Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/v9f5xc91

SOWING DATE AND NUTRIENT EFFECTS ON MAIZE GENOTYPES FOR ENHANCE YIELD

Noor Zada[1*] and Zahid Hussain

[1*,2]Department of Agriculture, Faculty of Sciences, Bacha Khan University, Charsadda, Pakistan

***Corresponding author:** Noor Zada
*Email: noormkd8@gmail.com

ABSTRACT
In recent climate changes, the optimum sowing time for best maize (*Zea* mays L.) genotype with desired nutrients management is the best option to overcome production cost in the developing countries. This study was aimed to compare three sowing timings starting from very early i.e. Feb. 20, with a 10 days difference i.e. Mar. 02 and Mar. 12 comparing three recommended maize hybrids (CS-200, Garanon and Pioneer 3025) under provided nutrient managements (sole bacterial coated urea (PGPB), sole bacterial coated DAP, 50% each bacterial coated urea and normal urea, and 50% each bacterial coated urea and DAP) to yields a uniform rates of 150 kg N ha^{-1} and 90 kg P ha^{-1}. Experiment was conducted in a randomized complete block design replicated three times with split plot arrangement. Sowing timings and genotypes were in the main-plot as treatment and nutrients combinations in sub-plots. Early sowing i.e Feb. 20 resulted in with a higher dry matter partitioning for stem, leaves, and ears before tasseling of the plant growth and development in both years of the study (2018 and 2019). The same early sowing timing has also resulted in with dry matter partitioning within stem, leaves and ears at the crop physiological maturity for both years of the study and hence resulted in with better traits i.e. grain number row^{-1} and grain ear^{-1}, unit grain weight (g) and hence the final grain yield. Higher dry matter accumulation and partitioning within stem, leaf, and ear at pre-silking and post-silking favors the early sowing in the season and superiority of the maize genotypes Garanon with healthy traits. Moreover, sole bacterial coated DAP has also resulted in with higher dry matters and healthy traits and hence the grain yield. The study concludes that early sowing in February of the hybrid Garanon) if treated with sole bacterial coated DAP is the best option for maize growers in a climate similar to Charsadda Pakistan for maize production.

Keywords: maize hybrids, sowing timings, nutrients management, yield traits and grain yield

INTRODUCTION
Genotype with environment has a close association to determine the crop yield. Changes in the climatic conditions demands optimum sowing time of a crop for best production. Proper nutrients and optimum sowing time ensures the highest return per unit area. Maize productivity mostly depends on appropriate sowing of a good variety and ensures soil with proper nutrient management for the soil health subject to irrigation water availability and/or sufficient moisture by natural rainfall (Ramankutty et al., 2002). Timely sowing of maize in season is important to harvest optimum yield. By onset of the spring followed by summer, the delay in sowing of a crop has significantly decreased yield due to limiting its reproductive growth i.e. anthesis in hot temperature and thereafter the grain development (Anapalli et al., 2005). Selection of appropriate sowing time for the best suitable variety

that was properly fertilized with recommended agro-management practices have guaranteed best net return (Qureshi et al., 2007). To achieve better yield with efficient resources management i.e. nutrients, water and sunlight ensures optimum productivity (Ogobomo and Remison, 2009). Under the existing climate change transition phase, selection of good hybrid is important for food security. Among the major yield limiting factors, best suitable hybrid with optimum sowing time are the prime's ones to be taken in consideration. High yielding hybrid perform a key role to successful maize production (Inamullah et al., 2011a). Comparison of different maize hybrids for yield potential is necessary for Peshawar valley (Inamullah et al., 2011b).

Our soil is mostly deficient with P and organic matter which are the major limiting factors of cereal crop production in Khyber Pakhtunkhwa. The application of phosphorous solubilizing bacteria (PSB) with sowing dates has shown an increase in the P availability and equally a positive effect on the crop productivity. However, there is a need for the research to investigate the interactive effects of sowing date with phosphorous solubilizing bacteria (PSB) for P in the Khyber Pakhtunkhwa.

This study aims to address the sowing time response on maize genotypes with crop treated with different types of fertilizer on the plant growth, dry matter partitioning and healthy traits to evaluate the future of the maize crop for the growers to address their livelihood in changing climate of the region. The study, therefore, designed to evaluate three potential maize hybrids by sowing them from early spring with 10 days intervals in the season treated with simple urea and di ammonium phosphate as well as treated with bacterial coated urea and bacterial coated di ammonium phosphate.

MATERIALS AND METHODS

Field experiment was conducted for different sowing dates, nutrients management and maize genotypes. The study was conducted at the Research Farm, Bacha Khan University Charsadda during 2018 and repeated in 2019 by using fresh hybrid. The experimental soil shows less than 1% organic matter and silt loam in the soil classification (Table 1). The rainfall data collected at the farm are shown in Fig. 1. Treatments of the experiment was sowing timings (i.e. Feb. 20, Mar. 02 and 12), genotypes (CS-200, Garanon and Pioneer-3025) and nutrients management (i.e. Plant growth promoting bacterial coated urea (PGPB) , bacterial coated DAP, 50% each bacterial coated urea + urea and 50% each bacterial coated urea + DAP). The N was adjusted with urea for a plot where N required. The total nutrients were ensured to yield 150 and 90 (kg ha^{-1}) of N and P, respectively. Experiment was laid out in Randomized Complete Block with split plots in three replications. Sowing dates (SD) and genotypes (G) were in main plots and nutrients management in sub plots. Each plot has 5 rows, 70 cm a part. Nitrogen and P were adjusted from urea and SSP. The irrigation and other management practices were made when necessary. Seed drill was used for sowing. Thinning was done once when crop was at knee stage.

The data was recorded on ear length (cm), grain number ear^{-1}, the grain rows ear^{-1}, 1000 grain weight (g), biological, grain yield and shelling percentage

Statistical Analysis

Field data were analyzed statistically as per procedure of RCBD split-plots and LSD (0.05) used for mean comparison (Jan et al., 2009). The statistical analyses were carried out with Statistix software version 8.1 (Informer Technologies Inc.) and means were expressed in different figures made in Sigma Plot version 12.5 (Systat Software Inc., USA).

RESULTS

Ear length

Ear length (cm) was significantly ($p<0.05$) affected by various treatments, including sowing dates, hybrids and fertilizer types during 1st year, 2nd year of the study and average over the two years data. During 1st year i.e 2018 sowing dates were found significant for ear length with maximum for 20th February. The early sowing on 20th February increased the ear length by 1.69 and 2.93 cm than sowing on 2nd and 12th March respectively. Similarly, the hybrids were also found significant for ear length with highest length observed from Garanon and lowest from CS 200. However, no significant

variation in ear length were observed with Garanon and Pioneer 3025. In case of nutrients, sole bacterial coated DAP had resulted in maximum ear length (19.75 cm). While the minimum ear length (17.15 cm) was observed with 50% bacterial coated urea + 50% urea. During 2nd year significant differences in ear length were also observed with different sowing dates. The sowing on 2nd and 12th March had resulted in statistically similar but less ear length than early sowing on 20th February. The hybrids also brought about significant variation in ear length during 2nd year. Among hybrids the Garanon had resulted more ear length (19.98 cm) than CS-200 (17.18 cm). While no profound variations were observed for ear length across Garanon and Pioneer 3025. Likewise, the ear length observed with 50% bacterial coated urea + 50% urea and 50% bacterial coated urea + 50% DAP were statistically similar but lower than ear length observed with sole bacterial coated DAP. Across average over year's data, the ear length decreased from 20.05 cm to 17.32 cm with delaying sowing dates from 20th February to 12th March. Among hybrids the Garanon and Pioneer 3025 had an ear length increased by 2.12 and 1.73 cm than CS 200 respectively. The nutrients also brought about significant variations in ear length with highest values at sole bacterial coated DAP (19.74 cm) and lowest at 50% bacterial coated urea + 50% urea (17.75 cm).
Regarding interactions, the SD * H was found significant for ear length across average over years data. However, the remaining interactions were found non-significant at the same interval. The SD * H interaction revealed that the hybrids irrespective of their type had increased the ear length with sowing on 20th February. However, the response of Garanon and Pioneer 3025 was more pronounced across all sowing dates than CS 200. It was also observed that Pioneer 3025 had increased the ear length over Garanon with sowing on 20th February and 2nd March compared with delayed sowing on 12th March.

Table 1.Ear length (cm) as affected by sowing dates, hybrids and nutrients management during 2019 and 2020.

Treatments	Years (Y)		Means
	2018-19	2019-20	
Sowing dates (SD)			
20 February	19.94 a	20.15 a	20.05 a
02 March	18.25 b	18.50 b	18.37 b
12 March	17.01 c	17.62 b	17.32 c
$LSD_{0.05}$	1.17	1.00	0.74
Hybrids (H)			
CS-200	17.41 b	17.18 b	17.29 b
Garanon	18.85 a	19.98 a	19.42 a
Pioneer-3025	18.94 a	19.12 a	19.03 a
$LSD_{0.05}$	1.17	1.00	0.74
Nutrients (150 kg ha^{-1} N+ 90 kg ha^{-1} P) (N)			
Sole bacterial coated urea	18.42 b	18.93ab	18.68 b
Sole bacterial coated DAP	19.75 a	19.73 a	19.74 a
50% bacterial coated urea + 50% urea	17.15 c	18.34 b	17.75 c
50% bacterial coated urea + 50% DAP	18.27bc	18.03 b	18.15bc
$LSD_{0.05}$	1.24	1.00	0.79
Mean	18.40	18.76	
Interactions			
SD x H	NS	*	**
SD x N	NS	*	NS
H x N	NS	NS	NS
SD x H x N	NS	NS	NS

Grains ear^{-1}

Grains ear^{-1} were significantly higher during 2nd year (338) compared to 1st year (331) of the experiment. During 2018 sowing dates were found non-significant for number of grains ear^{-1}. However, the grains number greatly varied among hybrids. The highest number of grains ear^{-1} were observed with Garanon (434) followed by Pioneer-3025 (408) and lowest numbers with CS-200 (391). In case of nutrients, sole bacterial coated DAP had resulted in maximum number of grains ear^{-1} (427) that was statistically at par with sole bacterial coated urea (415). However, the lowest number of grains ear^{-1} (395) were observed with 50% bacterial coated urea + 50% urea. During 2nd year significant differences in number of grains ear^{-1} were observed with different sowing dates. However, hybrids and nutrients brought about significant variation in number of grains ear^{-1}. Among hybrids the Garanon had resulted in higher grains ear^{-1} (446) than CS-200 (395) and Pioneer-3025 (420). Likewise, the grains ear^{-1} observed with sole bacterial coated urea, 50% bacterial coated urea + 50% DAP and 50% bacterial coated urea + 50% urea were statistically similar but lower than grains ear^{-1} observed with sole bacterial coated DAP. The sowing dates were found significant for number of grains ear^{-1}. Reduction in number of grains ear^{-1} from 420 to 412 were observed with delaying sowing dates from 20th February to 12th March. Among hybrids the Garanon had increased the number of grains ear by 26 and 47 numbers than pioneer 3025 and CS 200 respectively. Likewise, sole bacterial coated DAP had resulted more number of grains ear^{-1} (430) than 50% bacterial coated urea + 50% urea (403).

Regarding interactions, SD * H was found significant for grains ear^{-1} across average over years data. However, the remaining interactions were found non-significant at the same interval.
SD * H interaction revealed that CS-200 increased the grains ear^{-1} with sowing on 20th February compared with sowing on 2nd March and and 12th March. Conversely, the grains ear^{-1} across Garanon increased with sowing on 2nd March. However, the Pioneer-3025 had increased the number of grains ear^{-1} with delaying sowing dates from 20th February to 12th March.

Grains row^{-1}

Grains row^{-1} were not significantly different across both years of the experiment. During 1st year sowing on 20th February had resulted higher number of grains row^{-1} (42) than sowing on 2nd March (39) and 12th March (37). Likewise, the hybrids were found significant for grains row^{-1} with highest number noted from Garanon (43) than CS-200 (36) and Pioneer-3025 (39). Among nutrients, application of sole bacterial coated DAP had resulted maximum number of grains ear^{-1} (42) while minimum (38) was observed with 50% bacterial coated urea + 50% urea. During 2nd year, more number of grains row^{-1} was counted when sowing was done on 20th February than delayed sowing. Among hybrids, the Garanon had resulted higher number of grains row^{-1} (45) than CS-200 (36) and Pioneer-3025 (39). Likewise, the grains row^{-1} observed with 50% bacterial coated urea + 50% urea and 50% bacterial coated urea + 50% DAP was statistically comparable but lower than sole bacterial coated urea. The higher number of grains row^{-1} across average over year's data was observed with sowing on 20th February than delayed sowing (12th March). Likewise, the hybrids were found significant for grains row^{-1} with highest number noted from Garanon (44) than CS-200 (36) and Pioneer-3025 (39). Similarly, the maximum number of grains row^{-1} (42) was observed with sole bacterial coated DAP while minimum with 50% bacterial coated urea + 50% urea (39). However, the number of grains row-^{1} observed with all treatments except sole bacterial coated DAP were statistically comparable.

Regarding interactions, SD * H was found significant for grains row^{-1} during 2nd year and average data. However, SD * N during 2nd year and SD * H * N during 1st year were found significant for grains row^{-1}. SD * H interaction revealed that CS-200 and Pioneer 3025 had increased the grains row^{-1} with early sowing (20th February) than delayed sowing (12th March). Conversely, the grains row^{-1} across Garanon increased with delaying sowing dates with highest values at 12th March than 20th February. It was also observed that grains row^{-1} was in the order of Garanon > Pioneer 3025 > CS 200 across all sampling intervals
.

Table 2.Number of grains ear^{-1} as affected by sowing dates, hybrids and nutrients management during 2019 and 2020.

Treatments	Years (Y) 2018-19	2019-20	Means
Sowing dates (SD)			
20 February	417 a	423 a	420 a
02 March	409 a	420 a	414 b
12 March	407 a	417 a	412 b
$LSD_{0.05}$	NS	NS	5.4
Hybrids (H)			
CS-200	391 c	395 c	393 c
Garanon	434 a	446 a	440 a
Pioneer-3025	408 b	420 b	414 b
$LSD_{0.05}$	8.6	7.3	5.4
Nutrients (150 kg ha^{-1} N+ 90 kg ha^{-1} P) (N)			
Sole bacterial coated urea	415 ab	418 b	417 b
Sole bacterial coated DAP	427 a	433 a	430 a
50% bacterial coated urea + 50% urea	395 c	412 b	403 c
50% bacterial coated urea + 50% DAP	407 bc	417 b	412 bc
$LSD_{0.05}$	12.9	9.5	7.9
Mean	331	338	
Interactions			
SD x H	NS	NS	*
SD x N	NS	*	NS
H x N	NS	NS	NS
SD x H x N	NS	**	NS

1000 grains weight

Thousand grains weight was not significantly different during 2018-19 and 2019-20. During 2018-19, the sowing on 20th February and 2nd March had resulted in statistically similar but higher 1000 GW than delayed sowing. Likewise, the hybrids were found significant for 1000 GW with maximum values noted from Garanon (326.30 g) than CS-200 (321.04 g) and Pioneer-3025 (322.90 g). However, CS-200 and Pioneer 3025 were statistically similar for 1000 grains weight. Among nutrients, the sole bacterial coated DAP had resulted maximum 1000 GW (328.25 g) while minimum (317.50 g) was observed with 50% bacterial coated urea + 50% urea. During 2nd year, the early sowing on 20th February had increased the 1000 grains weight by 7.48 g than delayed sowing. Among hybrids, the Garanon and Pioneer 3025 had resulted higher grains weight than CS 200. Likewise, the 1000 grains weight observed with sole bacterial coated DAP was 10.7 g higher than grains weight recorded at 50% bacterial coated urea + 50% urea.

The sowing dates were found significant for 1000 grains weight across average data. The 1000 GW decreased from 417.12 g to 410.12 g as the sowing dates were delayed from 20th February to 12th March.

Table 3.1000 grains weight (g) of maize as affected by sowing dates, hybrids and nutrients management during 2019 and 2020.

Treatments	Years (Y) 2018-19	2019-20	Means
Sowing dates (SD)			
20 February	325.83 a	328.41 a	327.12 a
02 March	325.10 a	324.39 ab	324.74 b
12 March	319.32 b	320.93 b	320.12 c
$LSD_{0.05}$	1.64	4.10	2.12
Hybrids (H)			
CS-200	321.04 b	321.00 b	321.02 c

Garanon	326.30 a	327.60 a	326.95 a
Pioneer-3025	322.90 b	325.12 a	324.01 b
$LSD_{0.05}$	1.64	4.10	2.12
Nutrients (150 kg ha^{-1} N+ 90 kg ha^{-1} P) (N)			
Sole bacterial coated urea	324.39 ab	325.40 b	324.90 c
Sole bacterial coated DAP	328.25 a	330.17 a	329.21 a
50% bacterial coated urea + 50% urea	317.50 c	319.47 c	318.48 d
50% bacterial coated urea + 50% DAP	323.51 b	323.25 b	323.38 b
$LSD_{0.05}$	4.41	4.46	3.10
Mean	323.41	324.58	
Interactions			
SD x H	NS	NS	NS
SD x N	NS	NS	NS
H x N	**	NS	NS
SD x H x N	NS	**	NS

Biological yield

Biological yield was significantly higher during 2nd year (19354 kg ha^{-1}) compared with 1st year (19097 kg ha^{-1}) of the experiment. The biological yield ranged over from 18138 kg ha^{-1} to 16982 kg ha^{-1} during 1st year and from 18351 kg ha^{-1} to 17335 kg ha^{-1} during 2nd year, indicating the significant effect of sowing dates. It was also observed that ranking of different sowing dates across both years was similar with highest values at early sowing and lowest values at delayed sowing. Likewise, the nutrients management also brought about significant variations in biological yield. In case of hybrids, the Garanon had increased the biological yield by 11.7% and 11.3% over CS-200, by 12.5% and 15.2% over Pioneer 3025 respectively during 1st year and 2nd year. In addition, the CS 200 and Pioneer 3025 were found statistically non-significant for biological yield during 1st year. Across average over years data, the ranking of sowing dates and hybrids were similar to that observed during 2nd year, However, it ranged over from 18245 kg ha^{-1} to 17159 kg ha^{-1} with sowing dates and from 19125 kg ha^{-1} to 16800 kg ha^{-1} with hybrids. In case of nutrients, the sole bacterial coated DAP was found superior to rest of the treatments in term of increasing the biological yield.

The interactions between factors were generally not significant across average data, except for the interaction between sowing dates and hybrids (SD * H). Generally, these results suggest that the effects of sowing date and nutrient treatments may vary depending on the hybrid used. The SD * H interaction, plotted against average data revealed that biological yield across CS-200 and pioneer 3025 reduced with delaying sowing dates from 20th February to 12th March. However, the reduction was more pronounced with CS 200 (7.3%) than Pioneer 3025 (6.8%). On the other hand, a slight increase (2.7%) in biological yield was observed across Garanon with delaying sowing dates. In addition, no significant differences in biological yield with sowing on 20th February and 2nd March was observed across CS 200 and Pioneer 3025. Furthermore, the biological yield with Garanon was higher than other hybrids across all sowing dates.

Table 4.Biological yield (kg ha^{-1}) of maize as affected by sowing dates, hybrids and nutrients management during 2019 and 2020.

Treatments	Years (Y)		Means
	2018-19	2019-20	
Sowing dates (SD)			
20 February	19638 a	19851 a	19745 a
02 March	18982 b	19362 b	19172 b
12 March	18482 c	18835 c	18659 c
$LSD_{0.05}$	250	205	155
Hybrids (H)			
CS-200	18412 b	18889 b	18650 b
Garanon	20395 a	20854 a	20625 a
Pioneer-3025	18295 b	18305 c	18300 c

$LSD_{0.05}$	250	205	155
Nutrients (150 kg ha^{-1} N+ 90 kg ha^{-1} P) (N)			
Sole bacterial coated urea	19166 b	19550 ab	19358 a
Sole bacterial coated DAP	19477 a	19692 a	19584 a
50% bacterial coated urea + 50% urea	18649 c	18821 c	18735 c
50% bacterial coated urea + 50% DAP	18845 c	19334 b	19090 b
$LSD_{0.05}$	277	337	216
Mean	19097	19354	
Interactions			
SD x H	*	NS	**
SD x N	*	NS	NS
H x N	*	NS	NS
SD x H x N	NS	**	NS

Grain yield

Grains yield of maize was significantly higher during 2nd year (8674 kg ha^{-1}) compared to 1st year (8402 kg ha^{-1}) of the experiment. Grain yield was significantly affected by sowing dates, hybrids and nutrients management during 1st year, 2nd year and average data. The ranking of different sowing dates was similar for grain yield during 1st year and year having highest values with early sowing (8505 and 8827 kg ha^{-1}) and lowest values with delayed sowing (8259 and 8487 kg ha^{-1}) respectively. Likewise, across average data, the grain yield across sowing at 20th February and 2nd March was statistically similar but higher than its values observed with late sowing. Regarding hybrids, the Garnon and Pioneer 3025 had resulted in statistically similar but more grain yield than CS 200 during 1st year. Being statistically similar yield, the Garnon had increased the grain yield by 9% than Pioneer 3025 but 25% than CS 200. Whereas, the grain yield recorded with Garanon was 29% and 27% higher than CS 200 during 2nd year and average data. The nutrients application during 1st year had resulted higher yield with sole bacterial coated DAP (8757 kg ha^{-1}) but lower with 50% bacterial coated urea + 50% urea (8095 kg ha^{-1}). However, no significant differences in grain yield was observed with sole bacterial coated urea and sole bacterial coated DAP as well as between 50% bacterial coated urea + 50% urea and 50% bacterial coated urea + 50% DAP. In the following year, the grain yield ranged over from 9174 kg ha^{-1} (sole bacterial coated DAP) to 8290 kg ha^{-1} (50% bacterial coated urea + 50% urea) indicating the significant effect of nutrients. The highest ranking of sole bacterial coated DAP in term of grain yield was also observed across average data compared with other managements.
Regarding interactions, all the two way interactions: SD * H, SD * N and H * N was found significant for grains yield across average over years data. While, the three-way interaction (SD x H x N) was found non-significant. SD * H interaction revealed that CS-200 reduced the grains yield by 14% with delay in sowing dates from 20th February to 12th March. Conversely, the grains yield across Garanon increased by 2% with delaying sowing dates to 2nd March compared with early sowing at 20th February. Moreover, the grain yield observed with Garanon across sowing at 20th Febrauray and 2nd March was statistically comparable. However, the Pioneer-3025 had increased the number of grains ear-1 with sowing on 2nd March than 20th Febrauary and 12th March.

Table 5.Grain yield (kg ha^{-1}) of maize as affected by sowing dates, hybrids and nutrients management during 2019 and 2020.

Treatments	Years (Y)		Means
	2018-19	2019-20	
Sowing dates (SD)			
20 February	8505 a	8827 a	8666 a
02 March	8443 ab	8709 ab	8576 a
12 March	8259 b	8487 b	8373 b
$LSD_{0.05}$	222	270	168
Hybrids (H)			
CS-200	7542 b	7626 c	7584 c
Garanon	9165 a	9536 a	9351 a

Pioneer-3025	8500 a	8860 b	8680 b
$LSD_{0.05}$	222	270	168
Nutrients (150 kg ha^{-1} N+ 90 kg ha^{-1} P) (N)			
Sole bacterial coated urea	8547 a	8715 bc	8631 b
Sole bacterial coated DAP	8757 a	9174 a	8966 a
50% bacterial coated urea + 50% urea	8095 b	8290 d	8192 d
50% bacterial coated urea + 50% DAP	8210 b	8518 cd	8364 c
$LSD_{0.05}$	215	238	158
Mean	8402	8674	
Interactions			
SD x H	**	*	**
SD x N	**	**	*
H x N	**	*	*
SD x H x N	NS	**	NS

Harvest index

Harvest index of maize was not significantly different across both years. The harvest index was not significantly affected by sowing dates during 1st year, 2nd year and average data. The hybrids brought about significant variations in harvest index during 1st year, 2nd year and average data. The ranking of different hybrids were similar for harvest index across all sampling intervals with highest values observed at Pioneer 3025 (46.5, 48.5, and 47.5%) and lowest with CS 200 (40.9, 40.4, and 40.7%) during 1st year, 2nd year and average data respectively. In case of nutrients, the higher harvest index was observed with sole bacterial coated DAP (45%) and lower with but lower with 50% bacterial coated urea + 50% urea (43.4%). The nutrients were also found significant for harvest index during 2nd year and average data. The sole bacterial coated urea, 50% bacterial coated urea + 50% urea, 50% bacterial coated urea + 50% DAP had resulted statistically similar but lower values for harvest index than sole bacterial coated DAP across both years.

Regarding interactions, the SD * H, and H * N was found significant for harvest index across average over years data. While, the SD * N and three-way interaction (SD * H * N) was found non-significant. SD * H interaction revealed that CS-200 reduced the harvest index by 5.4% with delay in sowing dates from 20th February to 12th March. Conversely, the harvest index across Garanon and Pioneer 3025 increased by 2.1% and 3% respectively with delaying sowing dates to 2nd March compared with early sowing at 20th February. The H * N interaction showed that CS 200 and Garanon were more responsive than Pioneer 3025 to sole bacterial coated DAP than other nutrients management. The Pioneer 3025 was responsive to nutrients management in the order of sole bacterial coated urea > sole bacterial coated DAP > 50% bacterial coated urea + 50% DAP = 50% bacterial coated urea + 50% urea.

Table 6.Harvest index (%) of maize as affected by sowing dates, hybrids and nutrients management during 2019 and 2020.

Treatments	Years (Y)		Means
	2018-19	2019-20	
Sowing dates (SD)			
20 February	43.5 a	44.5 a	43.9 a
02 March	44.5 a	45.0 a	44.7 a
12 March	44.6 a	45.1 a	44.9 a
$LSD_{0.05}$	NS	NS	NS
Hybrids (H)			
CS-200	40.9 c	40.4 c	40.7 c
Garanon	45.0 b	45.8 b	45.4 b
Pioneer-3025	46.5 a	48.5 a	47.5 a
$LSD_{0.05}$	1.29	1.44	0.93
Nutrients (150 kg ha^{-1} N+ 90 kg ha^{-1} P) (N)			
Sole bacterial coated urea	44.6 ab	44.6 b	44.6 b

Sole bacterial coated DAP	45.0 a	46.6 a	45.8 a
50% bacterial coated urea + 50% urea	43.4 bc	44.1 b	43.8 b
50% bacterial coated urea + 50% DAP	43.6 c	44.1 b	43.9 b
$LSD_{0.05}$	1.20	1.58	0.98
Mean	44.33	45.12	
Interactions			
SD x H	**	*	**
SD x N	*	*	NS
H x N	**	NS	*
SD x H x N	NS	NS	NS

V. DISCUSSION

Yield and yield components

The grains yield was significantly affected among sowing dates. Early sowing (20th February) had resulted more grains yield compared to sowing at 2nd March and 12th March. This increase in grain yield may be due to the fact that maize planted at optimum time provided favorable condition for growth and hence grain yield increased as compared to late planting. These findings are in line with Aziz et al. (2007), Jaliya et al (2008), Namakka et al. (2008) who reported higher grain yield for optimum planting and lower grain yield for delayed planting. The other possible reason for higher yield with early plantation might be due the longer growth cycle and favorable temperature during grain filling stage (Ahmad et al., 2018). Moreover, with late planting, the lower grain yield was largely due to the short grain filling phase owing to high temperature and radiation level which may amplify the yield decline. These results were in line with the findings of Bhusal et al. (2016) who reported that in late sowing, crop had shorter period to produce grains that limit the yield.

Significant differences were observed across hybrids for grains yield. Difference in varieties for grains yield is might be due to differences in their thousand grain weight, ear length, rows per ear and grains per row. The hybrid Garanon had the highest yield, followed by Pioneer-3025 and CS-200. The high yielding hybrid Garanon is known for its high-yielding potential, and its use has been reported to result in higher grain yield in previous studies (Jamil et al., 2017; Maqbool et al., 2019). Among nutrients, 50% bacterial coated urea + 50% DAP had resulted in more grain yield compared to 50% bacterial coated urea + 50% urea. These findings are in conformity with Khaliq et al. (2004); Boateng et al. (2006) who reported maximum grain yield when DAP applied in combination with urea.

LITERATURE CITED

1. Adriani, D.E., H. Noor, and A. Budiani. 2018. Influence of planting date and plant density on growth and yield of two maize varieties. IOP Conference Series: Earth and Environ. Sci. 102(1): 012007.
2. Ahmad, I., S.A. Wajid, A. Ahmad, M.J.M. Cheema, and J. Judge. 2018. Assessing the impact of thermo-temporal changes on the productivity of spring maize under semi-arid environment. Int. J. Agric. Biol. 20(10): 2203-2210.
3. Ahmed, A. A.1995. Response of wheat plants to nitrogen and biological fertilization under conditions of North West Coast of Egypt. M.Sc. Thesis, Fac. of Agric. Ain-Sliams Univ., Egypt.
4. Ahsok, K., R.C. Gautam, R. Singh and K.S. Rana. 2005. Growth, yield and economics of maize wheat cropping sequences as influenced by integrated nutrient management. Ind. J. Agri. Sci. 75(11): 706-711.
5. Akhtar, M., A. Javaid, M. Aslam, M. Anwar-ul-Haq, and M. Tahir. 2017. Impact of different sowing dates on growth, yield and quality of wheat. Journal of Agricultural Research, 55(3): 337-346.
6. Alam, M. S., M.A.R. Sarker, and A. Akter. 2020. Assessment of hybrid maize varieties for grain yield and yield components. J. Bangladesh Agric. Univ. 18(1): 51-57.
7. Alam, M. S., M.S. Islam, M.K. Islam, M.S. Rahman, and M.F. Hossain. 2015. Growth, yield and yield contributing characters of maize (Zea mays L.) as influenced by sowing date. Int. J. Natural Social Sci. 2(3): 43-50.

8. Ali, S., M. Inamullah, M. Amanullah and D.H. Muhammad, 2015. Yield response of Maize (Zea mays L.) hybrids sown on various dates during kharif in Peshawar-Pakistan. J. Environ. Earth Sci., 5: 13–18
9. Al-Madini, A.M., M.A. El-Sayed, W.I. Shaban. 2021. Effect of nitrogen, phosphorus and potassium fertilization on growth, yield and yield components of maize (Zea mays L.). J. Plant Nut. 44: 1933-1942.
10. Anapalli SS, Ma L, Nielsen DC, Vigil MF, Ahuja LR (2005) Simulating planting date effects on corn production using RZWQM and CERES Maize models. Agronomy J 97: 58-71.
11. Amanullah, M. Zakirullah, M. Tariq, K. Nawab, A. Z. Khan, Farhatullah, Z. Shah, A. Jan, S K.Khalil, M. T. Jan, M. Sajid, Z. Hussain and H.U. Rahman. 2010. Levels and time of phosphorus application influence growth, dry matter partitioning and harvest index in maize. Pak. J. Bot., 42(6): 4051-4061.
12. Aziz, A., Hidayat, U.R. and Najibullah, K. (2007) Maize Cultivar Response to Population Density and Planting Date for Grain and Biomass Yield. Sarhad Journal of Agriculture, 23, 25-30.
13. Bao, X., X. Wen, and X. Sun. 2022. Effects of environmental conditions and leaf area index changes on seasonal variations in carbon fluxes over a wheat–maize cropland rotation. *International Journal of Biometeorology*, *66*: 213-224.
14. Bassetti, P., F. Martinelli, A. Pelliconi, D. De Benedetto. 2019. Effects of sowing dates and nitrogen fertilization on maize productivity, grain quality and nutritive value of the silage. Agricultural and Forest Meteorology, 267: 70-81.
15. Belete, D., K. Dagne, and T. Tamado. 2017. Assessment of physiological maturity and yield loss in maize hybrids (Zea mays L.) under drought stress. Adv. Crop Sci. Tech. 5: 338.
16. Bello, O. B., B. Badu-Apraku, M.A.B. Fakorede, A. Menkir, and M. Gedil. 2020. Genetic analysis of early maize physiological maturity and its relationship with grain yield and agronomic traits. Euphytica, 216(8): 1-19.
17. Bello, O. B., H. Tijani-Eniola, and E.Y. Oyinlola. 2019. Agronomic traits and yield of maize varieties as influenced by sowing dates in southwestern Nigeria. Agricultural and Food Science Research, 6(2): 9-15.
18. Bhusal, K., R. Subedi and J. Shertha, 2016. Effect of sowing dates on growth and grain yield of maize inbred lines. J. Agri. Search, 3: 244- 247
19. Boateng, S.A., J. Zickermann and M. Kornahrehs. 2006. Poultry manure effect on growth and yield of maize. J. Appld. Econ. 9: 150-157.
20. Buriro, M., T.A. Bhutto and A.W. Gandahi, 2015. Effect of sowing dates on growth, yield and grain quality of hybrid Maize. J. Basic Appl. Sci., 11: 553–558
21. Chabot, R., Antoun, H. and Cescas. M.P. (1993). Stimulation de la croissance du maïs et de la laitue romaine par des microorganismes dissolvant le phosphore inorganique. Canadian J. Microbiol., 39: 941– 7.
22. Chang, C., T.G. Sommerfeldt, T. Entz. 1993. Barley performance under heavy applications of cattle feedlot manure. Agron J 85:1013–1018.
23. Das, K., R.Dang, T. N Shevananda. 2008. Influence of bio-fertilizers on the availability of nutrients (N, P and K) in soil in relation to growth and yield of Stevia rebaudiana grown in South India. International Journal of Applied Research in Natural Products, 1(1): 20-24.
24. Echarte, L., F. Andrade, and V. Sadras. 2000. Wheat sowing date affects grain yield and yield components in the south-eastern Pampas of Argentina. Field Crops Res. 68: 167-177.
25. El-Kalla, S. E., A. E. Sharief, A.A. Leilah, A. M. Abdalla and S. A. K. El- Awami. 2002. Utilization of some agriculture practices to improve some wheat cultivars productivity. J. Agric. Sci. Mansoura Univ. 27: 6583-5697.
26. El-Khawas, S. A., K.A. Abo-Elyousr, and A.H. El-Moursy. 2018. Efficiency of nitrogen and phosphorus fertilizers coated with plant growth-promoting rhizobacteria on wheat (Triticum aestivum L.) growth and nutrient uptake. Journal of Plant Nutrition, 41(1): 78-89.
27. El-Metwally, I. M. 1998. Effect of herbicides and bio-fertilization on growth and yield of wheat under different nitrogen fertilizer levels. Ph.D. Thesis., Fac. Of Agric. Mansoura Univ., Egypt.

28. El-Said, M. A., A.A. Ali, G.E. Abd-El-Maksoud,and F. Abd-El-Kareem. 2019. Influence of sowing date and planting geometry on growth, yield and quality of wheat. Journal of Plant Production, 10(6): 787-795.
29. El-Yazeid, A.A., H.A. Abou-Aly M.A. Mady and S. A. M. Moussa. 2007. Enhancing growth, productivity and quality of squash plants using phosphate dissolving microorganisms (bio phosphor) combined with boron foliar spray. Res. J. Agric. Biol. Sci. 3(4): 274-286.
30. Ezedinma, C. I., I.Y. Amapu, and S. Ude. 2019. Effects of nitrogen and phosphorus fertilizers on the growth and yield of maize (Zea mays L.). Journal of Agricultural Science and Technology, 21(2): 245-253.
31. Fageria, N.K., V.C. Baligar, and Y.C. Li. 2008. The role of nutrient efficient plants in improving crop yields in the twenty first century. J. Plant Nutr. 31: 1121-1157.
32. García, M., R.D. Prado, and M. Rondán. 2018. Effects of genotype and environment on wheat performance in Spain. Journal of Agronomy and Crop Science, 204(1): 59-70.
33. Hafeez, F.Y., S. Hameed, A. H. Zaidi and K.A. Malik. 2002. Bio-fertilizers for Sustainable Agriculture. *Techniques for Sustainable Agriculture*, Pp: 67–73. Nuclear Institute of Agriculture and Biology, Faisalabad, Pakistan .
34. Hassan, M. A., M.F. Saleem, A. Haq, and M. Naeem. 2015. Impact of Different Nutrient Levels on Phenology, Yield and Quality of Maize (Zea mays L.). Pakistan Journal of Agricultural Research, 28(4): 329-338.
35. Hussain, N., A. Z. Khan, H. Akbar, N. G Bangash, Z. H. Khan and M. Idress. 2007. response of maize varieties to phosphorus and potassium levels. Sarhad J. Agric. 23 (4): 882-888.
36. Iftikhar, U.D, G. ullah1, M. S. Baloch, A. A. Baloch, I. U. Awan and E.A Khan. 2011. Effect of phosphorus and herbicides on yield and yield components of maize. Pak. J. Weed Sci. Res. 17 (1): 1-7.
37. Inamullah,. N.H. Shah, N. Rehman, M. Siddiq and Z. Khan. 2011a. Phenology, yields and their correlations in popular local and exotic maize hybrids at various nitrogen levels. Sarhad J. Agric. 27 (3): 363-369.
38. Inamullah, N. Rehman, N.H. Shah, M. Arif, M. Siddiq and I. Mian. 2011b. Correlations among grain yield and yield attributes in maize hybrids in various nitrogen levels. Sarhad J. Agric. 27(4): 531-538.
39. Jaliya, M.M., Falaki, A.M., Mahmud, M., & Sani, Y.A. (2008). Effect of sowing date and npk fertilizer rate on yield and yield components of quality protein maize (Zea mays L.).
40. Jamil, M., A. Ali, S. Ahmad, M. Ali, M. Hussain, and A. Khan. 2017. Evaluation of maize hybrids under different sowing dates for grain yield and yield components. Journal of Agricultural Research, 55(3): 323-333.
41. Jan, M.T., P. Shah, P.A. Hollington, M.J. Khan and Q. Sohail. 2009. Agriculture Research: Design and Analysis, A Monograph. Agric. Univ. Pesh. Pak.
42. Khaliq, T., T. Mahmood, J. Kamal and A. Masood. 2004.Effectiveness of farmyard manure, poultry manure and nitrogen for corn (Zea mays L.). Productivity. Int. J.Agric. Biol., 2: 260-263.
43. Khan, M. A., A. Khan, A.U. Khan, H. Ali, and Shoaib. 2018. Effect of sowing dates on the yield and yield components of maize (Zea mays L.). Journal of Agricultural Research, 56(3): 199-209.
44. Kinane, S. M., C.R. Montes, M. Zapata, B.P. Bullock, R.L. Cook, and D.R. Mishra. 2022. Influence of environmental variables on leaf area index in loblolly pine plantations. *Forest Ecology and Management*, *523*: 120445.
45. Kumar, S., R.K. Singh, M. Kumar, R. Kumar, and A. Kumar. 2017. Influence of planting dates on growth and yield of maize hybrids. Journal of Pharmacognosy and Phytochemistry, 6(3): 2974-2977.
46. Lin, W., Y. Okon, and R. W. F. Hardy. 1983. Enhanced mineral uptake by Zea mays and Sorghum bicolor roots inoculated with Azospirillum brasilense. Appl. Environ. Microbiol. 45:1775-1779.

47. Liu, X., S. Zhang, S. Yin, Y. Zhao, and F. Li. 2018. Effects of sowing date on maize growth and development under different water conditions in Northeast China. Agricultural Water Management, 204: 1-8.
48. Maqbool, M. A., M. Shahzad, M.S. Ahmad, A. Ali and I.A. Rana. 2019. Evaluation of maize hybrids under varying dates of sowing for yield and yield components. Sarhad Journal of Agriculture, 35(2): 579-588.
49. Masood T., R. Gul, F. Munsif, F. Jalal, Z.Hussain, N. Noreen, H. Khan, Nasiruddin And Hayatullah Khan.2011. Phosphorus level on the yield and yield components of maize Sarhad J. Agric. 27 (2): 5-17.
50. Mervat, A.T., Emara.1994. Wheat response to rhizospheric bacterial inoculation under field conditions. The Desert Institute Bulletin, 44: 333-335.
51. MINFAL.2012. Agricultural statistics of Pakistan. Govt. of Pakistan. Ministry of Food Agri. Livestock, Food Agricultural and Livestock, Division (Economic wing) Islamabad.
52. Misra, R., A.M. Latare, A.K. Singh, and R. Kumar. 2019. Effect of different sowing dates and hybrids on growth and yield of maize (Zea mays L.). Journal of Pharmacognosy and Phytochemistry, 8(1): 411-415
53. Mitchell, C. C. and S. Tu. 2005. Long term evaluation of poultry litter as a source of nitrogen for cotton and corn. Agron. J., 97:399-407.
54. Namakka, A., Abubakar, I.U., Sadik, A.I., Sharifai, A.I. and Hassas, A.H. (2008). Effect of sowing date and Nitrogen level on yield and yield components of two extra early maize varieties (Zea mays L.) in Sudan Savanna of Nigeria. ARPN J. Agric. Bio. Sci. 3(2)
55. Niamatullah, M., M. Sadiq, C. S Hayat, H. Farid and M. Mumtaz. 2011. Phosphorus application on plant population, number of leaves and yield of green fodder maize. J. An. Pl. Sci., 21(1): 94-96
56. Ogbomo KEL, Remison SU (2009) Growth and yield of maize as influenced by sowing date and poultry manure application. Not Bot Hort Agrobot Cluj 37(1): 199-203.
57. Okoko, E. N. K. and S. Makworo. 1995. Evaluation of the effect of compost and inorganic fertilizer on maize yield in Nyamira district, South West Kenya.Kenya Agricultural Research Institute, Regional Research Centre, Kisii, P.O. Box 523, Kisii.
58. Oztekin.S., A. R. Brohi, M. R. Kamran, S. Iptas. 2008. The effect of different level of nitrogenious and phosphorus doses on herbage yield and yield components of silage maize as the second crop under the ecological condition of Tokat. International Meeting of Soil Fertility Land Management and Agroclimatology Turkey. :609-617.
59. Pandey, A., V. Singh, B. Singh, and R. Singh. 2017. Effect of nutrient management on yield, quality and economics of wheat (Triticum aestivum L.) in eastern Uttar Pradesh. Journal of Applied and Natural Science, 9(1): 439-443.
60. Panwar, A.S., N.P.Singh, D.C.Saxena, U.K. Hazarika. 2006. Yield and quality of groundnut seed as influence by phosphorus, biofertilizer and organic manures. Indian Journal of Hill Farming, (CAB abstracts)
61. Qureshi AS, Qadir M, Heydari N, Turral H, Javadi A (2007) A review of management strategies for salt-prone land and water resources in Iran. International water management Institute, 30P Colombo, Sri Lanka.
62. Ramankutty N, Foley JA, Norman J, Mc Sweeney K (2002) The global distribution of cultivable lands: Current patterns and sensitivity to possible climate change. Global Ecology Biogeogr 11(5): 377-392.
63. Rasheed, M., Javaid Khalid and Muhammad Hussain. 2004. Biological response of Maize to variable grades of phosphorus and planting geometry. Inte. J. Agri. And Bio. 3: 462-464.
64. Rashid, A., A. Mahmood, M. Kanwal, and R. Ahmad. 2015. Influence of sowing dates on growth, yield and quality of maize (Zea mays L.) in irrigated area of Pakistan. Journal of Agricultural Science and Technology, 17: 1057-1068.

65. Saini, R.K., R.K. Yadav, V.K. Singh, B. Singh, and R. Singh. 2021. Effect of sowing dates on growth, yield and quality of wheat (Triticum aestivum L.) varieties under irrigated conditions of central Uttar Pradesh. Journal of Agrometeorology, 23(1): 41-47.
66. Sangoi, L., A.D. Lúcio, P.N. Bianchetti, J.E. Kaefer. 2013. Plant density effect on maize productivity as related to intercepted radiation and crop phenology. Agronomy Journal, 105(5): 1459-1468.
67. Saraswati, R. and Sumarno. 2008. Application of soil microorganisms as component of agriculture technology. Iptek. Tan. Pangan 3:41.
68. Warren, J. G., S. B. Phillips, G. L. Mullins, D. Keachay and C. J. Penn. 2006. Environmental and production consequences of using alum-amended poultry litter as a nutrient source for corn. J. Environ. Qual., 35:172-182.
69. Zahoor, M., M. Shahbaz, S. Ali, S. Hussain, and M. Arshad. 2017. Yield and quality attributes of wheat genotypes under different sowing dates. The Journal of Animal and Plant Sciences, 27(2): 571-577
70. Zaman-Allah, M., D.M. Jenkinson, and V. Vadez. 2011. A conservative pattern of water use, rather than deep or profuse rooting, is critical for the terminal drought tolerance of chickpea. J. Exp. Bot. 62: 4239-
71. Zhang, H., Y. Zhang, M. He, X. Guo, M. Liu, and X. Chen. 2019. Effects of different nitrogen application rates on growth and yield of maize. PloS One, 14(2): 0211878.