedling (S_2).

At 65 DAT, the maximum number of plant leaf was (23.11) which found in the 14 days seedling age (S_1) while the minimum (20.11) was recorded from 21 days seedling (S_2). At 75 DAT the maximum leaf number (21.33) was observed in the 14 days seedling (S_1) while the minimum number (17.88) was recorded in 21 days seedling (S_2).

Table 6. Effect of different seedling age on leaf number of sunflower

Seedling age	Leaf number					
	25 DAT	**35 DAT**	**45DAT**	**55 DAT**	**65 DAT**	**75 DAT**
14 days	12.11a	17.77a	22.77a	24.44a	23.11a	21.33a
21 days	11.00b	15.22b	21.44b	22.22b	20.11b	17.88b
(Mean±SE)	*11.55±0.41*	*16.50±0.89*	*22.11±0.55*	*23.33±0.77*	*21.61±0.73*	*19.61±0.95*
LS	*	**	*	*	**	**
CV (%)	*7.69*	*11.55*	*5.33*	*7.09*	*7.20*	*10.35*

**= $p \leq 0.05$, **= $p \leq 0.01$, ns= non-significant, LS= level of significance and CV= Co-efficient of variation; Data in each column of the table followed similar letter are not significantly different at $p \leq 0.05$ significant level according to LSD test.*

Interaction of transplanting date and seedling age

The interaction of transplanting dates and seedling age had no significant effect on number of leaf number at different DAT and at harvest (Table 7).

At 25 DAT the numerically maximum number of leaf (12.66) was observed from the interaction of 25th December transplanting with 21 days seedling age (T_1S_2) while the minimum number of leaf (10.66) was recorded from combine interaction of 15th January transplanting and 14 days seedling (T_3S_1). At 35 DAT the highest number of leaf (19.00) was recorded from 25th December transplanting with 21 days seedling (T_1S_2) whereas, the lowest leaf number (13.33) was found from 15th January transplanting with 14 days seedling (T_3S_1).

At 45 DAT the height leaf number (24.33) was recorded from 25th December transplanting with 14 days seedling (T_1S_1) whereas, the lowest (20.66) was found in 15th January transplanting with 21 days seedling (T_3S_2). At 55 DAT the maximum number of leaf (26.66) was observed from the interaction of 25th December transplanting with 14 days seedling age (T_1S_1) while the minimum number of leaf (21.00) was recorded from combine interaction of 15th January transplanting and 21 days seedling (T_3S_2).

At 65 DAT the numerically maximum number of leaf (25.00) was observed from the interaction of 25th December transplanting and 14 days seedling age (T_1S_1) whereas, the minimum number of leaf (17.66) was recorded from combine interaction of 15th January transplanting with 21 days seedling (T_3S_2) .At 75 DAT the maximum number of leaf (25.00) was recorded from 25th December transplanting with 14 days seedling (T_1S_1). And the minimum (16.00) was found from 15th January transiting with 21 days seedling (T_3S_2).

Table 7. Interaction effect of transplanting dates and seedling age on leaf number of sunflower

Interaction	**Leaf Number**					
	25 DAT	**35 DAT**	**45 DAT**	**55DAT**	**65 DAT**	**75 DAT**
T_1S_1	11.33	16.66	24.33	26.66	25.00	25.00
T_1S_2	12.66	19.00	22.33	23.33	22.33	20.00
T_2S_1	11.00	15.67	23.00	24.00	23.66	21.33
T_2S_2	12.00	18.33	21.33	22.33	20.33	17.66
T_3S_1	10.66	13.33	21.00	22.66	20.66	17..66
T_3S_2	11.67	16.00	20.66	21.00	17.66	16.00
(Mean±SE)	*11.55±0.72*	*16.50±1.55*	*22.11±0.96*	*23.33±1.34*	*21.61±1.27*	*19.61±1.66*
LS	*ns*	*Ns*	*ns*	*ns*	*ns*	*ns*
CV (%)	*7.69*	*11.55*	*5.33*	*7.09*	*7.20*	*10.35*

ns= non-significant, LS= level of significance and CV= Co-efficient of variation;

T_1S_1= 25th December transplanting with 14 days seedling, T_1S_2= 25th December transplanting with 21 days seedling
T_2S_1=5th January transplanting with 14 days seedling, T_2S_2=5th January transplanting with 21 days seedling
T_3S_1= 15th January transplanting with 14 days seedling, T_3S_2=15th January transplanting with 21 days seedling

4.1.3 Stem diameter (cm)

Transplanting date

Stem diameter had significant effect (*$p \leq 0.05$* and *$p \leq 0.01$*) except at 65 DAT in response of different transplanting dates of the sunflower (Table 8).

At 25 DAT the maximum stem diameter (2.35 cm) was recorded from 25th December planting (T_1) while the minimum (2.00 cm) was found in 15th January transplanting (T_3). In 35 DAT, the maximum stem diameter (3.56 cm) was observed in 25th December transplanting (T_1) which was statistically similar with 5th January transplanting (T_2) whereas, the minimum (3.08 cm) was found in the transplanting date of 15th January (T_3).

In case of 45 DAT the maximum stem diameter (5.33 cm) was recorded from the transplanting date of 25th December (T_1) which was statistically at par with 5th January transplanting (T_2) whereas, the minimum (4.63 cm) was found in transplanting date of 15th January (T_3). At 55 DAT the highest stem diameter (6.41 cm) was recorded from 25th December transplanting (T_1) which was statistically identical to 5th January transplanting (T_2) while the lowest (5.34 cm) was found in 15th January transplanting (T_3). In 65 DAT, the maximum stem diameter (6.86 cm) was observed in the transplanting date of 25th December (T_1) and the minimum stem diameter (6.38 cm) was seen in transplanting date of 15th January (T_3).

At 75 DAT the highest stem diameter (7.47 cm) was observed in the transplanting date of 25th December (T_1) which was statistically similar with 5th January transplanting (T_2) whereas, the lowest (6.81 cm) was found in 15th January (T_3) transplanting. At harvest the topmost stem diameter (7.47 cm) was observed from 25th December transplanting which was statistically at par to 5th January transplanting whereas the lowermost (6.72 cm) was recorded from 15th January transplanting.

Table 8. Effect of different transplanting dates on stem diameter of sunflower

Transplanting dates	**Stem Diameter (cm)**						
	25DAT	**35DAT**	**45DAT**	**55DAT**	**65DAT**	**75DAT**	**Harvest**
25 December	2.35a	3.56a	5.33a	6.41a	6.86	7.47a	7.47a
5 January	2.23b	3.35ab	5.09a	6.09a	6.75	7.19ab	7.32a
15 January	2.00c	3.08b	4.63b	5.34b	6.38	6.81b	6.72b
(Mean±SE)	*2.19±0.05*	*3.33±0.13*	*5.02±0.14*	*5.94±0.18*	*6.66±0.22*	*7.16±0.21*	*7.16±0.22*
LS	**	*	**	**	*ns*	*	*
CV (%)	*4.22*	*6.85*	*5.13*	*5.26*	*5.79*	*5.22*	*5.37*

**= $p \leq 0.05$, **= $p \leq 0.01$, ns= non-significant, LS= level of significance and CV= Co-efficient of variation; Data in each column of the table followed similar letter are not significantly different at $p \leq 0.05$ significant level according to LSD test.*

Seedling age

Seedling age had significant effect ($p \leq 0.05$ and $p \leq 0.01$) on stem diameter at different DAT (Table 9).

At 25 DAT the maximum stem diameter (2.24 cm) was recorded from 14 days seedling (S_1) while the minimum (2.15 cm) was observed from 21 days seedling (S_2). In case of 35 DAT, the largest stem diameter (3.44 cm) was found in seedling age of 14 days (S_1) whereas, the smallest stem (3.21 cm) observed from 21 days seedling (S_2).

In 45 DAT, the highest stem diameter was (5.16 cm) which observed in the 14 days seedling (S_1) and the lowest was (4.88 cm) recorded from 14 days seedling (S_2). At 55 DAT the maximum stem diameter (6.07 cm) was recorded from 14 days seedling (S_1) while the minimum (5.82 cm) was noticed from 21 days seedling (S_2). In case of 65 DAT, the highest stem diameter (6.92 cm) which was found in the 14 days seedling age (S_1) and the lowest diameter was (6.40 cm) observed from 14 days seedling (S_2).

At 75 DAT largest stem diameter (7.36 cm) was observed in the 14 days seedling (S_1) and the minimum (6.96 cm) was recorded in 21 days seedling (S_2). At harvest the highest stem diameter (7.51 cm) was noted from 14 days seedling (S_1) while the lowest stem diameter (6.83 cm) was found from 21 days seedling (S_2).

Table 9. Effect of different seedling age on stem diameter of sunflower

Seedling age	**Stem Diameter**						
	25 DAT	**35 DAT**	**45 DAT**	**55 DAT**	**65 DAT**	**75 DAT**	**Harvesting**
14 days	2.24	3.44	5.16a	6.07	6.92a	7.36a	7.51a
21 days	2.15	3.21	4.88b	5.82	6.40b	6.96b	6.83b
(Mean±SE)	*2.19±0.04*	*3.33±0.10*	*5.02±0.12*	*5.94±0.14*	*6.66±0.18*	*7.16±0.17*	*7.16±0.18*
LS	*Ns*	*Ns*	*	*ns*	*	*	**
CV (%)	*4.22*	*6.85*	*5.13*	*5.26*	*5.79*	*5.22*	*5.37*

*= $p \leq 0.05$, **= $p \leq 0.01$, *ns= non-significant, LS= level of significance and CV= Co-efficient of variation; Data in each column of the table followed similar letter are not significantly different at* $p \leq 0.05$ *significant level according to LSD test.*

Interaction of transplanting date and seedling age

The study showed that combined effect of transplanting dates and seedling age had no significant impact on stem diameter at different DAT and at harvest. Only att 25 DAT the interaction effect had significant influence ($p \leq 0.05$) of (Table 10).

At 25 DAT the maximum stem diameter (2.49 cm) was observed from the interaction of 25th December transplanting with 14 days seedling age (T_1S_1) while the minimum (1.95 cm) was recorded from the interaction of 15th January transplanting with 14 days seedling (T_3S_1) which was statistically similar with 15th January transplanting with 21 days seedling (T_3S_2).

At 35 DAT the highest stem (3.72 cm) was found in the interaction of transplanting date of 25th December transplanting with age of 14 days seedling (T_1S_1) while the lowest (3.03 cm) was noted in the transplanting date of 15th January with 21 days seedling (T_3S_2). At 45 DAT the maximum stem diameter (5.62 cm) was recorded from 25th December transplanting with 14 days seedling (T_1S_1) while the minimum (4.63 cm) was seen in 15th January transplanting with 14 days seedling (T_3S_1).

At 55 DAT the maximum stem diameter (6.66 cm) was found from the interaction of 25th December transplanting with 14 days seedling age (T_1S_1) while the minimum (5.22 cm) was observed from combine interaction of 15th January transplanting and 21 days seedling (T_3S_2). At 65 DAT the maximum stem diameter (7.21 cm) was recorded from 25th December transplanting with 14 days seedling (T_1S_1) whereas, the smallest (6.10 cm) was found in 15th January transplanting with 21 days seedling (T_3S_2).

At 75 DAT the largest stem diameter (7.71 cm) was noted from 25th December transplanting with 14 days seedling (T_1S_1) while the lowest (6.60 cm) was observed from 15th January transplanting with 21 days seedling (T_3S_2). At harvest the maximum plant height (7.90 cm) was recorded from 25th December transplanting with 14 days seedling (T_1S_1) whereas, the minimum (6.28 cm) was found in 15th January transplanting with 21 days seedling (T_3S_2).

Table 10. Interaction effect of transplanting date and seedling age on stem diameter of sunflower

Interaction	Stem diameter						
	25 DAT	**35 DAT**	**45 DAT**	**55 DAT**	**65 DAT**	**75 DAT**	**Harvest**
T_1S_1	2.49a	3.72	5.62	6.66	7.21	7.71	7.90
T_1S_2	2.22b	3.41	5.05	6.16	6.51	7.24	6.73
T_2S_1	2.28b	3.49	5.22	6.12	6.90	7.34	7.47
T_2S_2	2.18bc	3.21	4.95	6.06	6.61	7.04	7.48
T_3S_1	1.95d	3.12	4.63	5.45	6.65	7.03	7.16
T_3S_2	2.05cd	3.03	4.64	5.22	6.10	6.60	6.28
(Mean±SE)	*2.19±0.07*	*3.33±0.18*	*5.02±0.21*	*5.94±0.25*	*6.66±0.31*	*7.16±0.30*	*7.16±0.31*
LS	*	*ns*	*ns*	*ns*	*ns*	*ns*	*Ns*
CV (%)	*4.22*	*6.85*	*5.13*	*5.26*	*5.79*	*5.22*	*5.37*

**= $p \leq 0.05$, ns= non-significant, LS= level of significance and CV= Co-efficient of variation; Data in each column of the table followed similar letter are not significantly different at $p \leq 0.05$ significant level according to LSD test.*

T_1S_1= 25th December transplanting with 14 days seedling, T_1S_2= 25th December transplanting with 21 days seedling
T_2S_1=5th January transplanting with 14 days seedling, T_2S_2=5th January transplanting with 21 days seedling
T_3S_1= 15th January transplanting with 14 days seedling, T_3S_2=15th January transplanting with 21 days seedling

4.2 Effect of transplanting date, seedling age and their interaction on phenology of sunflower

4.2.1 Days to first heading

Transplanting date

First heading of sunflower varied significantly ($p<0.001$) among the transplanting dates (Fig. 5A). The difference in days to first heading due to transplanting date ranged from 34.50 to 41.50 days. Transplanting at 25th December (T_1) required more time (41.50 days) for first heading while transplanting at 15th January (T_3) required less time (34.50 days) for first heading.

Seedling age

The result showed that seedling age significantly influenced ($p<0.001$) first heading of sunflower (Fig. 5B). Seedling age of 14 days (S_1) required more time (39.67 days) for first heading whereas 21 days seedling (S_2) required less time (36.11 days) for first heading.

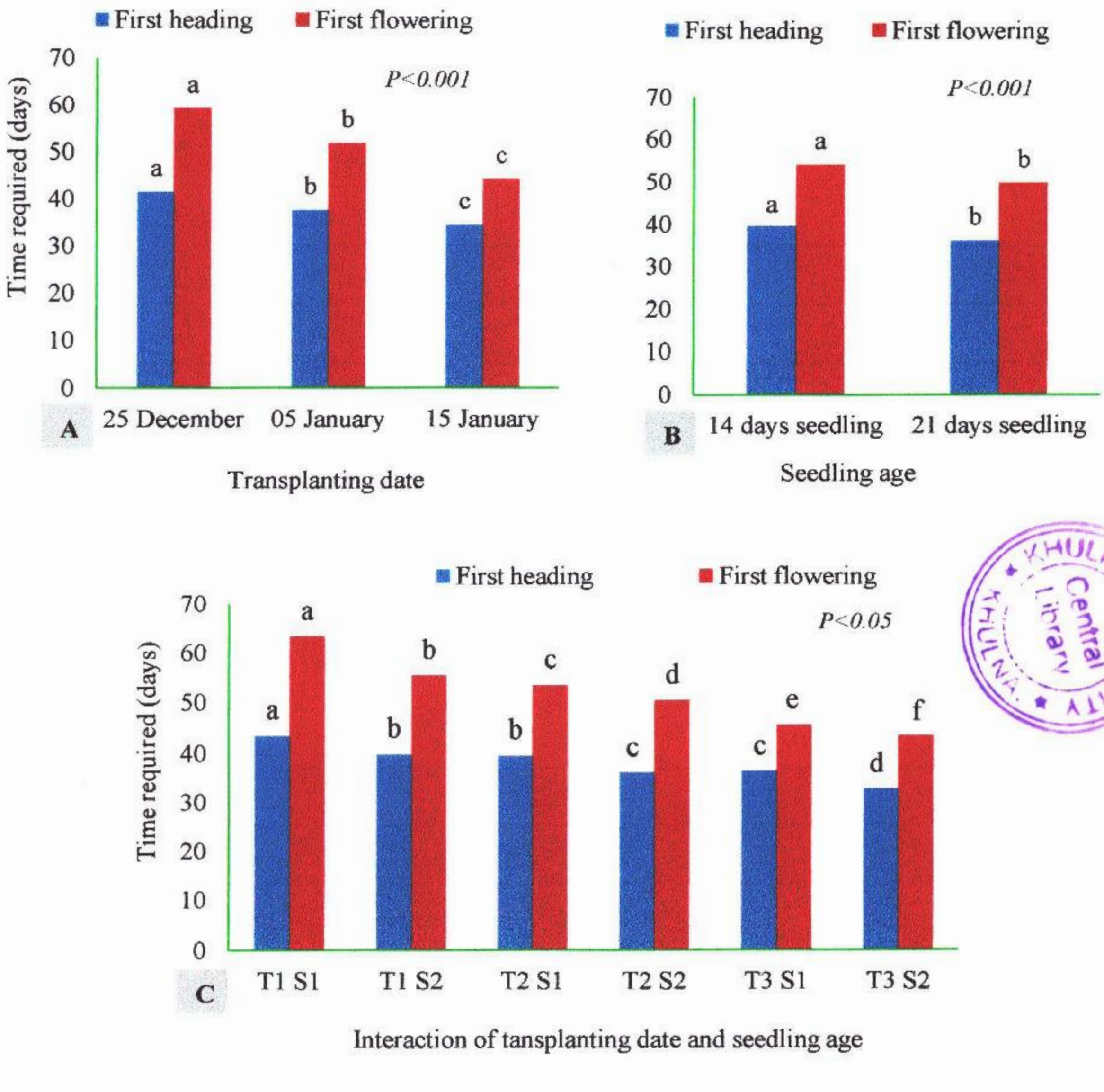

Figure 5: Effect of transplanting date (A), seedling age (B) and their interaction (C) on first heading (DAT) and first flowering (DAT) of sunflower grown in the southwestern coastal soil.

Interaction of transplanting date and seedling age

The combine effect of transplanting date and seedling age had significant effect (Fig. 5C) on first heading of sunflower. The effect of transplanting date and seedling age on first heading ranged from 32.67 to 43.33 days. The maximum time required for first heading (43.33 days) recorded from the combined effect of 25th December transplanting and 14 days seedling (T_1S_1) and minimum time (32.67 days) was observed in transplanting at 15th January and seedling age 21 days (T_3S_2).

4.2.2 Days to first flowering

Transplanting date

The result regarding first flowering of sunflower showed significant differences *($p \leq 0.001$)* among transplanting dates (Figure 5A). The difference in first flowering of three transplanting dates ranged from 44.33 days to 59.33 days. Transplanting at 25th December (T_1) required maximum time (59.33 days) for first flowering while minimum time (44.33 days) was noticed in 15th January (T_3) transplanting at needed for first heading.

Seedling age

Seedling age affected significantly *($p \leq 0.001$)* in date required for first flowering of sunflower (Figure 5B). 14 days seedling (S_1) required more time (54.00 days) for first heading. And S_2 (21 days seedling) required less time (49.67 days) for first heading.

Interaction effect of transplanting date and seedling age

The interaction effect of transplanting date and seedling age had significant *($p \leq 0.001$)* effect (Figure 5C) on first flowering of sunflower. The effect of transplanting date and seedling age in first flowering date ranged from 43.33 to 63.33 days. The maximum time required (63.33 days) for first flowering in the combined effect of 25th December transplanting with and 14 days seedling

(T_1S_1) while minimum time (43.33 days) recorded from 15th January transplanting with 21 days seedling.

4.3 Yield contributing component

4.3.1 Head diameter (cm)

Transplanting date

Head diameter among different transplanting dates varied significantly *($p \leq 0.01$)* (Table 11). The mximum head diameter (15.09 cm) was found in 25th December (T_1) transplanting which was statistically similar with 5th January transplanting (T_2). On the other hand the lowest head diameter (11.56 cm) was observed in 15th January transplanting (T_3).

Seedling age

Seedling age had significant effect ($p<0.01$) on head diameter. The effect of seedling age was significant at 1% level on head diameter (Table 12). The maximum head diameter (14.60 cm) was found in 14 days seedling (S_1) while the minimum (12.46 cm) was recorded 21 days seedling from in S_2().

Interaction of transplanting date and seedling age

The interaction of transplanting date and seedling age had no significant effect on head diameter of sunflower (Table 13). The head diameter varied from 10.89 cm to 16.46 cm. The largest head (16.46 cm) was recorded from 25th December transplanting with 14 days seedling (T_1S_1) whereas the smallest (10.89 cm) was observed in 15th January transplanting with 21 days seedling (T_3S_2).

4.3.2 Head Circumference

Transplanting date

Head circumference under different transplanting date showed significant variation ($p<0.01$) (Table 11). The maximum head circumference (47.74 cm) was recorded from of 25th December transplanting (T_1)which was statistically at par with 5th January transplanting and the minimum (38.69 cm) was observed from 15th January transplanting (T_3).

Seedling age

Head circumference was varied significantly (*$p<0.05$*) at different age of seedling (Table 12). The maximum head circumference (46.03 cm) was recorded in 14 days seedling (S_1) while the minimum (41.70 cm) was recorded from 21 days seedling (S_2).

Interaction of transplanting date and seedling age

The interaction of transplanting date and seedling age had non-significant effect on head circumference of sunflower (Table 13). 25th December transplanting with 14 days seedling (T_1S_1) provide the largest head circumference (50.44 cm) while the lowest (36.90 cm) was observed from T_3S_2 15th January transplanting with 21 days seedling.

4.3.3 Number of filled seed head^{-1}

Transplanting date

Number of filled seeds head^{-1} varied significantly *($p\leq 0.001$)* among the transplanting dates (Table 11). The maximum number of filled seeds head^{-1} (758.17) was recorded from the transplanting date of 25th December (T_1) whereas, the minimum (497.83) was obtain from 15th January transplanting (T_3).

Seedling age

Seedling age had significant influence *($p\leq 0.001$)* on filled seeds head^{-1}. The number of filled seeds head^{-1} ranged from 561.67 to 711.44.t seedling age (Table 12). The maximum number of filled seed head^{-1} (711.44) was observed in 14 days seedling (S_1) while the minimum (561.67) was found in 21 days seedling (S_2).

Interaction effect of transplanting date and seedling age

Interaction of transplanting dates and seedling age had significant (*$p \leq 0.001$*) effect on number of filled seed head^{-1} (Table 13). The number of maximum seed head^{-1} (876.00) was obtained from 25th December transplanting with 14 days seedling (T_1S_1) while the minimum (450.33) was counted in 15th January transplanting with 21 days seedling (T_3S_2).

4.3.4 Number of unfilled seed head^{-1}

Transplanting date

Number of unfilled seeds head^{-1} did not vary significantly due to different transplanting dates (Table 11). The number of unfilled seeds head^{-1} varied from 47.50 to 63.50. The highest number of unfilled seeds head^{-1} (63.50) was found from the transplanting date of 15th January (T_3) and the lowest (47.50) was obtained from 25th December transplanting (T_3).

Seedlings age

No significant variation was found in case of number of unfilled seeds head^{-1} due to the seedling age (Table 12). The number of unfilled seeds head^{-1} varied from 44.33 to 65.00. The maximum number of unfilled seed head^{-1} (65.00) was counted in 14 days seedling (S_1) while the minimum (44.33) was recorded from 21 days seedling (S_2).

Interaction effect of transplanting date and seedling age

The combine effect of transplanting date and seedling age had no significant influence on number of unfilled seed head^{-1} (Table 13).The number of unfilled seed head^{-1} varied from 29.33 to 76.66. The number of highest unfilled seed head^{-1} (76.66) was obtained from the transplanting date of 15th January with 14 days seedling (T_3S_1) whereas the lowest (29.33) was counted from 15th January transplanting with 21 days seedling (T_3S_2).

4.3.5 Stover yield (t ha^{-1})

Transplanting date

The data in table 11 regarding stover showed significant *($p \leq 0.05$)* difference at different dates transplanting. The highest stover yield was (3.78 t ha^{-1}) was obtained from 25th December transplanting (T_1) which was statistically similar with 5th January transplanting (T_2) while the lowest (2.94 t ha^{-1}) was obtain from 15th January transplanting (T_3).

Seedlings age

Seedling age had non-significant effect on stover yield. Between the two seedling ages the highest stover yield (3.41 t ha^{-1}) was obtained from 14 days seedling (S_1) and the lowest (3.14 t ha^{-1}) was recorded from 21 days seedling (S_2).

Interaction of transplanting date and seedling age

Stover yield had no significant differences due to the combined effect of transplanting dates and seedling age (Table 13). The stover yield varied from 2.85 to 4.08 t ha^{-1}. The maximum stover yield 4.08 t ha^{-1} was observed in 25th December transplanting with 14 days seedling (T_1S_1) while the minimum (2.85 t ha^{-1}) was found in 15th January transplanting with 14days seedling (T_3S_1).

4.3.6 1000-Seed weight

Transplanting date

Different transplanting date had significant *($p \leq 0.001$)* effect on 1000-seed weight (Table 11). The seed weight varied from 50.42 g to 57.33 g. The maximum 1000-seed weight (57.33 g) was found in 25th December transplanting (T_1) whereas the minimum (50.42 g) was observed in 15th January transplanting (T_3).

Seedlings age

1000 seed weight of sunflower varied significantly ($p \leq 0.001$) due to the seedling age (Table 12). The highest 1000-seed weight (56.11 g) was found in 14 days seedling (S_1) while the lowest (49.94 g) was found from 21 days seedling (S_2).

Interaction effect of transplanting date and seedling age

The interaction of transplanting date and seedling age had significant ($p \leq 0.001$) effect on 1000-seed weight of sunflower (Table 13). The 1000-seed weight varied from 44.33 g to 58.83 g. The highest seed weight of 1000-seed (58.83 g) was found in transplanting date of 25th December with 14 days seedling (T_1S_1) whereas the lowest (44.33 g) was observed in 15th January transplanting with 21 days seedling (T_3S_2).

4.3.7 Seed yield (t ha^{-1})

Transplanting date

Transplanting dates had highly significant ($p \leq 0.001$) effect on seed yield of sunflower (Fig. 6A).The maximum seed yield (2.60 t ha^{-1}) was obtained from 25th December transplanting (T_1) while the minimum (1.67 t ha^{-1}) was obtained from 15th January transplanting (T_3).

Seedlings age

In case of seedling age seed yield was varied significantly ($p \leq 0.001$) due to the seedling age (Fig. 6B). The maximum seed yield (2.40 t ha^{-1}) was obtained from the 14 days seedling (S_1) and the lowest (1.92 t ha^{-1}) was obtained from 21 days seedling (S_2).

Interaction effect of transplanting date and seedling age

The interaction of transplanting date and seedling age had significant influence ($p \leq 0.001$) on seed yield of sunflower (Figure 6C). The maximum seed yield (2.90 t ha^{-1}) was obtained from the interaction of 25th December transplanting with 14 days seedling (T_1S_1) while the minimum (1.67

t ha^{-1}) was gained from the interactive effect of 15th January transplanting with 21 days seedling (T_3S_2) which was statistically similar with 15th January transplanting with 14 days seedling (T_3S_1) and 5th January transplanting with 21 days seedling (T_2S_2).

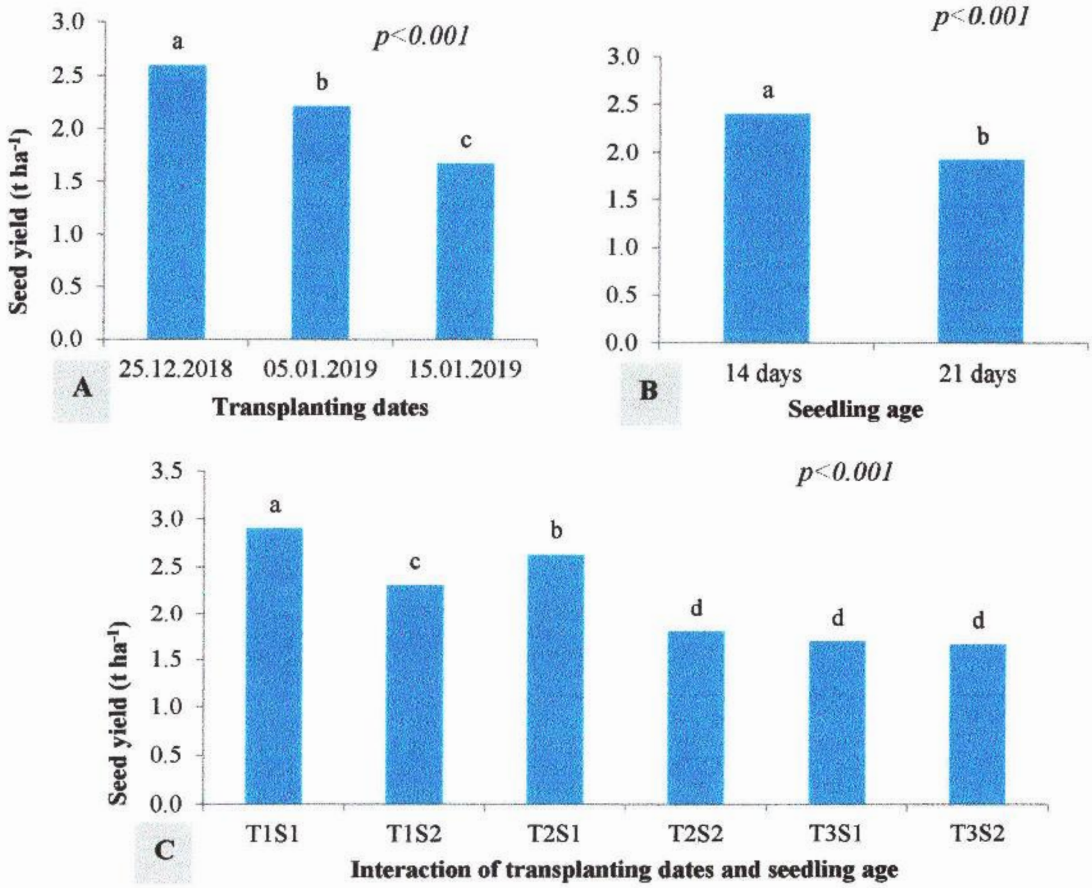

Figure 6: Effect of transplanting date (A), seedling age (B) and their interaction effect (C) on seed yield of sunflower grown in the southwestern coastal soil.

4.3.8 Total dry matter (t ha^{-1})

Transplanting date

Total dry matter (TDM) accumulation of sunflower showed significant (*$p \leq 0.01$*) variation among the dates of transplanting (Figure 7A). 25th December transplanting (T_1) accumulate the maximum TDM (6.38 t ha^{-1}) while the lowest (4.61 t ha^{-1}) was recorded from 15th January transplanting (T_3).

Seedling age

Seedling age influenced the TDM significantly (*$p \leq 0.05$*) (Figure 7B). The maximum TDM (5.81 t ha^{-1}) was returned from 14 days seedling (S_1) while the minimum (5.06 t ha^{-1}) was obtained from the 21 days seedling (S_2).

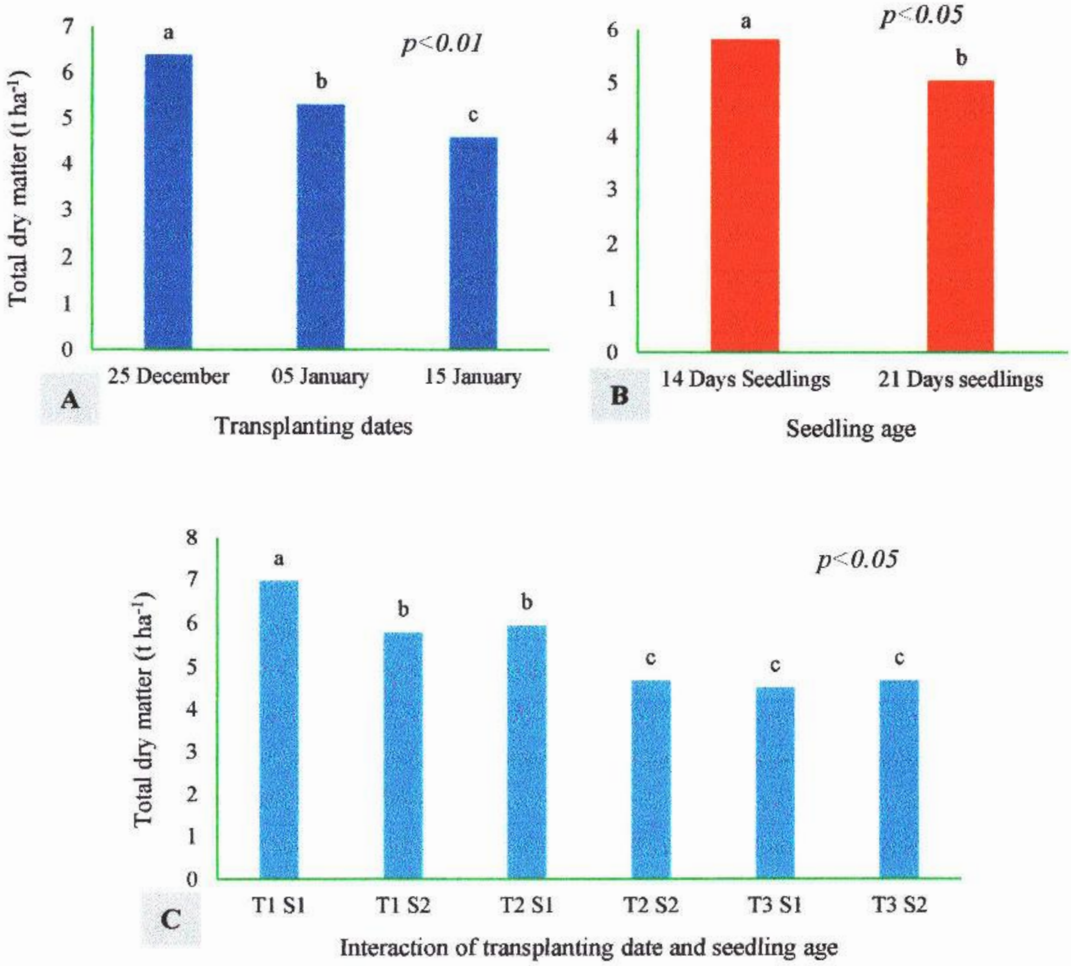

Figure 7: Effect of transplanting date (A), seedling age (B) and their interaction effect (C) on total dry matter of sunflower grown in the southwestern coastal soil.

Interaction effect of transplanting date and seedling age

The interaction of transplanting date and seedling age had significant influence on TDM (Figure 7C). The maximum TDM (6.97 t ha^{-1}) was accumulated in the interaction of 25th December transplanting with 14 days seedling (T_1S_1) while the minimum (4.69 t ha^{-1}) was obtained from 15th January transplanting with 21 days seedling (T_3S_2).

4.3.9 Harvest index (%)

Transplanting date

The data in table 11 regarding harvest index was non-insignificant among the transplanting dates The highest harvest index was (42.03%) and found in transplanting date of 5th January (T_2) while the lowest harvest index (36.27%) was obtain from 15th January transplanting (T_3).

Seedling age

Seedling age had no significant effect on harvest index. Between the two seedling ages the maximum harvest index was (41.54%) was obtained from 14 days seedling (S_1) while the lowest (37.81%) was calculated from 21 days seedling (S_2).

Interaction of transplanting date and seedling age

The combine effect of transplanting date and seedling age had no significant influence on harvest index of sunflower (Table 13). The harvest index varied from 35.33 to 45.83%). The maximum harvest index (45.83%) was observed in 5th January with 14 days seedling (T_2S_1) whereas the minimum (35.33%) was recorded from 15th January transplanting with 21 days seedling (T_3S_2).

Table 11. Effect of different dates of transplanting on yield and yield attributes of sunflower

Transplanting date	Head dia. (cm)	Head circum. (cm)	Filled seed head^{-1}	Unfilled seed head^{-1}	Stover yield (t ha^{-1})	1000 seed weight (g)	Harvest index (%)
25th December	15.09a	47.74a	758.17a	47.50	3.78a	57.33	40.72
5th January	13.94a	45.17a	653.67b	53.00	3.12ab	51.33	42.03
15th January	11.56b	38.69b	497.83c	63.50	2.94b	50.42	36.27
Mean ±SE	*13.52±0.53*	*43.86±2.25*	*636.56±13.47*	*54.66±16.34*	*3.27±3.09*	*53.02±0.85*	*39.67±2.71*
LS	**	**	***	*ns*	*	***	*ns*
CV (%)	*6.86*	*8.90*	*27.69*	*55.35*	*16.35*	*2.81*	*11.84*

*=$p \leq 0.05$, **=$p \leq 0.01$, ***=$p \leq 0.0001$, *ns= non-significant, LS= level of significance and CV= co-efficient of variation; data in each column of the table followed similar letter are not significantly different at* $p \leq 0.05$ *significant level according to LSD test.*

Table 12. Effect of different age of seedling on yield and yield attributes of sunflower

Seedling age	Head dia. (cm)	Head circum. (cm)	Filled seed head^{-1}	Unfilled seed head^{-1}	Stover yield (t ha^{-1})	1000 seed weight (g)	Harvest index (%)
14 days	14.60a	46.03a	711.44a	65.00	3.41	56.11	41.54
21 days	12.46b	41.70b	561.67b	44.33	3.14	49.94	37.81
(Mean±SE)	*13.52±0.43*	*43.86±1.83*	*636.56±11.00*	*54.66±13.34*	*3.27±2.52*	*53.02±0.70*	*39.67±2.21*
LS	**	*	***	*ns*	*ns*	***	*ns*
CV (%)	*6.86*	*8.90*	*25.46*	*58.94*	*16.35*	*2.81*	*11.84*

*= $p \leq 0.05$, **= $p \leq 0.01$ ***=$p \leq 0.0001$, *ns= non-significant, LS= level of significance and CV= Co-efficient of variation; Data in each column of the table followed similar letter are not significantly different at* $p \leq 0.05$ *significant level according to LSD test.*

Table 13. Effect of different transplanting dates and age of seedling on yield and yield attributes of sunflower

Interaction	Head dia.(cm)	Head circum. (cm)	Filled seed head^{-1}	Unfilled seed head^{-1}	Stover yield (t ha^{-1})	1000 seed weight(g)	Harvest index (%)
$T_1 S_1$	16.46	50.44	876.00a	55.00	4.08	58.83	41.57
$T_1 S_2$	13.71	47.16	640.33b	40.00	3.48	55.83	39.87
$T_2 S_1$	15.09	45.04	746.33c	63.33	3.32	53.00	45.83
$T_2 S_2$	12.78	43.17	561.00d	63.66	2.91	49.67	38.24
$T_3 S_1$	12.24	40.48	512.00e	76.66	2.85	56.50	37.22
$T_3 S_2$	10.89	36.90	483.67e	29.33	3.04	44.33	35.33
(Mean±SE)	*13.52±0.75*	*43.86±3.18*	*636.56±19.05*	*54.66±23.11*	*3.27±4.37*	*53.02±1.21*	*39.67±3.83*
LS	*ns*	*ns*	***	*ns*	*ns*	**	*ns*
CV (%)	*6.86*	*8.90*	*17.29*	*54.85*	*16.35*	*2.81*	*11.84*

**= $p \le 0.05$, **= $p \le 0.01$ ***=$p \le 0.0001$, ns= non-significant, LS= level of significance and CV= Co-efficient of variation; Data in each column of the table followed similar letter are not significantly different at $p \le 0.05$ significant level according to LSD test.*

T_1S_1= 25th December transplanting with 14 days seedling, T_1S_2= 25th December transplanting with 21 days seedling

T_2S_1=5th January transplanting with 14 days seedling, T_2S_2=5th January transplanting with 21 days seedling

T_3S_1= 15th January transplanting with 14 days seedling, T_3S_2=15th January transplanting with 21 days seedling

CHAPTER V

DISCUSSION

The definition of 'ideal' transplant age for sunflower is a question which has not yet received a decisive answer because no study to date, to our knowledge, is found on seedling transplanting of sunflower. The results indicated that transplanting of 14 days seedling performed better results than that of 21 days seedling. In the early stage of growth, crops (sunflower in this study) require nitrogen. In the polybag (where seedling was produced) no N fertilizer was added until 21 days. The older seedling got N after 21 days, seven days before the younger seedling (14-day-old) at every transplanting. This might be the cause of poor growth of older seedlings. Moreover, transplanting older seedling had less time for the readjustment of their vegetative development before the initiation of reproductive growth or the completion of the vegetative phase than that of younger seedlings. That is why younger plants might produce taller plants with thicker and larger number of leaf. The older seedling reached to different phonological stages earlier than that of younger seedling which supports that the older seedlings got less time in main field thus produced less biomass that ultimately produced low seed yield. Increased in head diameter as well as increased head circumference results in increased in seed/head and thus higher seed yield in younger seedling with early transplanting.

Younger seedling with early transplanting had yield advantage over older (21-day-old) seedling with either early or late transplanting. That could be because of early perceived favorable temperature, and longer sunshine hours, especially at later stages, promoted crop growth compared with late transplantation of sunflower. Early transplanted plants were benefitted with residual moisture in the field for better establishment of the seedling. Also early transplanted plants got favourable temperature. When high day temperatures can cause damages to components of leaf photosynthesis, reducing carbon dioxide assimilation rates compared to environments having closer to optimal temperatures (Mirshekari et al., 2012). The decrease in plant height with delaying in transplanting could be attributed to shorter period of vegetative growth of plants. Moreover, with delaying in transplanting, high temperature hastens the development, shortens the duration and reduces the growth per day from planting to harvest thus reduces plant height (Ahlawat and Gangaiah, 2009) and significant decrease in the stem length was observed (Garsid, 2004).

Chimenti et al. (2001) reported that constant air temperatures above 25°C during the whole period of grain filling decreased the final weight of grains. High temperatures during the period of reproductive growth lead to decline of reproductive growth period, failure in the number of crops and finally decrease the number of seeds and then the decline comes to seed yield. Maximum grain weight, highest seed filling percentage and maximum seed yield was attained from the interaction of 14 days seedling age and 25th December transplanting sunflower. The effect of transplanting date on sunflower yield performance and found changes in yield reduction with date of planting (Bange et al.1997).

La Vega and Hall (2002), Shahbaz et al. (2005) concluded that late planting dates affect negatively sunflower yield through reduction in all yield components. Seed yield was affected by date of transplanting. The higher seed yield might be attributed to the larger head and more number of seeds per head. The longer growth duration had the opportunity to contribute to those parameters in early planting both in trial and extrapolation area. By planting sunflower earlier, plants could be enabled to get the full benefit of soil moisture and nutrients during the extended growing season, allowing more total seeds head^{-1} to form and the achenes to mature because of sufficient time to fill. The age of transplants is one of the factors affecting the seed yield (Weston

1988). The sunflower cultivated from older transplants reaches to reproductive stage with less biomass accumulation thus produce low seed yield.

CHAPTER VI

SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

The research was conducted at Pankhali under Dacope Upazila which represents the south western coastal region of Bangladesh. The duration of the experiment in the field was December, 2018 to April, 2019. The experiment was conducted to evaluate the establishment and yield of sunflower in response of different age of the seedling and different dates of transplanting. The experiment was laid out in a factorial randomized complete block design with three replications.

Data were collected under different parameters namely plant height (cm) under 25 DAT,35 DAT,45 DAT,55 DAT,65 DAT,75 DAT and at harvest, leaf number (under 25 DAT,35 DAT,45 DAT,55 DAT,65 DAT,75 DAT), stem diameter (cm) under 25 DAT,35 DAT,45 DAT,55 DAT,65 DAT,75 DAT and at harvest, head diameter (cm), head circumference (cm), number of filled seed head^{-1}, number of unfilled seed head^{-1}, weight of 1000 seed (g), stover yield (t/ha), seed yield (t ha^{-1}) and harvest index (%) were estimated after harvest. Randomly ten plants were selected for height, stem diameter, leaf number and for other yield attribute from each plot. Collected data were statistically analyzed following ANOVA technique. Results on different agronomic characters of sunflower were done on the basis of three effect: seedling age, transplanting date and transplanting date with seedling age interaction effect.

Seedling age had significant effect on plant height (cm), leaf number, stem diameter (cm), first heading, first flowering, head diameter (cm), head circumference (cm), number of filled seed head^{-1}, weight of 1000 seed (g), and seed yield (t ha^{-1}). In case of seedling age highest plant height (103.79 cm), leaf number (24), stem diameter (7.51 cm), head diameter (14.60 cm), head circumference (46.03 cm), number of filled seed head^{-1} (711.44), number of unfilled seed head^{-1} (65.00), weight of 1000 seed (56.11 g), stover yield (3.41 t/ha), seed yield (2.40 t/ha) and harvest index (41.54 %) was found from 14 days seedling.

From the transplanting dates it was observed that there were significant effect of plant height (cm), leaf number, stem diameter (cm), head diameter (cm), head circumference (cm), number of filled seed head^{-1}, weight of 1000 seed (g), and seed yield (t ha^{-1}). The tallest plant (108.66 cm), leaf number (25), stem diameter (7.47 cm), head diameter (15.09 cm), head circumference (7.74 cm), number of filled seed head^{-1} (758.17), number of unfilled seed head^{-1}(65.00) weight of 1000 seed (57.33 g), stover yield (3.78 t ha^{-1}), seed yield (2.60 t ha^{-1}) and harvest index (2.60%) were found from 25th December transplanting.

From the interaction of transplanting date and seedling age had no significant effect on plant height, leaf number, stem diameter (cm), first heading, head diameter (cm), head circumference (cm), number of unfilled seed head^{-1}, stover yield (t ha^{-1}), and harvest index (%). But significant effect was found in first flowering, number of filled seed head^{-1} and seed yield (t ha^{-1}). In the interaction of transplanting dates and seedling age the highest plant height (115.86 cm), leaf number (25), stem diameter (7.90 cm), head diameter (16.46 cm), head circumference (50.44 cm), number of filled seed head^{-1} (876), weight of 1000 seed (58.83 g), stover yield (4.08 t ha^{-1}), seed yield (2.90 t ha^{-1}) was obtained from 25th December transplanting with 14 days seedling. Highest number of unfilled seed head^{-1} (76.66) was recorded from 15thJanuary transplanting with 14 days seedling and the maximum harvest index (45.83%) was found from 5th January transplanting with 14 days seedling.

Conclusion

Transplanting of sunflower is possible in the coastal region. From the findings of the experiment and discussion it is revealed that 14 days seedling with 25th December transplanting could the better option for the establishment and better yield of sunflower (var. Hysun-33) in the coastal wet soil of southwestern coastal Bangladesh.

Recommendations

However to reach a specific conclusion it is recommended that-

- This experiment need to be repeated in forthcoming years for better understanding and conformity of the result.
- The experiment should be trailed in the farmer's field at different locations of the southwestern coastal region.

CHAPTER VII

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