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RESEARCH PAPER

Optimization of sowing time of maize hybrids for spring season in North western India

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Abstract A field experiment was conducted at G.B.P.U. A &T, Pantnagar during spring season 2019 to study the effect of different sowing dates and hybrids on growth, yield and economics of maize.The experiment consisting of six dates of sowing (5 February, 12 February, 19 February, 26 February, 5 March and 12 March) in main plot and five hybrids (Pant Sankar Makka 5, Pant Sankar Makka 6, DH 300, DKC 9108 and P 1866) in sub plot was laid out in split plot design with three replications. The plant height, days to 50% flowering, cob length, cob girth, 100-grain weight, grain irrigation water use efficiency and economics were influenced significantly by sowing dates. The values of all these parameters were significantly higher in 5th and 12th February sowing and reduced significantly with delay in sowing. Performance of hybrids DKC 9108 and P 1866 was superior to other hybrids with respect to production and net return. The results indicated that maize in spring season in North western India should be sown in the first fortnight of February. The productivity of DKC 9108 and P 1866 is high in spring season.

Keywords: Hybrid • Maize • Sowing date • Planting • Spring season

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Introduction

In India, maize is primarily grown during *kharif* (rainy season) however *rabi* (winter) and spring (summer) seasons are more prospective for enhanced production and productivity. Cultivation of maize during spring season in north western plain of India is gaining popularity as productivity is high and thus high economic returns. Spring maize also fits well in the cropping system after vegetable pea, potato, ratoon sugarcane etc., harvested in January and February. Apart from high yield, spring maize also had advantages of minimum insect pests, diseases and weeds infestation leading to low cost of cultivation. The productivity of maize is primarily governed by environmental conditions and management practices (Bhat *et al*., 2024). Among the management practices, time of sowing is one of the major concerns and it becomes more important in spring maize cultivation. Too early sowing may hinder the germination and vegetative growth due to low temperature. Whereas late sowing may coincide reproductive phase to high temperature leading to low pollen viability, seed set grain filling and reduced yield. Yield components and grain quality parameters of maize varieties are significantly affected by different sowing dates (Cao *et al.*, 2024). Therefore, it is necessary to determine appropriate sowing duration of spring maize for optimized and enhanced harvest by adequate utilization of growth factors such as moisture, nutrients and solar radiation. In the spring season, the major two constraints of crop production are high temperature and evaporation at later growth stages and limited soil moisture content. High temperature affects the vegetative and reproductive phase of maize crop and influences the capacity of grain filling and duration of crop (Hatfield and Prueger, 2015; Lohani *et al*., 2020). It also restricts root growth and thus reduces the ability of plants to extract moisture and nutrients from the soil. Apart from the management practices, selection of appropriate maize cultivars is essentially required for taking advantage of environmental conditions. In fact, there are inherent potential of tolerance and adaptability of maize cultivars against the extreme of environmental and biotic factors. Many maize cultivars have potential to adapts well to the spring season maize since they have genetic potential to tolerate high temperature, low moisture and also able to complete life cycle efficiently with high yield without affecting subsequent crop in specific cropping system. Such genetically elite maize cultivars need to be identified for complying with the existing environmental conditions of the spring season. Therefore, an experiment was conceptualized, planned and conducted to find out suitable maize hybrid and optimum sowing time for spring season.

Materials and methods

The field experiment was conducted during the spring season, 2019 at the N.E. Borlaug crop research centre of G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand representing the *Tarai* belt of Uttarakhand. The soil of experiment field was silty clay loam in texture, neutral in reaction (pH 7.3), medium in organic carbon (0.71%), low in available nitrogen (231 kg/ha), medium in available phosphorus (18.4 kg/ha) and medium in available potassium (209 kg/ha).The experiment consisting of six dates of sowing (5 February, 12 February, 19 February, 26 February, 5 March and 12 March) in main plot and five hybrids (Pant Sankar Makka 5, Pant Sankar Makka 6, DH 300, DKC 9108 and P 1866) in sub plot was laid out in split plot design with three replications. One pre sowing irrigation was given and the field was prepared by three harrowing and one levelling. The furrows were opened by furrow opener at the distance of 60 cm and seeds were spaced at 25 cm with in row. Fertilizers were applied through NPK mixture (12:32:16), urea and muriate of potash. The 25 per cent of nitrogen and full dose of phosphorous and potassium was applied as basal. Remaining nitrogen was applied in 3 equal splits at 4 leaf- stage, knee height stage and at initiation of tasseling, respectively. One hoeing was done in different treatment to control weeds. One spray of chlorantraniliprole @ 0.3 ml/litre water was also made to protect the crop from infestation of insects at knee height stage. The depth of irrigation was 5 cm. The number of irrigations were 8, 8, 8, 7, 7 and 7 in 5 February, 12 February, 19 February, 26 February, 5 March and 12 March, respectively and crop was harvested in June on dates 6, 6, 10, 14, 18 and 19, respectively. The plant height was measured at harvest from ground surface to the ligules of the upper most fully opened leaf. The date by which 50 per cent of the plants bear tassel and silk was recorded as date of 50 per cent tasseling and 50% silking. Anthesis silk interval (ASI) was calculated by taking difference between days to 50% silking and days to 50% tasseling in respective treatments. The number of days between sowing date and harvesting date were counted and reported as crop duration in days. At the time of harvest, the number of plants and cobs in each net plot were counted and were expressed on hectare basis. Five cobs were randomly selected from each net plot. The husk was removed and length was measured with the help of foot scale. The average cob length was reported in cm. The cobs selected for measuring cob length were also used for recording cob girth. The girth was measured at three points i.e. bottom, middle and top of the cob. The average of these three values was expressed as cob girth in cm. The cobs were harvested manually and were shelled when grain moisture content was about 15 per cent. To make the economics time relevant, inputs cost and minimum support price of maize grain prevailed during year 2024 were considered. Net returns was calculated by deducting the cost of cultivation from the gross returns. The benefit to cost ratio (B:C) was worked out by dividing net returns from cost of cultivation. The data obtained from various observations were statistically analyzed as per procedure of split plot design by using the standard techniques of Analysis of Variance (Gomez and Gomez, 1984). Treatment means were compared at 5% level of significance. Economics was not analyzed statistically because net return in few treatments was negative.

Results and discussion

Effect of sowing date

Data presented in Table 1 and 2 revealed that sowing date significantly affected growth and productivity of maize but plant population and number of cobs did not vary statistically. Plant population depends on number of seeds sown in unit area and mortality percentage. In present

Table 1. Effect of sowing dates and hybrids on growth and yield attributes of maize in spring season

Treatment	Plants ($\times10^3$)/ha	Cobs ($\times10^3$)/ha	Plant height (cm)	Days to 50% tasseling	Days to 50% silking	ASI (days)	Cob length (cm)	Cob girth (cm)	100-grain weight (g)
Date of sowing									
5 February	63.4	63.4	137.8	77.2	81.2	4.00	15.0	13.3	26.8
12 February	63.4	63.4	139.7	72.6	76.5	3.87	15.0	13.3	26.7
19 February	62.9	62.9	137.1	70.0	73.3	3.27	14.0	13.0	25.4
26 February	64.1	64.1	133.8	69.1	72.2	3.07	13.0	13.0	23.5
5 March	63.3	63.3	128.1	67.6	70.6	3.00	11.4	13.0	17.7
12 March	63.4	63.4	122.6	64.4	67.4	3.00	11.0	12.1	14.9
SEm±	0.5	0.5	1.0	0.1	0.1	0.09	0.1	0.1	0.16
CD (5%)	NS	NS	3.3	0.4	0.4	0.28	0.3	0.2	0.52
Hybrids									
Pant Sankar Makka 5	63.4	63.4	127.4	70.7	74.1	3.39	13.0	12.6	21.9
Pant Sankar Makka 6	63.2	63.2	128.2	71.2	74.6	3.33	13.0	12.4	21.8
DH 300	63.1	63.1	125.9	71.1	74.4	3.28	12.0	12.2	19.3
DKC 9108	64.1	64.1	143.3	69.8	73.2	3.39	14.0	13.4	24.9
P 1866	63.3	63.3	141.2	68.0	71.4	3.44	14.0	13.3	24.6
SEm±	0.6	0.6	1.0	0.1	0.1	0.05	0.1	0.1	0.23
CD (5%)	NS	NS	2.9	0.3	0.3	NS	0.2	0.2	0.70

study the crop geometry (60 cm × 25 cm) in each treatment was same hence plant population remained non-significant. Since number of cobs per unit area depends on plant population, non-significant variation in plant population was responsible for at par difference in number of cobs in different sowing dates. These results are in line of Shrestha *et al.* (2016) who also reported non-significant differences in number of cobs due to different sowing dates. In general growth and yield attributes reduced with delay in sowing time. A trend of reduction in plant height was noted with delay in sowing date particularly after 19 February. The tallest plants (139.7 cm) were noted in second date of sowing (12 February) which were significantly superior to all dates except first and third date of sowing. Lower plant height under delayed sowing may be attributed to high temperature. These results corroborate the findings of Amajadin *et al.* (2015) who reported reduction in plant height due to high temperature. Days to reach 50% flowering and anthesis silk interval (ASI) reduced significantly with delay in sowing. Maize sowing on 5 February exhibited significantly maximum number of days to reach 50% tasseling (77.2 days) and 50% silking (81.2 days) and minimum respective values (64.4 and 67.4 days) were recorded in the last sowing on 12 March. This sowing date also showed significantly longer ASI (4.0 days) but was at par with second date of sowing. ASI was minimum (3.0 days) in last sowing date. Crop sown early faced relatively low temperature and shorter sunshine hours for longer period so took more days to complete vegetative stage and reached 50% tasseling stage late. With delay in sowing atmospheric temperature increased and late sown maize crop came early into flowering stage and had less ASI. Franco *et al.* (2016) also found less number of days required for tasseling due to rise in temperature. Crop sown in second fortnight of February and in March faced relatively high temperature during 50% tasseling to harvest stage. High temperature during reproductive phase adversely affected pollen viability, receptivity of silk, cell division in endosperm, duration in grain filling, kernel development and enzyme activities. Heat stress reduce the viability and amount of pollens (Lizaso *et al*., 2018). Crop sown on 5th and 12th February being at par with each other recorded significantly more cob length (15.0 cm), cob girth (13.3 cm) and 100-grain weight (26.8 g) than other dates. Significantly lowest cob length, cob girth and 100-grain weight were recorded in the delay date of sowing i.e. 12 March. Crop performance was good in early sowing as evident from plant height and days to reach 50% flowering. Better growth of plant and favourable temperature regime helped in making proper reproductive development and more translocation of photosynthates

Table 2. Effect of sowing dates and hybrids on yield, water use efficiency and B:C ratio of maize in spring season

Treatment	Grain yield (kg/ha)	Shelling (%)	Days to maturity	Irrigation water use efficiency (kg/ha-cm)	B:C ratio
Date of sowing					
5 February	7155	75.8	121.0	895	1.70
12 February	7246	75.6	114.0	906	1.74
19 February	6611	74.0	111.0	827	1.50
26 February	5157	70.9	108.0	737	1.00
5 March	3134	68.2	105.0	448	0.22
12 March	2342	66.3	96.0	335	- 0.09
SEm±	69	0.7	-	9	-
CD (5%)	220	2.4	-	29	-
Hybrids					
Pant Sankar Makka 5	5072	71.1	109.2	664	0.93
Pant Sankar Makka 6	5059	71.9	109.2	661	0.93
DH 300	4658	72.4	109.2	611	0.78
DKC 9108	5858	72.1	109.2	768	1.23
P 1866	5726	71.6	109.2	751	1.18
SEm±	71	0.6	-	9	-
CD (5%)	202	NS	-	27	-

from source to sink. Therefore, sowing in first fortnight of February resulted in to longer and wider cobs and heavier seed weight. High average daily temperature in late sowing depressed cob development and grain filling. Cao *et al.* (2024) also reported the adverse effect of high temperature on yield attributes of maize. The crop maturity period was maximum (121 days) in the first date of sowing and reduced with delay in sowing as 114, 111, 108, 105 and 96 days, respectively. Crop sown on 5March and 12th March faced high temperature during vegetative and reproductive growth stages which fulfilled growing degree day demand fastly and resulted into early maturity. These results are in accordance to Abaza *et al.* (2023) who also reported longer crop duration due to low temperature. Crop sown on 12 February had significantly more grain yield (7246 kg/ha) than other dates but remained at par with that of sown on 5 February. The yield reduction in grain yield on sowing dates 19 February, 26 February, 5 March and 12 March was 8.76, 28.83, 56.75 and 67.68 per cent over sowing on 12 February. Significantly higher grain yield in sowing during first fortnight of February was due to higher values of yield attributes viz. cob length, cob girth and 100-grain weight. A reduction in the values of yield attributes with delay in sowing resulted into poor grain yield (Patel *et al*., 2024). High temperature during reproductive stage in late sown crops was responsible for lower yield (Koca and Canavar, 2014). Sowing dates also differed significantly for shelling percentage where first date of sowing being at par with second and third date of sowing recorded statistically more value (75.8%) than rest of sowing dates. Lower shelling in late sown crop was due to improper grain filling in cobs as a result of high temperature. Irrigation water use efficiency was maximum (906 kg/ha-cm water) in 12 February sowing which was at par with 5 February sowing but significantly superior to other sowing dates. Differences in grain yield and amount of water applied in irrigation caused variation in irrigation water use efficiency. Crop sown in first fortnight of February irrigated 8 times as compared to 7 irrigation in other dates but significantly more grain yield resulted in to higher irrigation water use efficiency. The reduction in water use efficiency of maize with delay in sowing has also reported by Abaza *et al.* (2023). The cost of cultivation was Rs. 58892/ha in first three sowing dates and was Rs. 57238/ha for later three sowing dates (Figure 1). The difference in cost of cultivation was due to difference in number of irrigation applied which was 8 in first three sowing dates and 7 in later three sowing dates. Gross return was the highest (Rs. 161235/ha) in 12 February sowing followed by 5 February and it decreased remarkably with delay in sowing (Figure 1). The maximum net return (Rs. 102344/

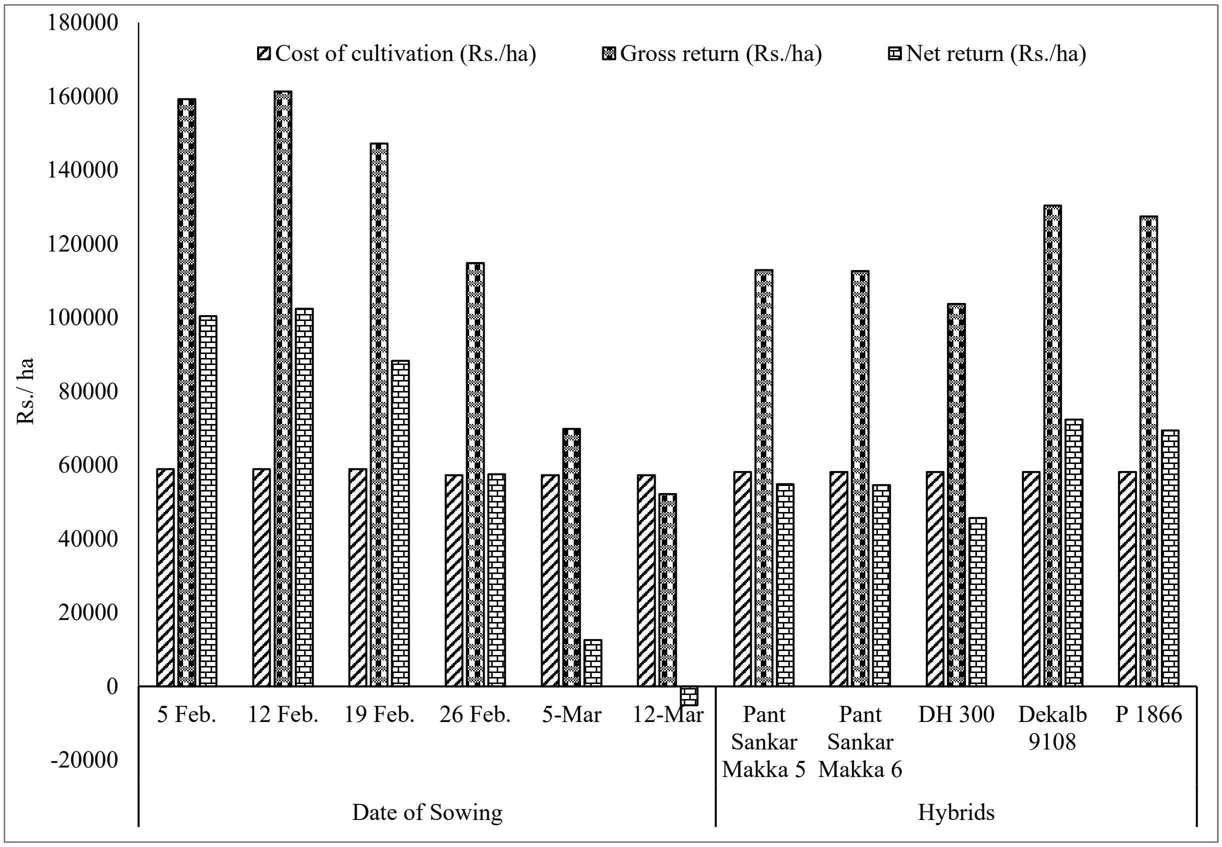

Figure 1. Economics of maize as affected by sowing date and hybrids in spring season

ha) in 12 February sowing was almost equal to 5 February sowing and was higher by Rs. 14131, 44835 and 89846/ha than following sowing dates, respectively. Crop sown on 12 March showed loss of Rs. 5121/ha. B:C ratio was the highest (1.74) on 12 February sowing closely followed by 5 March sowing. The variation in gross and net return were due to differences in grain yield and cost of cultivation. Early sown crop produced more grain yield and thus showed higher net return.

Response of hybrids

Significant differences were noted among hybrids (Table 1 & 2) but non significant variation were recorded for plant population and number of cobs/ha. All hybrids were sown at same planting geometry so variations in plant population were not significant and hence at par differences in number of cobs/ha. Among hybrids DKC 9108 being at par with P 1866 attained significantly more plant height (143.3 cm), cob length (14.0 cm), cob girth (13.4 cm) and 100-grain weight (24.9 g) than other hybrids. Pant Sankar Makka 6 took significantly maximum number of days to reach 50% tasseling (71.2) and 50% silking (74.6) while P 1866 had significantly lowest number of days (68.0 and 71.4, respectively). Non-significant variations were observed for ASI among hybrids. Genetic make up and expression of genes are responsible for growth and deployment of plant under specific environment conditions. Significant differences among different hybrids for plant height, phenology and cob characteristics were due to their genotypic differences. The variations in cob girth and cob length among hybrids were due to genetically induced variation (Khedwal *et al*., 2018; Coelho *et al*., 2020). DKC 9108 produced significantly more grain yield (5858 kg/ha) than other hybrids but remained at par with P 1866 (Table 2). The yield advantage in DKC 9108 over Pant Sankar Makka 5, Pant Sankar Makka 6 and DH 300 was 15.50, 15.79 and 25.76 per cent, respectively. The differences in grain yield were due to significant variation in yield attributes such as cob length, cob girth and 100-grain weight. DKC 9108 and P 1866 had superior value of yield attributes than other hybrids and therefore recorded more grain yield. All hybrids showed statistically same shelling percentage. It indicated that ratio of grain to cob was same in all hybrids. Hybrid DKC 9108 being at par with P 1866 had significantly more irrigation water use efficiency (768 kg/ha-cm water) than other hybrids. The lowest irrigation water use efficiency was noted in DH 300. Irrigation water use efficiency is directly related to grain yield and inversely with amount of irrigation water. All hybrids were irrigated equal in frequency and amount of water. Therefore, hybrids with more grain yield attained more irrigation water use efficiency. The cost of cultivation was same (Rs. 58065/ha) in all hybrids because of same level of inputs (Figure 1). The maximum gross return was recorded in DKC 9108 (Rs. 130333/ha) followed by P 1866 (Rs. 127397/ha). DH 300 was the poorest in gross return. The highest net return (Rs. 72268/ha) and B:C ratio (1.23) were obtained in DKC 9108 followed by P 1866. The lowest net return and B:C were noted in DH 300. Differences in gross and net return were due to differences in grain yield. Cost of cultivation was same in all hybrids. Therefore, hybrids with more net return had higher value of B:C.

Conclusion

The optimum sowing time for sowing of spring maize in North western plain zone of India is the first fortnight of February. Sowing of maize in March is not economically viable. Productivity and profitability of hybrids DKC 9108 and P 1866 is high so these can be grown successfully in spring season.

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