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Performance of Rabi maize (*Zea mays* L.) as influenced by date of sowing under Terai zone of West Bengal

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Abstract
Rabi maize is now gaining popularity in the northern part of West Bengal due to its high yield potentiality and economic sustainability. Present investigation was conducted during 2019-20 and 2020-21 at the instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India to evaluate the performance of rabi maize under different sowing dates. The experiment was arranged out in randomized block design with three replications having 7 different dates of sowing *viz*. D_1=1st November, D_2=8th November, D_3=15th November, D_4=22nd November, D_5=29th November, D_6=6th December and D_7=13th December and replicated thrice. Maize variety DKC 9081 was used in the trial and sown with a spacing of 60 X 30 cm. Results revealed that 1st November sown (D_1) crop recorded highest germination (93.29%) which was closely followed by 8th November sown (D_2) crop and thereafter there was a declining trend of germination irrespective of sowing dates and year of experimentation. On an average variety took 153 to 159.50 days to mature. Maturity was delayed by 1 to 6 days with the dates of sowing. 8th November sown (D_1) crop mature 6.5 days earlier as compared to 13th December sown crop (D_7). Dates of sowing had pronounced effect on yield attributes of maize and recorded highest values of cob length (22.12 & 21.73 cm), cob diameter (19.56 & 18.57 cm), no. of rows cob^{-1} (17.07 & 17.43), number of grains row^{-1} (42.93 & 42.60) and seed index (40.08 & 44.60 g) whenever sown in 15th of November (D_3), which ultimately leads to higher grain (10.59 &10.84 t ha^{-1}) of maize during both the years of investigation followed by D_5, D_4 and D_6. Highest B: C ratio of 1.88 and 2.09 was realized with 15th November sown maize.

Keywords: Germination, maize, maturity, sowing date and yield

Introduction
Among the cereals, maize (*Zea mays* L.) ranks third in total world food production after wheat and rice and it is the staple food in many countries, particularly in the tropics and sub-tropics. Maize is considered as the "Queen of Cereals". Being a C4 plant, it is capable to utilize solar radiation more efficiently even at higher radiation intensity. It has arisen as a significant crop in the off season and non-traditional regions. Growing of Rabi maize is becoming a common in Peninsular India (Andhra Pradesh, Karnataka and Tamil Nadu), as well as in the north-eastern plains. In northern part of West Bengal, area under maize is increasing continuously particularly as a pre kharif and Rabi crops. During pre kharif season maize emerged as a profitable crop in place of jute however during Rabi season farmers grow maize after harvesting of kharif rice, which sometimes causes delayed vacant of land resulting into delayed sowing and lower yield. Due to large changes in weather during sowing period, the utmost significant cause for variation in yield is probably the sowing date (Alam *et al*, 2020) [2].

To augment higher crop yield per unit area, proper sowing time is the most important factor in order to best utilise moisture, nutrients, and light (Bhandari *et al.*,2018) [5]. Sowing of the crop at right time ensures better plant growth; pest invasion is kept to a minimum level (Sanp and Singh, 2018) [9] and also inhibits weed growth (Kumari *et al*., 2021) [8]. There are evidences that optimum time of sowing is one of the several cultural manipulations and play a vital role in boosting up the yield, particularly in Indian sub-continent where the ideal time of sowing differs to wide range due to extensively changing agro-climate conditions. Though, optimum time of sowing is decided by several factors, fluctuation in temperature during the growing season play a vital role. Keeping the above facts in mind present experiment has been conceptualized to standardize optimum date of sowing for higher productivity during rabi season.

2. Materials and Methods

The present experiment was conducted at the instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal during rabi season of 2019-20 and 2020-21. The farm is situated at 26^{0}19'86" N latitude and 89^{0}23'53" E longitude at an elevation of 43 meters above mean sea level. The soil at the experimental site was sandy loam (62.51% sand, 19.74% silt and 17.39% clay) in texture and acidic in nature having pH of 5.54. The initial organic carbon 0.71%, available nitrogen 181.33 kg ha^{-1}, available phosphorus 22.71 kg ha^{-1} and available potash 164.32 kg ha^{-1} were recorded before initiation of experiment in 2019. The amount of rainfall received during experimental period was 560.30 mm and 449 mm in the year 2019-20 and 2020-21, respectively. During the period of experimentation (November to May) average maximum and minimum temperature was 27.6 ^{0}C & 15 ^{0}C and 28.6 & 13.3 ^{0}C, respectively during 2019-20 and 2020-21.

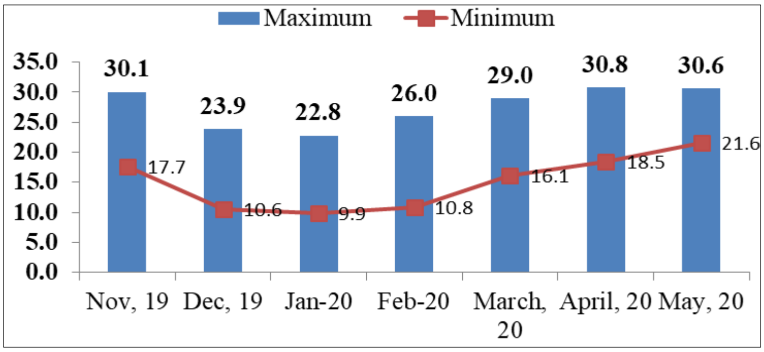

Fig 1: Maximum and minimum temperature during the period of experimentation (2019-2020)

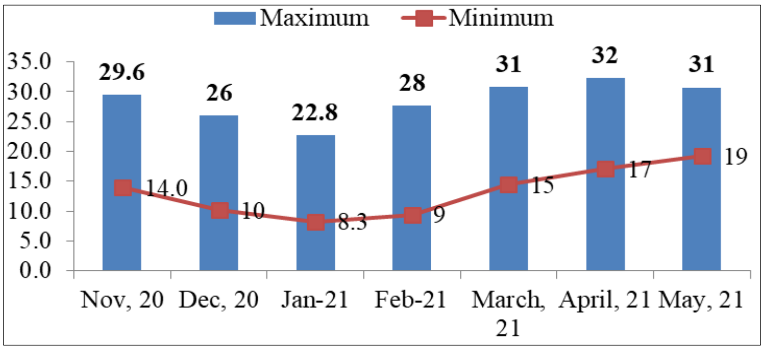

Fig 2: Maximum and minimum temperature during the period of experimentation (2020-2021)

Maize variety DKC 9081 was used in the trial and sown with a spacing of 60 cm X 30 cm. The experiment was laid out in randomized block design with three replications having 7 different dates of sowing *viz*. D_1=1st November (met wk 44), D_2=8th November (met wk 45), D_3=15th November (met wk 46), D_4=22nd November (met wk 47), D_5=29th November (met wk 48), D_6=6th December (met wk 49) and D_7=13th December (met wk 50). NPK was applied @ 150:70:70 kg ha^{-1} in all the treatments. Full amount of phosphorus, 75% of potassium and 40% nitrogen was applied at the time of final land preparation. Remaining 60% nitrogen was applied in three equal split at 4th leaf, 8th leaf and tasseling stage while rest of potassium was applied at tasseling stage. All the other agro-techniques were followed as per requirement and data were collected on agronomic aspects namely germination %, days to mature, plant height at different growth stages, cob length, cob diameter, kernel row cob^{-1}, number of seed row^{-1}, and seed index. Grain yield was calculated by converting the yield obtained from one square meter area to one hectare and expressed in t ha^{-1}. All the data were subjected to statistical analysis using statistical software SPSS, version-20.

3. Results and Discussion

3.1Effect on germination% and maturity

In maize, temperature strongly influences growth, morphology, development, production, quality and the time necessary to reach maturity. Germination processes (both imbibition and elongation) are strongly temperature dependent (Verma *et al*., 2012) [12]. The maximum rates of shoot and radicle elongation are achieved at approximately 30 °C, but elongation ceases at temperatures below 9 °C and above 40 °C.

Germination% and maturity were recorded treatment wise and presented in fig. 1 and 2. There was a sharp variation in germination % with the date of sowing, 1st November sown (D_1) crop recorded highest germination (93.29%) which was closely followed by 8th November sown (D_{12}) crop and thereafter there was a declining trend of germination irrespective of year of experimentation. Declining of germination is simply due unfavourable climatic condition particularly temperature after middle of November that means third date of sowing and onwards. Lowest germination was found whenever crop was sown in the middle of December (as shown in fig. 1 & 2).

On an average variety took 153 to 159.50 days to mature (Fig. 2). Maturity was delayed by 1 to 6 days with the dates of sowing. 8th November sown (D_1) crop mature 6.5 days earlier as compared to 13th December sown crop (D_7). Delayed maturity is simple due to exposure of lower night temperature after sowing (as shown in fig. 1 & 2). Andrew *et al.* (2006) [4] and Verma *et al.* (2012) [12] also reported delayed silking and maturity whenever maize sown late during rabi season.

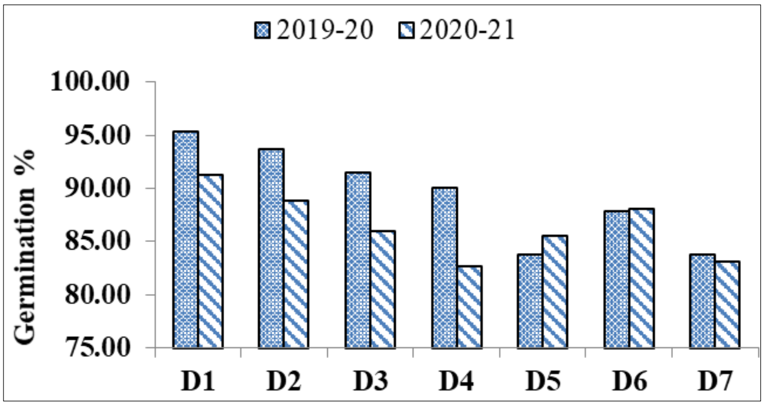

Fig 3: Effect of date of sowing on germination % of *rabi* maize

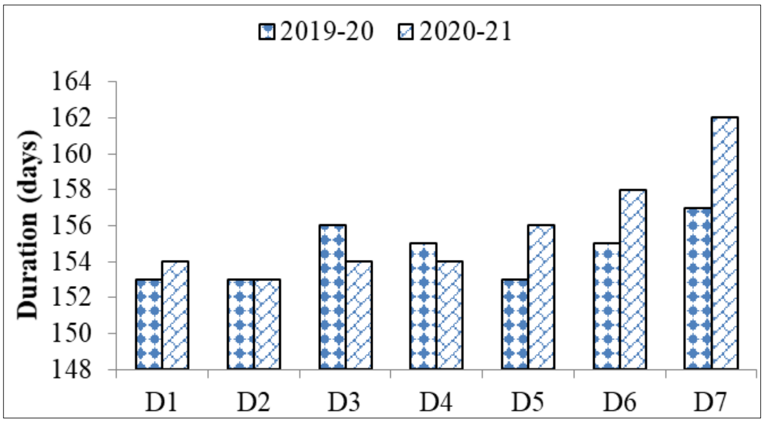

Fig 4: Effect of dates of sowing on harvest duration of *rabi* maize

3.2 Effect on plant height

Plant height was recorded 30 days intervals starting from 30 days after sowing and presented in table 1. Highest early growth (upto 60 days after sowing) in terms of plant height (64.09 & 43.45 cm at 30 DAS and 142.10 & 122.87 cm at 60 DAS respectively during 2019-20 and 2020-21) was observed whenever sown early *i.e.* 1st of November followed by D_2 and D_3. Higher plant height might be due to synthesis of more auxin, which awakens cell elongation in the early sown crop which exposed with the favourable climatic condition particularly temperature. Photosynthesis, respiration, transpiration, transport and cell growth are also promoted by higher temperature. This result supports the findings of Andrew *et al.* (2006) [4] and Buriro *et al.* (2015) [6].

Lowest plant height is being observed at D_5 (29th November sown crop) during both the year. After acclimatized initial low temperature stress, 90 days onwards highest plant height was recorded at D_7 (13th December sown crop) followed by D_6, D_5 and D_4. Irrespective of sowing dates, second year experimentation recorded lowest plant growth in terms of height might be due to unfavourable climatic condition during the active growth stages.

Table 1: Plant height (cm) of *rabi* maize at different growth stages as influenced by dates of sowing

Treatments	30 DAS		60 DAS		90 DAS		120 DAS		At harvest	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
D_1	64.09	43.45	142.10	122.87	231.60	209.97	245.20	277.57	261.53	275.03
D_2	57.57	37.74	113.47	94.51	214.93	205.47	274.93	293.27	279.87	290.27
D_3	37.78	34.03	84.82	75.19	189.93	199.57	289.80	310.40	283.73	304.93
D_4	32.87	30.67	107.47	73.40	184.87	214.20	310.93	305.73	292.53	302.87
D_5	18.97	21.23	64.47	72.77	183.20	228.41	317.73	307.00	317.93	308.80
D_6	19.40	21.82	57.33	62.86	212.07	253.17	319.53	305.87	318.40	304.80
D_7	19.61	22.77	84.53	80.30	250.80	276.77	323.13	317.00	334.53	313.00
S.Em.(±)	8.14	5.81	16.85	12.97	15.24	17.40	19.81	12.14	20.45	10.68
CD at 5%	26.02	17.40	51.45	39.84	46.50	52.12	58.63	36.48	62.01	32.05

Table 2: Yield attributes and grain yield of *rabi* maize as influenced by dates of sowing

Treatments	Cob length (cm)		Cob diameter (cm)		Kernel row cob^{-1}		No. of seed row^{-1}		Seed index (g)		Grain yield (t ha^{-1})	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
D_1	20.36	19.52	18.02	17.60	16.80	16.00	38.07	36.40	36.35	38.63	7.38	7.93
D_2	20.41	19.89	18.68	18.55	16.40	17.20	37.47	40.20	36.00	41.47	7.49	9.82
D_3	22.12	21.63	19.56	18.57	17.07	17.43	42.93	42.60	40.08	44.60	10.59	10.84
D_4	21.66	20.91	18.73	18.63	16.80	16.40	39.67	41.33	33.13	40.37	8.35	9.62

D_5	21.75	20.92	18.75	18.16	16.67	17.07	40.47	41.67	36.27	41.03	9.31	10.23
D_6	21.78	20.87	18.79	18.13	16.00	16.40	39.33	42.00	37.85	40.92	9.09	9.72
D_7	20.65	20.27	18.11	18.18	14.80	16.13	38.33	41.00	36.78	40.44	9.07	9.64
S.Em.(±)	0.43	0.65	0.49	0.31	0.72	0.42	1.62	1.94	2.01	1.90	0.58	0.65
CD at 5%	1.28	1.95	1.46	0.94	2.14	1.26	4.85	5.81	6.04	5.71	1.75	1.94

3.3 Effect on yield attributes and yield

Dates of sowing had pronounced effect on yield attributes of maize and recorded highest values of cob length (22.12 & 21.73 cm), cob diameter (19.56 & 18.57 cm), no. of rows cob^{-1} (17.07 & 17.43), number of grains row^{-1} (42.93 & 42.60) and seed index (40.08 & 44.60 g) whenever sown in 15th of November (D_3), which ultimately leads to higher grain (10.59 &10.84 t ha^{-1}) of maize during both the years of investigation followed by D_5, D_4 and D_6. Higher grain yield is due to higher net photosynthesis due to coincidence of optimum temperature and simultaneously translocation of photosynthates into the grain thereby healthy grain which helped in producing higher yield. The results are in close conformity with the findings of Amjadian *et al.* (2013) [3], Sulochana *et al.* (2015) [11], Gurung *et al.* (2017) [7] and Sanp and Singh, (2018) [9].

Despite of initial vigorous growth significantly lowest yield attributes and grain yield was noticed in 1st November (D_1) and 8th November sown crop (D_2) during both the years might be exposure of unfavourable climatic condition mostly temperature during reproductive stage resulted into lower net photosynthesis. This finding also partially agrees with the report of Ahmed *et al*. (2011) [1] that too early sowing resulted in progressive reduction of grain yield.

3.4 Economics of *rabi* maize

Acceptance and rejection of any technology finally depend on its economic feasibility. Economics of rabi maize as influenced by date of sowing was calculated based on prevailing market price and presented in table 3. Highest gross return to the tune of ₹190620 and ₹208128 ha^{-1} was obtained during 2019-20 and 2020-21 respectively, whenever maize was sown on 15th of November (D_3) followed by D_5, D_6 and D_7. Highest net return to the tune of ₹124472 & ₹140735 ha^{-1} and B: C ratio of 1.88 and 2.09 was realized from treatment D_3 which was followed by D_5, D_6 and D_7 simply due to higher grain yield as contributed by optimum sowing time which facilitates higher photosynthesis and better dry matter production. Lowest gross return and B: C ratio was found whenever maize was sown in the 1st of November, due to lower grain yield. In general gross return, net return and B: C ratio was less during 2019-20 irrespective of sowing dates as compared to 2020-21.

Table 3: Economics of *rabi* maize as influenced by dates of sowing during both the year of experimentation

Treatments	Cost of cultivation (₹ ha^{-1})		Gross return (₹ ha^{-1})		Net return (₹ ha^{-1})		B:C ratio	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
D_1	66148.25	67393.50	132840	152256	66692	84863	1.01	1.26
D_2	66148.25	67393.50	134820	188544	68672	121151	1.04	1.80
D_3	66148.25	67393.50	190620	208128	124472	140735	1.88	2.09
D_4	66148.25	67393.50	150300	184704	84152	117311	1.27	1.74
D_5	66148.25	67393.50	167580	196416	101432	129023	1.53	1.91
D_6	66148.25	67393.50	163620	186624	97472	119231	1.47	1.77
D_7	66148.25	67393.50	163260	185088	97112	117695	1.47	1.75

4. Conclusion

It can be concluded from two year field experiments that sowing window of rabi maize can be adjusted between middle of November to first week of December for yield maximization. So farmers of north Bengal can profitably grow rabi maize during middle of November to first week of December in the existing cropping system.

5. Acknowledgement

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