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RESEARCH ARTICLE

Study of Sowing dates and Hybrids Effect in Maize-based Cropping System under Arid Conditions of Southern Punjab, Pakistan

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ABSTRACT

Optimum sowing date and most suitable hybrid are two main adaptation strategies for maize crop for managing the unfavorable weather circumstances. The objective of this research was to determine the optimum sowing date and hybrid during spring and autumn seasons. Field trials were carried out in spring and autumn seasons during 2016 and 2017 at Agronomic Research Area, Bahauddin Zakariya University, Multan, Pakistan. During spring season, three hybrids i.e., P-33M15, M-DK6525 and S-NK8441 were allocated in main plot and five sowing dates i.e., 15-January, 5-February, 25-February, 15-March and 5-April, were placed in sub plot during both years. During autumn growing season, three autumn hybrids i.e., P-30R50, M-DK6714 and S-NK6621 were placed in main plot and five sowing dates i.e., 15-June, 05-July, 25-July, 15-August and 5-September, were applied in sub plot. Results showed that during spring season, hybrid P-33M15 performed well at sowing date 5-February as compared to other hybrids and sowing dates during 2016 and 2017. During autumn season, hybrid P-30R50 performed well at sowing date 25-July as compared to other hybrids and sowing dates in both years. In conclusion, for obtaining higher production, spring season is better as compared to autumn for maize crop.

INTRODUCTION

Maize (*Zea mays* L.) is a vital cereal crop in maize based cropping system in Punjab, Pakistan (Abbas et al., 2019). Maize is broadly utilized for making food items, feeding purpose and bio-energy production. Maize is grown during both spring and autumn growing seasons in Pakistan (Ahmed and Ahmad, 2019; Fatima et al., 2018; Abbas et al., 2017; Ahmad et al., 2016). After wheat and rice crop, maize crop is ranked 3rd position and mostly (95%), it is grown in Punjab and Khyber Pakhtunkhwa provinces in Pakistan (Ahmad et al., 2019; Ahmed et al., 2019a, 2017; Hussain et al., 2019; Tariq et al., 2019). Total growing area was almost 1.32. Average grain yield was 4.39-ton ha^{-1} and total grain yield was 5.98 million ton (Anonymous, 2017). In Pakistan, average grain yield of spring and autumn maize is very low as compared to advance countries due to poor crop management practices especially un optimum sowing date and poor selection of hybrids (Abbas et al., 2019; Shahzad and Ahmad, 2019; Sher et al., 2019; Naz et al., 2019; Ahmed et al., 2019b, 2018; Hussain et al., 2018; Liaqat et al., 2018; Moatshe et al., 2015).

Planting date and hybrid maturity are two major strategies used worldwide for crop adaptation and mitigation to manage for unfavorable growing conditions (Abbas et al., 2019; Tian et al., 2019; Mason et al., 2018; Bonelli et al., 2016; Dong et al., 2012; Li et al., 2010). Optimum sowing date is very important crop management decision to obtain highest achievable grain yield during spring and autumn season (Totin and Pepo, 2018; Srivastava et al., 2016; Florio et al., 2014). Weather conditions like temperature, rainfall and solar radiations are changed with changing of sowing dates (Ijaz et al., 2019a, b; Younis et al., 2019; Zahoor et al., 2019; Abdala et al., 2018; Komainda et al., 2015). Weather conditions played a significant role on growth and development of maize crop (Ge et al., 2016;

Komainda et al., 2016; Nandy et al., 2013). Sowing of maize too early and too delay caused in reduction of cob length, cob diameter and number of grain rows cob^{-1} during spring and autumn growing seasons (Abbas et al., 2019; Zhou et al., 2017; Varma et al., 2014; Tsimba et al., 2013). Net assimilation rate, leaf area duration and cumulative photo active radiation are also affected due to change in sowing dates (Srivastava et al., 2018; Long et al., 2017; Lu et al., 2017; Tian et al., 2015). Maize morpho-physiological parameters are negatively affected due to inappropriate sowing time in spring and autumn season (Lu et al., 2017; Xu et al., 2016; Shirkhani et al., 2012). Resources use efficiency is also negatively affected under stress conditions due to unsuitable weather circumstances. Maize yield components are lessened under temperature stress (Cassman, 2017; Liu et al., 2013; Peykarestan and Seify, 2012; Farsiani et al., 2011). Maize hybrids also respond differently with different sowing dates. Spring and autumn hybrids responded well under appropriate environmental growing conditions (Huang et al., 2018; Choi et al., 2017; Koca and Canavar, 2014). Temperature stress negatively affected source-sink relationship in hybrids during spring and autumn seasons (Baum et al., 2018; Kim et al., 2017; Begum et al., 2016; Dahmardeh and Dahmardeh, 2010).

Study of sowing dates and hybrids in maize based cropping system is not done, so, main objectives of this study were 1) to find out the most favorable sowing date and most excellent hybrid during spring and autumn season 2) To find out best growing season either spring or autumn season in Pakistan.

MATERIALS AND METHODS

Experimental site

Field trials were carried out in spring and autumn seasons during 2016 and 2017 at Agronomic Research Area, Bahauddin Zakariya University, Multan (Latitude; 30° 18´ N, Longitude; 71° 56´ E, elevation; 125 m, Climate: irrigated arid environment), southern Punjab, Pakistan. Dominated soil series in the study area is Miani (fine silty loam, mixed, hyerthermic, fluventic haplocambids). Soil of the experimental area is alluvial type, calcareous in nature, and pH is high ≥8.5. Texture class of soil is silty loam. Range of soil bulk density is from 1.18 to 1.29 g cm^{-3}. Organic matter is less than 0.35%. Soil is deficient with respective to total nitrogen (≤ 1%), available phosphorus (7-10 ppm) and available potassium (85-120 ppm).

Metrological conditions

Irrigated arid climatic condition exists in research area, in which, range of average temperature is from 24 to 37°C. Average temperature and rainfall during autumn season is higher as compared to spring season. Average rainfall was ranged from 118 to 175 mm. Nearest weather station is in central cotton research station, from which, weather data was attained. Average temperature during 2017 was higher as compared to 2016. Rainfall was more during 2016 in comparison to 2017.

Field experiments detail

One field trial was carried out during spring growing season and one experiment was conducted during autumn growing season in each year. Every experiment was laid out in randomized complete block design along with split plot arrangement in each season during 2016 and 2017. During spring season field trial, three hybrids i.e., P-33M15, M-DK6525 and S-NK8441 were applied in main plot and five sowing dates i.e., 15-January, 5-February, 25-February, 15-March and 5-April, were placed in sub-plot during both years. During autumn growing season field trial, three autumn hybrids i.e., P-30R50, M-DK6714 and S-NK6621 were placed in main plot and five sowing dates i.e., 15-June, 05-July, 25-July, 15-August and 5-September, were applied in sub-plot.

Crop husbandry

Sowing of spring hybrids during spring season and autumn hybrids during autumn season were done according to planting dates during 2016 and 2017. Breaking of compactness of land was done by using of two deep ploughing with the help of chisel plough and after that, seed bed preparation was performed by four times cultivations along with planking at *watter* condition. Recommended sowing method ridge was adopted, in which, ridge to ridge and plant to plant spaces were maintained at 70 and 18 cm, respectively. Seed rate of 24 kg ha^{-1} was applied in each field trial. 4-5 days after sowing, gap filling was done for fulfill the recommended plant population in experimental units in each experiment. Thinning after 20 days of sowing was done to keep up plant to plant distance. Recommendation dose of 248 kg ha^{-1} for N (fertilizer source urea), 165 kg ha^{-1} for P (fertilizer source DAP) and 115 kg ha^{-1} for K (fertilizer source K_2SO_4) was applied in each field trial during spring and autumn seasons. One third amount of nitrogen fertilizer and all amounts of phosphorus and potassium fertilizers were placed at seedbed preparation time in each trial, while, remaining each one third dosage of nitrogen fertilizer was applied at almost 18 and 40 days after sowing and before tasseling stage, respectively. Source of irrigation water was Tube-well. Weeds were controlled with the help of chemical and mechanical methods at various crop stages. Pesticides and fungicides were applied for control of pests and diseases.

Statistical analysis

Analysis of observed data was done with the help of software MSTAT-C statistical package (MSTAT-C Development Team 1989) on a laptop. For determine the significance between treatments and their average values, the least significance differences (LSD) test at 5% probability levels was applied according to described by Steel et al. (1997).

Table 1: Effect of hybrids and sowing dates on yield components of maize-based cropping system

Treatments	Spring crop								Autumn crop							
	Cob length (cm)		Cob girth (cm)		Grain rows cob^{-1}		Harvest index (%)		Cob length (cm)		Cob girth (cm)		Grain rows cob^{-1}		Harvest index (%)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Hybrids																
P-33M15 (P-30R50)	18.30a	17.32a	3.88a	3.74a	15.22a	14.79a	42.22a	41.57a	17.14a	16.22a	3.58a	3.40a	14.20a	13.72a	41.17a	40.39a
M-DK6525 (M-DK6714)	16.69b	15.74b	3.59b	3.45b	14.80b	14.28b	41.19b	40.30b	15.91b	15.01b	3.33b	2.98b	13.98b	13.04b	40.03b	39.22b
S-NK8441 (S-NK6621)	15.86c	14.59c	3.30c	3.19c	14.32c	13.67c	40.03c	38.96c	14.65c	13.27c	3.11c	2.74c	12.54c	11.54c	39.95b	38.91b
LSD 5%	0.26	0.37	0.07	0.09	0.12	0.15	0.52	0.79	0.24	0.18	0.08	0.03	0.10	0.18	0.34	0.31
Significance	**	**	**	**	**	**	**		**	**	**	**	**	**	**	**
Sowing dates																
15-Jan (15-Jun)	18.29b	17.18b	3.91b	3.77b	15.32b	14.85b	43.61b	43.12b	12.49e	11.45e	2.85e	2.50e	12.30e	11.53d	35.50e	34.91d
05-Feb (05-Jul)	20.06a	18.93a	4.08a	3.96a	15.81a	15.29a	46.03a	45.15a	14.30d	13.17d	3.15d	2.87d	13.12d	12.36c	39.65d	38.87c
25-Feb (25-Jul)	16.95c	15.91c	3.66c	3.53c	14.93c	14.45c	42.19c	40.72c	19.01a	17.94a	3.79a	3.50a	14.66a	13.87a	43.82a	42.96a
15-Mar (15-Aug)	15.62d	14.59d	3.31d	3.17d	14.43d	13.91d	37.71d	36.78d	17.36b	16.32b	3.56b	3.28b	14.10b	13.34b	42.16b	41.56b
05-Apr (05-Sep)	13.85e	12.82e	2.98e	2.88e	13.40e	12.75e	36.08e	35.61d	16.33c	15.29c	3.37c	3.05c	13.67c	12.73c	40.82c	39.43c
LSD 5%	0.53	0.75	0.16	0.19	0.25	0.31	1.07	1.61	0.49	0.38	0.14	0.07	0.19	0.37	0.70	0.64
Significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Mean	16.95	15.89	3.59	3.47	14.78	14.25	41.13	40.28	15.91	14.83	3.34	3.05	13.58	12.75	40.39	39.55

RESULTS

Cob length (cm)

During spring season, cob length was obtained 18.30 and 17.32 cm ($p \leq 0.05$) by P-33M15 during 2016 and 2017, respectively (Table 1), while, S-NK8441 produced lowest cob length 15.86 cm during 2016 and14.59 cm during 2017 ($p \leq 0.05$). Cob length was decreased by early or delay sowing dates in comparison to optimum sowing date (5th February). At sowing date 5th February, highest cob length 20.06 and 18.93 cm ($p \leq 0.05$) were obtained during 2016 and 2017, respectively. Lowest cob length 13.85 and 12.82 cm ($p \leq 0.05$) was attained during first and second year, respectively by sowing date 05th April.

During autumn season, cob length was also affected significantly during both years (Table 1). Highest cob length was achieved 17.14 and 16.22 cm ($p \leq 0.05$) by P-30R50 during first and second years, respectively, whereas, S-NK6621 took 14.65 cm during 2016 and 13.27 cm during 2017 ($p \leq 0.05$). Cob length was decreased by early or delay sowing dates in comparison to optimum sowing date (25th July). At sowing date 25th July, maximum cob length 19.01 and 17.94 cm ($p \leq 0.05$) was gained during 2016 and 2017, correspondingly. Minimum cob length 12.49 and 11.45 cm ($p \leq 0.05$) were obtained during first and second year, respectively by sowing of crop on 15th June.

Cob girth (cm)

Table 1 showed that during spring season, highest cob girth was obtained 3.88 and 3.74 cm ($p \leq 0.05$) by P-33M15 during 2016 and 2017, respectively, while, S-NK8441 produced lowest cob girth 3.30 cm during 2016 and 3.19 cm during 2017 ($p \leq 0.05$). Cob girth was decreased by early or delay sowing dates in comparison to optimum sowing date (5th February). At sowing date 5th February, highest cob girth 4.08 and 3.96 cm ($p \leq 0.05$) were obtained during 2016 and 2017, respectively. Lowest cob girth 2.98 and 2.88 cm ($p \leq 0.05$) was attained during first and second year, respectively by sowing date 05th April.

During autumn season, cob girth was also affected significantly during both years. Highest cob girth was achieved 3.58 and 3.40 cm ($p \leq 0.05$) by P-30R50 during first and second year, respectively, whereas, S-NK6621 took 3.11cm during 2016 and 2.74 cm during 2017 ($p \leq 0.05$) (Table 1). Cob girth was decreased by early or delay sowing dates in comparison to optimum sowing date (25th July). At sowing date 25th July, maximum cob girth 3.79 and 3.50 cm ($p \leq 0.05$) was gained during 2016 and 2017, correspondingly. Minimum cob girth 2.85 and 2.50 cm ($p \leq 0.05$) were obtained during first and second year, respectively by sowing date 15th June.

Grain rows cob^{-1}

During spring season, highest grain rows cob^{-1} were obtained 15.22 and 14.79 ($p \leq 0.05$) by P-33M15 during 2016 and 2017, respectively, while, S-NK8441 produced lowest grain rows cob^{-1} 14.32 during 2016 and 13.67 during 2017 ($p \leq 0.05$) (Table 1). Grain rows cob^{-1} were decreased by early or delay sowing dates as compared to optimum sowing date (5th February). At sowing date 5th February, highest grain rows cob^{-1} 15.81 and 15.29 ($p \leq 0.05$) were obtained during 2016 and 2017, respectively. Lowest grain rows cob^{-1} 13.40 and 12.75 ($p \leq 0.05$) was attained during first and second years, respectively by sowing date 05th April.

Table 2: Effect of hybrids and sowing dates on morpho-physiological parameters of maize-based cropping system

Treatments	Spring crop								Autumn crop							
	Net assimilation rate ($g\ m^{-2}\ d^{1}$)		Fraction of intercepted radiation (Fi)		Leaf area duration (days)		Cumulative intercepted PAR ($MJ\ m^{-2}$)		Net assimilation rate ($g\ m^{-2}\ d^{1}$)		Fraction of intercepted radiation (Fi)		Leaf area duration (days)		Cumulative intercepted PAR ($MJ\ m^{-2}$)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Hybrids																
P-33M15 (P-30R50)	6.68a	6.64a	0.934a	0.920a	274.81a	266.76a	644.21a	633.18a	5.95a	5.89a	0.892a	0.883a	267.42a	259.37a	627.38a	622.42a
M-DK6525 (M-DK6714)	6.48b	6.32b	0.923b	0.909b	265.38b	257.43b	631.57b	620.62b	5.89b	5.78b	0.879b	0.869b	256.57b	248.64b	614.01b	608.99b
S-NK8441 (S-NK6621)	6.31c	6.16c	0.911c	0.898c	253.62c	245.57c	615.83c	604.79c	5.75c	5.59c	0.863c	0.850c	248.01c	239.98c	603.97c	599.02c
LSD 5%	0.03	0.06	0.004	0.005	5.23	6.54	3.67	1.83	0.04	0.05	0.007	0.006	3.67	5.24	2.88	1.83
Significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
Sowing dates																
15-Jan (15-Jun)	6.69b	6.54b	0.944b	0.937a	279.02b	270.98b	648.65b	637.68b	5.43e	5.26d	0.718d	0.702d	219.98e	212.03d	580.65e	575.71e
05-Feb (05-Jul)	6.86a	6.81a	0.953a	0.946a	292.31a	284.29a	663.01a	651.99a	5.93c	5.89b	0.933b	0.925b	241.00d	233.05c	599.29d	594.35d
25-Feb (25-Jul)	6.60c	6.52b	0.921c	0.905b	266.27c	258.34b	632.70c	621.65c	6.11a	6.03a	0.962a	0.954a	283.01a	274.97a	649.31a	644.27a
15-Mar (15-Aug)	6.21d	6.05c	0.909d	0.887c	250.99d	243.03c	611.34d	600.28d	6.04b	5.94b	0.936b	0.930b	275.30b	267.34ab	632.29b	627.38b
05-Apr (05-Sep)	6.10e	5.96c	0.887e	0.871d	234.32e	226.25d	596.98e	586.01e	5.82d	5.62c	0.843c	0.826c	267.28c	259.31b	614.02c	608.97c
LSD 5%	0.06	0.11	0.008	0.011	10.65	13.32	7.46	3.73	0.07	0.09	0.014	0.011	7.46	10.65	5.86	3.72
Significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Mean	6.49	6.37	0.923	0.909	264.62	256.57	630.54	619.48	5.86	5.75	0.878	0.865	257.37	249.28	615.18	610.12

Table 1 indicated that during autumn season, grain rows cob^{-1} was also affected significantly during both years. Highest grain rows cob^{-1} were achieved 14.20 and 13.72 ($p \leq 0.05$) by P-30R50 during first and second years, respectively, whereas, S-NK6621 took 12.54 during 2016 and 11.54 during 2017 ($p \leq 0.05$). Grain rows cob^{-1} was decreased by early or delay sowing dates in comparison to optimum sowing date (25th July). At sowing date 25th July, maximum grain rows cob^{-1} 14.66 and 13.87 ($p \leq 0.05$) was gained for the period of 2016 and 2017, respectively. Minimum grain rows cob^{-1} 12.30 and 11.53 ($p \leq 0.05$) were obtained during first and second year, respectively by sowing date 15th June.

Harvest index (%)

During spring season, highest harvest index (HI) was obtained 42.22 and 41.57% ($p \leq 0.05$) by P-33M15 during 2016 and 2017, respectively, while, S-NK8441 gave lowest HI 40.03% during 2016 and 38.96% during 2017 ($p \leq 0.05$) (Table 1). The HI was decreased by early or delay sowing dates. At sowing date 5th February, highest HI 46.03 and 45.15% ($p \leq 0.05$) were obtained during 2016 and 2017, respectively. Lowest HI 36.08 and 35.61% ($p \leq 0.05$) was attained during first and second years, respectively by sowing date 05th April.

In autumn season, grain yield was also affected significantly during both years (Table 1). Highest HI was achieved 41.17 and 40.39% ($p \leq 0.05$) by P-30R50 during first and second years, respectively, whereas, S-NK6621 gave 39.95% during 2016 and 38.91% during 2017 ($p \leq 0.05$). The HI was decreased by early or delay sowing dates in comparison to optimum sowing date. At sowing date 25th July, maximum HI 43.82 and 42.96% ($p \leq 0.05$) was gained for the period of 2016 and 2017, correspondingly. Minimum HI 35.50 and 34.91% ($p \leq 0.05$) was obtained during first and second years, respectively by sowing date 15th June.

Net assimilation rate ($g\ m^{-2}\ d^{-1}$)

In spring season, highest net assimilation rate (NAR) was obtained 6.68 and 6.64 $g\ m^{-2}\ d^{-1}$ ($p \leq 0.05$) by P-33M15 during 2016 and 2017, respectively (Table 2), while, S-NK8441 gave lowest NAR 6.31 $g\ m^{-2}\ d^{-1}$ during 2016 and 6.16 $g\ m^{-2}\ d^{-1}$ during 2017 ($p \leq 0.05$). The NAR was decreased by early or delay sowing dates. At sowing date 5th February, highest NAR 6.86 and 6.81 $g\ m^{-2}\ d^{-1}$ ($p \leq 0.05$) were obtained during 2016 and 2017, respectively. Lowest NAR 6.10 and 5.96 $g\ m^{-2}\ d^{-1}$ ($p \leq 0.05$) was attained during first and second years, respectively by sowing date 05th April.

During autumn season, grain yield (GY) was also affected significantly during both years (Table 2). Highest NAR was achieved 5.95 and 5.89 $g\ m^{-2}\ d^{-1}$ ($p \leq 0.05$) by P-30R50 during first and second years, respectively, whereas, S-NK6621 gave 5.75 $g\ m^{-2}\ d^{-1}$ during 2016 and 5.59 $g\ m^{-2}\ d^{-1}$ during 2017 ($p \leq 0.05$). The NAR was decreased by early or delay sowing dates in comparison to optimum sowing date. At sowing date 25th July, maximum NAR 6.11 and 6.03 $g\ m^{-2}\ d^{-1}$ ($p \leq 0.05$) was gained for the period of 2016 and 2017, correspondingly. Minimum NAR 5.43 and 5.26 g m^{-2} d^{-1} ($p \leq 0.05$) was obtained during first and second years, respectively by sowing date 15th June.

Fraction of intercepted radiation (Fi)

Table 2 showed that during spring season, highest Fi value was obtained 0.934 and 0.920 ($p \leq 0.05$) by P-33M15 during 2016 and 2017, respectively, while, S-NK8441 gave lowest Fi value 0.911 during 2016 and 0.898 during 2017 ($p \leq 0.05$). Fi value was decreased by early or delay sowing dates. At sowing date 5th February, highest Fi value 0.953 and 0.946 ($p \leq 0.05$) were obtained during 2016 and 2017, respectively. Lowest Fi value 0.887 and 0.871 ($p \leq 0.05$) was attained during first and second year, respectively by sowing date 05th April.

During autumn season, grain yield was also affected significantly during both years. Highest Fi value was achieved 0.892 and 0.883 ($p \leq 0.05$) by P-30R50 during first and second year, respectively (Table 2), whereas, S-NK6621 gave 0.863 during 2016 and 0.850 during 2017 ($p \leq 0.05$). Fi value was decreased by early or delay sowing dates in comparison to optimum sowing date. At sowing date 25th July, maximum Fi value 0.962 and 0.954 ($p \leq 0.05$) was gained for the period of 2016 and 2017, correspondingly. Minimum Fi value 0.718 and 0.702 ($p \leq 0.05$) was obtained during first and second year, respectively by sowing date 15th June.

Leaf area duration (days)

During spring season, highest leaf area duration (LAD) was obtained 274.81 and 266.76 days ($p \leq 0.05$) by P-33M15 during 2016 and 2017, respectively (Table 2), while, S-NK8441 gave lowest LAD 253.62 days during 2016 and 245.57 days during 2017 ($p \leq 0.05$). The LAD was decreased by early or delay sowing dates. At sowing date 5th February, highest LAD 292.31 and 284.29 days ($p \leq 0.05$) were obtained during 2016 and 2017, respectively. Lowest LAD 234.32 and 226.25 days ($p \leq 0.05$) was attained during first and second years, respectively by sowing date 05th April.

Table 2 showed that during autumn season, GY was also affected significantly during both years. Highest LAD was achieved 267.42 and 259.37 days ($p \leq 0.05$) by P-30R50 during first and second years, respectively, whereas, S-NK6621 gave 248.01 days during 2016 and 239.98 days during 2017 ($p \leq 0.05$). The LAD was decreased by early or delay sowing dates in comparison to optimum sowing date. At sowing date 25th July, maximum LAD 283.01 and 274.97 days ($p \leq 0.05$) was gained for the period of 2016 and 2017, correspondingly. Minimum LAD 219.98 and 212.03 days ($p \leq 0.05$) was obtained during first and second years, respectively by sowing date 15th June.

Cumulative intercepted PAR (MJ m^{-2})

During spring season, highest PAR value was obtained 644.21 and 633.18 MJ m^{-2} ($p \leq 0.05$) by P-33M15 during 2016 and 2017, respectively, while, S-NK8441 gave lowest PAR value 615.83 MJ m^{-2} during 2016 and 604.79 MJ m^{-2} during 2017 ($p \leq 0.05$) (Table 2). PAR value was decreased by early or delay sowing dates. At sowing date 5th February, highest PAR value 663.01 and 651.99 MJ m^{-2} ($p \leq 0.05$) was obtained during 2016 and 2017, respectively. Lowest PAR value 596.98 and 586.01 MJ m^{-2} ($p \leq 0.05$) was attained during first and second year, respectively by sowing date 05th April.

Table 2 showed that during autumn season, GY was also affected significantly during both years. Highest PAR value was achieved 627.38 and 622.42 MJ m^{-2} ($p \leq 0.05$) by P-30R50 during first and second years, respectively, whereas, S-NK6621 gave 603.97 MJ m^{-2} during 2016 and 599.02 MJ m^{-2} during 2017 ($p \leq 0.05$). PAR value was decreased by early or delay sowing dates in comparison to optimum sowing date. At sowing date 25th July, maximum PAR value 649.31 and 644.27 MJ m^{-2} ($p \leq 0.05$) was gained for the period of 2016 and 2017, correspondingly. Minimum PAR value 580.65 and 575.71 MJ m^{-2} ($p \leq 0.05$) was obtained during first and second year, respectively by sowing date 15th June.

DISCUSSION

Most favorable growing circumstances were gained on sowing date 5th February during spring season and sowing date 25th July during autumn season in comparison to other sowing dates during 2016 and 2017 in maize based cropping system (Abbas et al., 2017). Highest cob length, cob girth, grain rows cob^{-1} and HI was obtained by spring maize crop growing at sowing date 5th February and autumn maize at sowing date 25th July (Liaqat et al., 2018; Moatshe et al., 2015). Reason is that sowing time influenced the growth and development of spring and autumn maize significantly during both years (Huang et al., 2018; Choi et al., 2017; Koca and Canavar, 2014). Sowing of maize too early and too delay caused in reduction of NAR, LAD, fraction of intercepted photoactive radiations and cumulative photo active radiations in spring and autumn maize crop (Tian et al., 2019; Mason et al., 2018; Bonelli et al., 2016; Dong et al., 2012; Li et al., 2010). Grain yield parameters are depended on light interception and cumulative photo active radiation. Change in grains cob^{-1} can be evaluated on the basis of the accumulation of photo assimilates during early vegetative stage to end of grain filling stage. Any temperature stress negatively affected source-sink relationship in spring and autumn maize under unfavorable sowing date (Totin and Pepo, 2018; Srivastava et al., 2016; Florio et al., 2014). Maize parameters were decreased in earlier sowing time due to inadequacy of source capacity and reducing of GY components was done in late sowing dates due to inadequacy of sink capacity for spring maize. Whereas, during autumn season, cob length, cob girth and grains cob^{-1} were decreased in advance sowing time due to restriction of sink capacity and in delaying of sowing date due to restraint of source capacity in maize based cropping system (Abdala et al., 2018; Komainda et al., 2015). Source capacity is frequently measured as a result of photo-assimilates accumulation in net photosynthesis rate. Sink capability is determined by number of growing grains cob^{-1} and grain size for collection of photo-assimilates formation. Limitation of sink is frequently measured as a grain weight reducing factor in maize crop (Ge et al., 2016; Komainda et al., 2016; Nandy et al., 2013). As a result, mostly recommended crop husbandry practices and main breeding work in maize have been focused to maximize the grains cob^{-1} (Cassman, 2017; Liu et al., 2013; Peykarestan and Seify, 2012; Farsiani et al., 2011). Optimum relationship between source and sink was gained at sowing date 5th February during spring season and 25 July during autumn season during both years. High temperature stress decreases grain production as a result of its harmful influence on plant physiological processes (Srivastava et al., 2018; Lu et al., 2017; Long et al., 2017; Tian et al., 2015). Sink capacity was negatively influenced by the interruption of the synchrony between anthesis and silking, decreased ovule fertilization and enhanced grain abortion (Zhou et al., 2017; Varma et al., 2014; Tsimba et al., 2013). In turn, this effect disturbs pollination and number of grain setting and can consequence in rigorous grain yield losses (Baum et al., 2018; Kim et al., 2017; Begum et al., 2016; Dahmardeh and Dahmardeh, 2010). Failure of pollen viability is happened as a result of heat stress effect in spring and autumn maize (Lu et al., 2017; Xu et al., 2016; Shirkhani et al., 2012).

Conclusion

Spring hybrid P-33M15 and autumn hybrid P-30R50 are more adaptable hybrids as compared to other hybrids. Optimum sowing date is 5th February during spring season and 25th July during autumn season. For obtain maximum attainable yield, spring season is best as compared to autumn season for maize crop.

Authors' contribution

GA conducted field trials, ZF, FR, PI reviewed literature, SH, MI, EH analyzed data along with Figure work, wrote this manuscript and SA supervised the study. All authors contributed equally and read the manuscript final draft before submission.

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