Original Research Article

PHYSIOLOGICAL PARAMETERS AND QUALITY OF POTATO UNDER DIFFERENT PLANTING DATES

ABSTRACT

A field experiment was conducted to study the influence of planting dates on physiological parameters and quality of potato cropduring the *Rabi* seasons of 2021-22 and 2022-23. The experiment was laid out with seven different planting dates viz., 15 Sept (D1); 30 Sept (D2); 15 Oct (D3); 30 Oct (D4) (Timely planting); 14 Nov (D5); 29 Nov (D6) and 14 Dec (D7) in randomized block design (RBD) with four replications. The potato (cv. Kufri Mohan) was planted with a seed rate of 3.5 t ha^{-1} and with a spacing of 60 cm x 20 cm. The recommended dose of chemical fertilizers viz., 180:80:120kg/ha^{-1} $N:P_2O_5:K_2O$, respectively was applied to the crop. The various physiological parameters viz., crop growth rate, relative growth rate and absolute growth rate; and quality parameters (protein, starch, dry matter and true density) were recorded. The results revealed that the timely planting treatment date (30 Oct) showed significant positive effect on physiological parameters in potato crop whereas effect was at par with respect to the quality parameters under studied planting dates.

KEYWORDS:CGR, RGR, AGR, Planting date, potato, true density, dry matter content, protein, starch content, quality of potato

INTRODUCTION

Potato is an important food crop having a significant contribution towards food and nutritional security, especially in the developing world (Scott *et al.,* 2019). It is considered as a balanced food due to the presence of high-quality proteins, vitamins and minerals, trace elements with lesser energy (Rana and Anwer, 2018). Potato is the staple food of almost half of the world's population (Thiele *et al.,* 2010). Potato is the fourth most important food crop in the world, after corn, rice, and wheat. It is known as a protective food because potato protein is rich in lysine, which is one of the most important amino acids. It is also the most important food crop in the world, and it contains approximately 78% water, 22% dry matter, 20.6% carbohydrates, 2.1% protein, 1.1% crude fiber, 0.9% ash, and 0.3% fat (Zhang *et al.,* 2017). In India, about 68% of potatoes are utilized for table purposes, 7.5% for processing, 8.5% for seed, and the remaining 16% of produce goes waste during pre- and post-harvest handling (Gupta *et al.,* 2009).In India, it is grown on an area of 2.14 million hectares with a production of 51.31 million tonnes and a productivity of 24.0 tonnes ha^{-1}. Currently, Madhya Pradesh contributes about 6.96 percent of area and 6.58 percent of production of potatoes in the country. Its productivity in Madhya Pradesh is 22762 kg ha^{-1}.The optimum growth and production of potato largely depend upon prevailing weather conditions and use of improved inputs like use of improved varieties, time of

planting, good seed quality and other cultural practicestill harvesting contribute in increasing potato yield. Among them, the optimum time of planting is major limiting factor for maximum production of potato.

The Planting of potato at optimum time result in maximum emergence, good crops growth and better utilization of light and temperature and minimum pest problem would enhance the yield. For best yields, potato crop requires long day conditions for good growth and short-day conditions for tuberization (Chadha, 2009). Optimum tuber formation takes place at 20 ^{0}C. Increase in temperature beyond 21 ^{o}C cause sharp reduction in the tuber initiation and yield and at 30 ^{o}C complete inhibition of tuber formation (Shekhawat, 2001). However, the studies related to the effect of planting dates on physiological parameters viz., crop growth rate, relative growth rate and absolute growth rate in potato are lacking. Similarly, the influence of planting dates on quality parameters such as protein content, dry matter content, true density and starch content is not clearly understood. Therefore, in order to study the effect of planting dates on physiological and quality parameters in potato was studied in a field experiment.

MATERIALS AND METHODS

The field experiment

The present experiment was carried out at the Research Farm of ICAR-Central Potato Research Institute (Regional Station), Gwalior (M.P.) during the *Rabi* seasons of 2021-22 and 2022-23. Geographically, Gwalior is located at 26^{o}13’ North latitude and 78^{o}14’ East longitude and 206 meters above mean sea level (AMSL) which lies in the North tract of M.P. enjoying subtropical climate, with extreme hot up to 48°C in summer and minimum temperature as low as 4.0°C during winter season. The annual rainfall ranges between 750 to 800 mm, most of which received from end of June to end of September, with few showers in winter months.

The experiment was laid out with seven different planting dates viz., D1- 15/09/2021; D2- 30/09/2021; D3- 15/10/2021; D4- 30/10/2021 (Timely planting); D5- 14/11/2021; D6- 29/11/2021 and D7-14/12/2021 in randomized block design (RBD) with four replications. The potato (cv. Kufri Mohan) was planted with a seed rate of 3.5 t ha^{-1} and with a spacing of 60 cm x 20 cm. The recommended dose of chemical fertilizers viz., 180:80:120 kg ha^{-1}N:P_2O_5:K_2O, respectively was applied before planting.Seed treatment was done with 3.0 % boric acid solution by dipping tubers for 30 minutes for controlling soil and tuber born diseases before keeping seed tubers in cold store. Seed treatment was performed at shady place and immediate after treatment, tuber were treated and covered with soil to protect the tubers from sun light.Seed tubers were planted manually at a uniform distance of 60 cm between row to row and 20 cm between plant to plant. The planting was done as per the designed treatments during first and second years. A uniform seed rate of 35 q ha^{-1} was used for planting. Weed was managed using Metribuzin 70%WP as a pre-emergence herbicide (one day after planting) @ 500g a.i. ha^{-1} in all treatments.Imidachloprid (17.8% SL) insecticide was used for controlling pest population at the 45 DAP.The first irrigation was given immediately after planting since planting was done under dry soil condition. It ensures proper establishment of potato plant. Subsequent irrigations were

given at about 10-15 days interval using ridge - furrow irrigation method as per crop requirement.

Observations recorded

The physiological parameters viz., absolute growth rate, crop growth rate and relative growth rate were computed following standard methods as depicted under:

Absolute growth rate (AGR)

Radford (1967) suggested AGR**.** It expresses increase in the dry weight per unit time and is expressed in g/plant^{-1}day^{-1}. It gives Absolute values of biomass between two intervals.

$$\mathrm{AGR} = \frac{\mathrm{W2} - \mathrm{W1}}{\mathrm{t2} - \mathrm{t1}}$$

Where,

W_1 and W_2 are the total dry weight per plant at time t_1 and t_2, respectively.

Crop growth rate (CGR)

It is the dry weight gain by a unit area of crop in a given time. The CGR is expressed in g/m^{-2}day^{-1}.

$$\mathrm{CGR} = \frac{\mathrm{W2} - \mathrm{W1}}{(\mathrm{t2} - \mathrm{t1})\ \mathrm{S}}$$

Where,

W_1 and W_2 are the total dry weight per plant at time t_1 and t_2, respectively.

S = Land area (m^2) over which dry matter recorded.

Relative growth rate (RGR)

It is the increase of material per unit weight per unit time. It is expressed in g/g^{-1}day^{-1}. It was suggested by Blackman, (1919).

$$\mathrm{RGR} = \frac{\mathrm{InW2} - \mathrm{I\ nW1}}{\mathrm{t2} - \mathrm{t1}}$$

Where,

W_1 and W_2 are the total dry weight per plant at time t_1 and t_2, respectively.

The quality parameters viz., true density, dry matter content, protein content and starch content were also determined by adopting following standard methods:

True density of potato

It was determined by water displacement method asreported by Mohsenin (1986) as:

$$True density of potato\ (gcc^{-1}) = \frac{W}{V}$$

Where,

W- Mass of potato tuber (g)

V- Volume of water displaced by tuber (cm^{-3})

Tuber dry matter content

The tuber dry matter was calculated by the following formula:

Tuber dry matter content (%) =100 x Dry weight of tuber / Fresh weight of tuber

Protein content

Protein content in tuber was worked out by multiplying thenitrogen content intuber with the factor 6.25, as suggested by(AOAC, 1970).

Starch content

Starch content in potato determined by water washmethod as described byMiernik and Jakubowski (2021).

All data related to the study were collected, compiled and statistically analyzed by using the analysis of variance technique (Fisher, 1958). Data so computed was subjected to Fisher's analysis of variance for judging the effect of various treatments.

RESULTS AND DISCUSSION

Crop growth rate

The crop growth rate (CGR) of potato under various planting date treatments determined at 0-30 DAP during 2021-22, 2022-23 and pooled of two years ranged 0.686- .891g/m^{-2} d^{-1}, 0.990 - 1.570g/m^{-2} d^{-1} and 0.838- 2.231g/m^{-2} d^{-1}, respectively (Table 1).The CGR determined at 0-30 DAP in 2021-22 showed that the timely planting treatment found superior over rest other treatments studied except the treatment D5 where t was found at par. Further, the treatments D1, D2 and D7 were also found at par with respect to the CGR in potato crop. The treatment D3 and D5 were also found statistically at par with each other. In 2022-23, the CGR found highest in timely planting treatment (D4) followed by the treatment D5 (1.968g/m^{-2} d^{-1}). The treatments D2, D3 and D5 were found statistically at par. Further, D1, D6 and D7 were also found statistically at par.

Table 1. Effect of planting dates on crop growth rate (CGR) in potato

Treatment	Crop growth rate (g/m-2 d^{-1})					
	0-30 DAP					
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
D1	1.129	1.255	1.192	6.761	8.457	7.609
D2	1.166	1.612	1.389	7.097	8.712	7.904
D3	1.556	1.830	1.693	10.200	11.038	10.619
D4	1.891	2.570	2.231	11.612	12.475	12.043
D5	1.616	1.968	1.792	10.339	11.095	10.717
D6	0.994	1.303	1.149	8.312	9.373	8.842
D7	0.686	0.990	0.838	7.699	8.848	8.274
SEm±	0.094	0.147	0.094	0.423	0.477	0.316
CD at 5%	0.281	0.439	0.279	1.263	1.422	0.943

The pooled data revealed that the timely planting treatment (D4) showed higher CGR followed by D5 (1.968g/m^{-2} d^{-1}) and D3 (1.693g/$m^{-2}d^{-1}$). The treatments D1, D2 and D6 were found statistically at par. The lowest CGR found in the treatment D7 (0.838g/$m^{-2}d^{-1}$).The CGR of potato under various planting date treatments determined at 30-60 DAP during 2021-22, 2022-23 and pooled of two years ranged 6.761- 11.612g/$m^{-2}d^{-1}$, 8.457- 12.745g/$m^{-2}d^{-1}$ and 7.609- 2.043g/$m^{-2}d^{-1}$, respectively (Table 1).

The CGR determined at 30-60 DAP in 2021-22 showed that the timely planting treatment found superior over rest other treatments studied. Further, the treatments D3 and D5 were found at par with respect to the CGR in potato crop. The treatment D2, D6 and D7 were also found statistically at par with each other. In 2022-23, the CGR found highest in timely planting treatment (D4 12.745 g/$m^{-2}d^{-1}$) followed by the treatment D5 (11.095g/$m^{-2}d^{-1}$). The treatments D3 and D5 were found statistically at par. Further, D1, D2, D6 and D7 were also found statistically at par. The pooled data revealed that the timely planting treatment (D4) showed higher CGR at 30- 60 DAP followed by D5 (10.717g/$m^{-2}d^{-1}$) and D3 (10.619g/$m^{-2}d^{-1}$). The treatments D1, D2 and D7 were found statistically at par. The lowest CGR found in the treatment D1 (7.609g/$m^{-2}d^{-1}$).

Relative growth rate

The relative growth rate (RGR) of potato under various planting date treatment 0.029g/$g^{-1}d^{-1}$, 0.020- 0.034g/$g^{-1}d^{-1}$ and 0.017- 0.029g/$g^{-1}d^{-1}$, respectively (Table 2).TheRGR determined at 0-30 DAP in 2021-22 showed that the treatment D4 (timely planting), treatment D3 and D5 found at par with each other and superior over rest other treatments studied. Further, the treatments D1, D2 and D6 were found at par with respect to the RGR in potato crop. The treatment D7 showed significantly lower RGR among all the treatments studied. In 2022-23, the RGR found statistically significant and highest in timely planting treatment (D4) followed by the treatment D5 (0.030g/$g^{-1}d^{-1}$). The treatments D1, D2 and D6 were found statistically at par. Further, D1, D6 and D7 were also found statistically at par. The pooled data revealed that the timely planting treatment (D4) showed highestRGR followed by D5 (0.028g/$g^{-1}d^{-1}$) and D3 (0.027g/$g^{-1}d^{-1}$). The treatments D3 and D5 were found statistically at par. Similarly, the treatments D1 and D6 were also found statistically at par. The lowest RGR was found in the treatment D7 (0.020g/$g^{-1}d^{-1}$).

Table 2. Effect of planting dates on relative growth rate (RGR) in potato

Treatment	Relative growth rate ($g/g^{-1}day^{-1}$)					
	0-30 DAP			30-60 DAP		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
D1	0.022	0.023	0.022	0.047	0.051	0.049
D2	0.022	0.027	0.024	0.048	0.051	0.050
D3	0.026	0.028	0.027	0.053	0.055	0.054
D4	0.029	0.034	0.031	0.055	0.056	0.056
D5	0.027	0.030	0.028	0.054	0.055	0.054
D6	0.020	0.023	0.022	0.050	0.052	0.051
D7	0.014	0.020	0.017	0.049	0.051	0.050
SEm±	0.001	0.001	0.001	0.001	0.001	0.001
CD at 5%	0.003	0.004	0.002	0.002	0.002	0.002

The RGR of potato under various planting date treatments determined at 30-60 DAP during 2021-22, 2022-23 and pooled of two years ranged 0.047- 0.055$g/g^{-1}d^{-1}$, 0.051- 0.055$g/g^{-1}d^{-1}$ and 0.049- 0.056$g/g^{-1}d^{-1}$, respectively (Table 2). The RGR determined at 30-60 DAP in 2021-22 showed that the treatment D4 (timely planting), treatment D3 (0.053$g/g^{-1}d^{-1}$) and D5 found at par with each other but found superior over rest other treatments studied. Further, the treatments D1 and D2 were found at par with respect to the RGR in potato crop. The treatment D7 showed significantly lower RGR among all the treatments studied. In 2022-23, the RGR found statistically significant and highest in timely planting treatment (D4) followed by the treatment D5 and D3. The treatments D1, D2, D6 and D7 were found statistically at par.The pooled data revealed that the timely planting treatment (D4) showed highest RGR followed by D5 (0.028$g/g^{-1}d^{-1}$) and D3 (0.027$g/g^{-1}d^{-1}$). The treatments D2, D6 and D7 were found statistically at par. Similarly, the treatments D1, D2 and D7 were also found statistically at par. The lowest RGR was found in the treatment D1 (0.049$g/g^{-1}d^{-1}$).

Absolute growth rate

The absolute growth rate (AGR) of potato under various planting date treatments determined at 0-30 DAP during 2021-22, 2022-23 and pooled of two years ranged 0.091- 0.249g/d^{-1}, 0.131 - 0.339g/d^{-1} and 0.111- 0.294g/d^{-1}, respectively (Table 3). The pooled data revealed that the timely planting treatment (D4) showed significantly higher AGR among the treatments studied. Further the treatments D3 and D5 were found statistically at par and superior over D1, D2, D6 and D7. The treatments D1, D2 and D6 were found statistically at par. The lowest RGR determined at 30-60 DAP was found in the treatment D7 (0.111g/d^{-1}).The absolute growth rate (AGR) of potato under various planting date treatments determined at 30-60 DAP during 2021-22, 2022-23 and pooled of two years ranged 0.892- 1.532g/d^{-1}, 1.116- 1.645g/d^{-1} and 1.004- 1.589g/d^{-1}, respectively (Table 3). The AGR in potato crop was found highest in the treatment D4 (timely planting) followed by the treatments D5 and D1. The treatment D4 showed statistically significant AGR as compared to all the treatments under study. Similarly, the treatments D3 and D5 were found at par but statistically superior over the treatments D1, D2, D6 and D7. The treatments D1, D2 and D7 were also found statistically at par. The lowest AGR was observed under the treatment D1 (1.004g/day^{-1}).

Table 3. Effect of planting dates on absolute growth rate (AGR) in potato

Treatment	Absolute growth rate (g/day^{-1})					
	0-30 DAP			30-60 DAP		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
D1	0.149	0.166	0.157	0.892	1.116	1.004
D2	0.154	0.213	0.183	0.936	1.149	1.043
D3	0.205	0.241	0.223	1.345	1.456	1.401
D4	0.249	0.339	0.294	1.532	1.645	1.589
D5	0.213	0.260	0.236	1.364	1.464	1.414
D6	0.131	0.172	0.152	1.096	1.236	1.166
D7	0.091	0.131	0.111	1.016	1.167	1.091
SEm±	0.012	0.019	0.012	0.056	0.063	0.042
CD at 5%	0.037	0.058	0.037	0.167	0.188	0.124

In general the planting dates in potato significantly influenced the physiological parameters. The higher CGR, RGR and AGR in potato at timely planting mainly attributed to the favorable conditions for crop growth. The early and late planting of potato affected the growth of potato crop which resulted in decline in the CGR, RGR and AGR. Vishwas *et al.* (2020) also reported highest dry matter accumulation under timely planting. The timely planting ensures the better vegetative growth in potato (Singh *et al.*, 2020; Vishwas *et al.*, 2020; Yenagi *et al.*, 2005) which encourages the plant physiological parameters.

True density

The true density of potato in 2021-22, 2022-23 and pooled of two years ranged 1.16-1.29g/cm^{-3}, 1.10- 1.26g/cm^{-3} and 1.14- 1.28g/cm^{-3} with a mean value of 1.20g/cm^{-3}, 1.17g/cm^{-3} and 1.18g/cm^{-3}, respectively (Table 4).

Table 4. Effect of planting dates on true density and starch content in potato

Treatment	True density of potato (g/cm^{-3})			Starch content (%)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
D1	1.21	1.23	1.22	12.37	12.75	12.56
D2	1.20	1.10	1.15	12.80	13.45	13.12
D3	1.16	1.12	1.14	12.64	12.68	12.66
D4	1.29	1.26	1.28	12.95	12.36	12.65
D5	1.18	1.16	1.17	12.81	12.98	12.89
D6	1.16	1.15	1.16	12.76	12.54	12.65
D7	1.18	1.17	1.18	12.72	12.56	12.64
SEm±	0.05	0.04	0.03	0.17	0.18	0.09
CD at 5%	0.13	0.13	0.08	0.50	0.53	0.26

The various planting dates studied did not have significant effect on true density of potato in both the years of study whereas the same showed varied significantly in pooled data of two years. In pooled data, the true density of potato was found highest in D4 (30 Oct) whereas the lowest true density of potato was recorded in D3 (15 Oct) treatment. The true density of potato determined in the treatment D4 (timely planting) showed significant effect over rest of the treatments. The treatment D3 showed poor true density of potato as compared to D and D4. All the treatment found statistically at par except treatmentsD3 and D4 (Table 4). Kaur and Aggarwal (2014) also observed the potato true density between 1.040g/cm^{-3} and 1.097g/cm^{-3}.

Starch content

The data pertaining to the starch content in potato is presented in Table 4. The starch content in potatodetermined during 2021-22, 2022-23 and pooled of two years ranged 12.37-12.95%, 12.36-13.45% and 12.56-13.12% with a mean value of 12.72%, 12.76% and 12.74%, respectively. The various planting dates studied did not have significant effect on starch content in potatoduring first year of study but eventually during second year the starch content significantly varied even in pooled data of two years. In 2022-23, the treatment D2 and D5 found statistically at par with respect to the starch content in potato. Similarly, the treatments D1, D3, D4, D6 and D7 also found statistically at par. The pooled data of two years followed exactly similar trends as observed during 2022-23 with respect to the starch content in potato. In general, the planting dates showed marginal but significant effect on starch content in potato (Table 4).Kumar *et al.* (2005) observed that starch content was positively correlated with specific gravity (r= 0.77) and dry matter content (r= 0.79). Kumlay *et al.* (2002) observed that starch content of potato increased gradually from the first sample date, but at last sampling date 11 (harvest time), the starch content of potato was almost stable. According to Feltran *et al.* (2004), the starch content had a positive correlation with specific gravity of potato. However, in present study the starch content of potato was not found influenced under various planting dates studied.

4.4.3 Dry matter content (%)

The data pertaining to the dry matter content in potato is presented in Table 5.The dry matter content in potato determined during 2021-22, 2022-23 and pooled of two years ranged 19.5-20.0%, 19.5-20.4% and 19.6-20.2% with a mean value of 19.8%, 19.9% and 19.8%, respectively. The various planting dates studied did not have significant effect on dry matter content in potato during both the years of study including pooled data of two years (Table 5). Kaur and Aggarwal (2014) also observed the dry matter content of potato ranging 14.06% to 24.31%.

Protein content

The protein content in potatodetermined during 2021-22, 2022-23 and pooled of two years ranged 8.02-8.63%, 8.03-8.55% and 8.09-8.55% with a mean value of 8.39%, 8.36% and 8.37%, respectively (Table 5). The various planting dates studied did not have significant effect on protein content in potatoduring both the years of study. However, the pooled data showed that the protein content in potato showed significant variation. The pooled data revealed that, the treatment D4 (8.09%) and D5 (8.09%) showed lowest protein content in potato. The treatments D1, D2, D3, D6 and D7 found statistically at par with respect to the protein content in potato. Similarly, the treatments D3, D4 and D5 also found statistically at par. In general, the planting dates showed marginal but significant effect on protein content in potato (Table 5).

Table 5. Effect of planting dates on dry matter and protein content in potato

Treatment	Dry matter content (%)			Protein content (%)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
D1	19.7	19.8	19.8	8.63	8.48	8.55
D2	20.0	20.4	20.2	8.44	8.55	8.49
D3	19.8	19.5	19.6	8.39	8.36	8.38
D4	20.0	19.6	19.8	8.14	8.03	8.09
D5	19.5	20.0	19.8	8.02	8.17	8.09
D6	19.8	20.0	19.9	8.52	8.55	8.53
D7	19.9	19.7	19.8	8.58	8.36	8.47
SEm±	0.19	0.21	0.19	0.166	0.205	0.111
CD at 5%	0.57	0.62	0.58	0.494	0.610	0.330

In general, the planting dates showed marginal but significant effect on protein content in potato. The lower protein in higher yield treatment is attributing to the dilution effect. Abbas *et al.* (2011) reported significant changes in quality parameters in different cultivars. Abbas *et al.* (2012) also found significant variation in quality parameter of potato. The present investigation relies on single variety hence the desired changes in quality parameters was not noticed. Singh (1995) studied the response of potato to different dates of planting and reported minimal and non-significant effect on the qualitative characters viz., dry matter starch content and specific gravity of tubers.

CONCLUSION

The timely planting treatment (D4- 30/10/2021) showed significant positive effect on physiological parameters of potato whereas the early and late planting treatments showed poor performance. However, the planting date did not influence the quality parametersin potato.

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