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Effects of seed cutting and treatment methods of potato on yield, quality and profitability of French fry variety *Kufri Frysona*

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ABSTRACT

Field studies were conducted at CPRI Campus, Modipuram (India) with French fry variety Kufri Frysona. The eight treatments consisted of whole vs cut seed piece, untreated or treated with fungicide and foliar spray of GA @10 and 20 ppm at 60 days after planting, were tested with the objective to increase French fry grade (FFG) tuber yield and net returns by decreasing the cost of seed tubers. Among treatments cut seed piece (30 g) treated with mancozeb (0.2%)+carbendazim (0.2%)+dusting of plaster of Paris (0.5%) was found best for FFG tuber number, FFG and net tuber yield besides maintaining good processing quality traits (fry colour, glucose content) at harvest and after long term storage upto 150 days. The same treatment also recorded maximum net returns and benefit cost ratio due to higher tuber yield and reduced seed cost by about 50%.

Key words: *Kufri Frysona*, fry quality, seed piece, storability, tuber yield,

The potato varieties released till 1998 in India were all meant for table purpose and none had the desirable attributes for making chips or French fries. For making good quality French fries the solids content should be high (> 20%) and glucose content should be as low as possible (preferably < 50 mg / 100 g fresh weight). Thus, the variety *Kufri Frysona* was released in 2009, integrating higher French fry grade and good quality attributes (Singh *et al.*, 2010). However, the potato yield and quality is known to be affected by growing environments and agronomic practices besides genotype. Among the cultural practices the seed rate, seed size, number of eyes / tuber are the factors which affect the plant growth and finally the tuber yield and quality (Rykbost and Locke, 1999; Nolte *et al.*, 2003). Size of the seed potato affects the number of stems / hill, as number of eyes per tuber is related to the surface area of the tuber. Therefore, large tubers lead to more number of stems per hill and ultimately higher tuber number / plant and reduced average tuber weight besides higher seed rate. Since seed potato is the precious material, therefore, its use in large quantity will lead to higher cost of cultivation on one hand and its dumping into the soil will lead to wastage of food material on other hand. It is documented that seed accounts for about 40% of the total cost of cultivation, hence its judicious use is very important for profitable potato farming. Seed rate comes out to be low by planting small tubers or by using cut seed pieces, besides increased average tuber weight. Cutting of the tuber should be done before the start of sprouting to avoid damage to the sprouts. Tubers should be cut longitudinally with utmost care that each piece has at least 2 to 3 eyes and should be treated with

fungicides to avoid fungal infection (Kumar *et al.*, 2013). It is also known as well as it's my personal observation that some farmers in districts of Firozabad and Agra in Uttar Pradesh use very low concentration of gibberellic acid (GA) as foliar spray during peak tuber bulking phase on potato variety *Kufri Bahar* to increase its length for fetching higher market price. Therefore, the aim of this study was to increase the French fry grade proportion in the total produce either by manipulation of seed size through manual cutting or by foliar spray of GA for cell enlargement to make the production of *Kufri Frysona* more remunerative to the farmers and processors.

Materials and Methods

The field experiment was conducted in sandy loam soil (Typic Ustochrept) during 2008-2010 at Central Potato Research Institute Campus, Modipuram, India (29o 4' N; 77° 46' E; 237 m amsl) in randomized block design with four replications. The treatments consisted of eight combinations of seed cutting, GA application, fungicide application [T_1: whole seed tuber of (60 g); T_2: whole seed tuber (60 g)+10 ppm GA, foliar spray at 60 d; T_3: whole seed tuber (60 g)+20 ppm GA, foliar spray at 60 d; T_4: whole seed tuber (40 g); T_5: longitudinally cut seed piece (30 g) treated with 0.2% mancozeb; T_6: longitudinally cut seed piece (30 g) treated with 0.2% mancozeb+0.2% carbendazim+ 0.5% dusting with plaster of Paris (POP); T_7: cut seed piece (2-3 eyes) of 30 g treated with 0.2% mancozeb; T_8: cut seed piece (2-3 eyes) of 30 g treated with 0.2% mancozeb+0.2% carbendazim + 0.5% dusting with plaster of Paris]. Chemical analysis of the soil (0-15 cm) showed neutral pH (7.2), low organic carbon (0.35%) and low alkaline $KMnO_4$-N (167.4 kg/ha), high 0.5 *M* $NaHCO_3$ extractable P (58.6 kg/ha) and medium 1N ammonium acetate extractable K (148.8 kg/ha). Half N (135 kg/ha), full P (52.4 kg/ha) and full K (99.6 kg/ha) were applied at the time of planting. The remaining half N (135 kg/ha) was applied at the time of hilling (25 days after planting). Nitrogen was applied through calcium ammonium nitrate at the time of planting and through urea at hilling. Phosphorus and potash were applied through diammonium phosphate and muriate of potash, respectively. The experimental crop was planted on 22 and 24th October during 2008 and 2009, respectively. Well-sprouted seed tubers/cut seed piece were planted at a spacing of 67.5 × 25 cm in plots of 4.05 × 4.0 m. The experimental crop was raised under assured irrigation using the furrow method. Observations on growth parameters, such as plant height, stem number and compound leaf number were recorded from five randomly selected potato plants from each plot at 60 days after planting (DAP). Dehaulming was done manually at 120 DAP and harvesting was done two weeks later after skin setting. At harvest, French fry grade (> 75 mm long), chip grade (45-75 mm) and small grade (< 45 mm) tuber number and yield were recorded at harvest from the whole produce of the plot. To calculate net yield, seed tuber weight was deducted from the total tuber yield. To estimate tuber dry matter content five French fry grade tubers from each plot were chopped in fine pieces and 50 g sample was oven dried at 80 °C till constant weight was achieved (Kumar *et al.*, 2012). Tuber specific gravity was measured by the Hydrometer method by taking 3.632 kg of French fry grade potato tubers from each plot (Gould, 1999).

Five fry size tubers were selected randomly from each plot and used for determining French fry colour score. Potato fries were prepared at laboratory scale which involved peeling of tubers in abrasive peeler, cutting into 1×1cm thick French fries using manual French fry cutter, washing and drying on paper towel. Dried fries were then fried in refined sunflower oil in a thermostatically controlled deep fat fryer at 180 °C till 5 min. Fries were evaluated for fry colour on a scale of 1-10, subjectively with the help of colour cards (Ezekiel *et al.*, 2003), where scale 1 represents white fries, free from any browning and of highly acceptable colour while 10 is brown and unacceptable colour. The fries with colour range of 1 to 3 were considered acceptable. The glucose content in potato tubers was quantified using YSI Biochemistry analyzer as described by Sowokinos (1978). Data collected from the experiments were statistically analyzed using statistical software CROPSTAT 7.2 (IRRI, 2009).

To calculate net returns price of the French fry and chip grade potato tubers were taken as Rs. 5000 t^{-1} (price paid by the processors to their contract growers during those years) and the price for small grade potato tubers were taken as Rs. 3000 t^{-1} (the prevailing market price for that quality of potato tubers). Cost of cultivation includes the costs of all inputs, such as seed potatoes (₹ 10000 t^{-1}), cutting and seed treatment, fertilizer, pesticides, labour and capital. Sample of thirty French fry grade tubers from each plot was stored at 10-12°C with two isopropyl-chlorocarbamate (CIPC, a sprout suppressant) foggings for six months to investigate the effect of cut seed on fry colour and glucose content during long term storage.

Results and Discussion

Plant growth traits and graded tuber number

The plant emergence and plant height was not affected significantly by the different treatments (Table 1). Stem number $plant^{-1}$ was significantly higher in treatments involving whole tuber of 60 g with and without GA treatments and also in T_8 treatment. Higher stems $plant^{-1}$ in big size seed tuber was due to more number of eyes as number of eyes per tuber is related to the surface area of the tuber (Kumar *et al.*, 2013). Leaf number $plant^{-1}$ was maximum in T_2 treatment followed by T_3 but statistically similar with treatments T_1 and T_8. Numerically highest French fry grade tuber numbers ha^{-1} was observed in treatment T_8, however, chip grade and total tuber number ha^{-1} were recorded maximum with T_1 treatment (where untreated whole seed tuber was used) which was statistically at par with T_8 treatment.

French fry grade and net tuber yield

The highest French fry grade tuber yield was obtained in treatment T_8 (19.4 t ha^{-1}) followed by treatment T_6 (17.8 t ha^{-1}), in both the treatments cut seed piece was treated with mancozeb + carbendazim + POP, which indicated superiority over mancozeb alone and over foliar spray of GA (Table 2). Similarly the total yields and net yields (after deducting the seed tubers used), was also recorded maximum in treatment T_8 among all the treatments. However, it was not significantly different from some of the other treatments in statistical terms. The finding of this study carries great significance because in best treatment the use of seed rate was 50% lesser than

Table 1. Effect of seed cutting and GA application on growth traits and tuber number of cv *Kufri Frysona* (2 year pooled data)

Treatments	Emergence (%)	Plant height (cm)	Stem number $plant^{-1}$	Leaf $plant^{-1}$	Tuber number (thousand ha^{-1})		
					French fry grade (>75 mm)	Chip grade (45-75 mm)	Total
T_1 = Whole tuber (60 g)	87.1	66.6	3.73	34.6	119.8	235.7	604.6
T_2 = Whole tuber (60 g) + 10 ppm GA[a]	85.9	66.2	4.28	40.7	98.8	188.2	551.7
T_3 = Whole tuber (60 g) + 20 ppm GA[a]	87.2	66.1	4.15	38.3	106.5	218.0	603.4
T_4 = Whole tuber small (40 g)	89.8	60.1	2.49	22.6	104.0	170.7	459.5
T_5 = Treated LC seed piece (30 g)[b]	82.4	62.9	3.06	27.5	102.6	190.0	503.7
T_6 = Treated LC seed piece (30 g)[c]	76.3	61.6	3.33	28.9	92.4	170.7	450.6
T_7 = Treated cut seed piece (30 g) with 2-3 eyes[b]	81.7	62.7	3.16	30.2	104.9	193.5	538.7
T_8 = Treated cut seed piece (30 g) with 2-3 eyes[c]	89.1	67.4	3.42	32.7	127.3	200.6	567.9
CD (P=0.05)	NS	NS	0.93	8.62	NS	38.2	62.1

LC = Longitudinal cut; [a] = Foliar spray at 60 days after planting; [b] = Seed piece treated with mancozeb (0.2%); [c] = Seed piece treated with mancozeb (0.2%) + carbendazim (0.2%) + dusting of plaster of Paris (0.5%)

Table 2. Effect of seed cutting and GA application on graded tuber yield of cv *Kufri Frysona* (2 year pooled data)

Treatments*	Seed tuber used	Tuber yield (t ha^{-1})				French fry grade (%)	Av. French fry tuber weight (g)
		French fry grade (>75 mm)	Chip grade (45-75 mm)	Total yield	Net yield		
T_1	3.56	17.6	16.4	40.9	37.3	42.9	146.9
T_2	3.56	16.5	12.4	36.0	32.4	45.2	167.0
T_3	3.56	17.2	15.9	40.2	36.6	43.3	161.5
T_4	2.34	16.8	12.2	35.1	32.8	48.0	161.5
T_5	1.78	16.2	14.4	36.8	35.0	44.0	157.9
T_6	1.78	17.8	11.7	35.2	33.4	49.9	192.6
T_7	1.78	16.2	14.3	38.0	36.2	42.5	154.4
T_8	1.78	19.4	15.6	42.3	40.5	45.8	152.4
CD (P=0.05)	-	2.0	1.6	4.4	3.6	5.2	32.3

*treatment details are given in Table 1

control treatment or farmers practice (T_1). Rykbost and Locke (1999) also reported that seed piece size is an important management tool for manipulation of tuber size to achieve specific market requirements.

Economics

To find out the viability and adaptability of any agronomic intervention, the analysis of economic variables is must to ensure either reduced cost of cultivation or higher net profits. In our study the maximum net returns (₹ 1,21,740 / ha) and B:C ratio (2.62) was recorded with treatment T_8 which was statistically higher than rest of the treatments tested for variety *Kufri Frysona* (Table 3). This can be attributed to numerically higher yields (French fry grade and total) and 50% lower seed cost compared to whole seed tuber (T_1) or control treatment. Rykbost and Locke (1999) also reported that profits was maximum when 50 g seed piece was used in case of variety Russet *Norkotah* compared to 64 g or 78 g seed piece of potato.

Fry quality parameters at harvest

Specific gravity is an indirect indicator of tuber solids content and starch content. The higher specific gravity is desirable for French fry

Table 3. Effect of seed cutting and GA application on economics and processing quality traits of cv *Kufri Frysona* at harvest (2 year pooled data)

Treatments*	Net returns (₹ ha^{-1})	B:C ratio	Specific gravity	Tuber dry matter Content (%)	French fry colour	Glucose Content (mg 100^{-1} g FW)
T_1	100,100	2.10	1.091	24.3	2.17	7.63
T_2	74,200	1.81	1.092	24.9	2.08	14.30
T_3	94,200	2.02	1.090	24.0	2.50	23.80
T_4	84,900	2.08	1.092	24.8	2.22	18.50
T_5	97,440	2.31	1.091	24.2	2.38	17.05
T_6	89,440	2.19	1.091	24.4	2.38	26.42
T_7	100,840	2.36	1.091	23.6	2.27	7.85
T_8	121,740	2.62	1.090	25.2	1.87	21.42
CD (P=0.05)	20,200	0.35	NS	NS	NS	NS

*treatment details are given in Table 1

making to get higher finish product recovery and lesser oil consumption during frying, favours the economics of production, superior taste and longer shelf life of the finished product (Pavlista and Ojala, 1997). Tuber specific gravity was not affected by different treatments of seed cutting and foliar spray of GA (Table 3). Besides the taste and texture of fries, the colour of fries should be free from any kind of browning which leads to deterioration of visual appeal and is associated with bitter taste. There was no significant effect of different treatments on tuber dry matter content, French fry colour and glucose content, however numerically highest tuber dry matter content was recorded in T_8 treatment (Table 3).

Fry quality parameters during storage at 10-12°C and under room temperature

Since potato is a seasonal crop and a perishable commodity, therefore to run the French fry industry on round the year, long term storage is imperative. For this purpose storage at elevated temperatures (10-12°C) with sprout suppressant treatment is done extensively to avoid the low temperature sweetening. Therefore, any agronomic manipulation done to increase the French fry grade, should not affect the quality at harvest as well as during storage. In this study as far as glucose content is concerned, the treatment of longitudinal cut with mancozeb, bavistin and POP (T_6) had consistently maintained low glucose levels till the end of study after six months (Table 4). However, this was not reflected in the fry colour, which was on higher side especially after 150 and 180 days. It is postulated that besides glucose, levels of sucrose, fructose and even nitrogenous compounds can affect colour of fried products (Kumar *et al.*, 2004). Since only glucose was analyzed in this study, the exact reason for higher fry colour cannot be speculated. The other treatments which had yielded acceptable fry colour upto 150 days include, normal seed with 10 ppm GA (T_2) , normal seed with 20 ppm GA (T_3), cut seed piece (2-3 eye) treated with mancozeb (T_7), cut seed piece (2-3 eye) treated with mancozeb + bavistin + PoP (T_8). Since our ultimate interest is in getting better overall product quality, these treatments can be adjudged as satisfactory for long term storage.

Table 4. Effect of seed cutting and GA application on processing quality of cv *Kufri Frysona* during storage at 10-12°C temperature with sprout suppressant CIPC

Treatments*	Days after storage at 10-12 °C with CIPC											
	30		60		90		120		150		180	
	Fry colour	Glucose **	Fry colour	Glucose **	Fry colour	Glucose **	Fry colour	Glucose **	Fry colour	Glucose **	Fry colour	Glucose **
T_1	2.65	0.50	2.25	9.51	2.95	47.25	3.05	2.26	3.40	43.08	6.00	61.50
T_2	4.50	2.01	1.25	6.50	3.20	6.64	3.10	3.31	2.86	15.41	3.66	56.91
T_3	1.20	1.29	2.63	3.31	1.90	7.34	3.60	4.11	3.06	10.65	3.93	37.91
T_4	3.00	1.41	2.38	15.1	1.70	8.28	3.60	10.76	5.00	60.70	4.73	59.20
T_5	3.80	4.48	2.63	8.92	2.30	7.19	4.25	6.23	3.30	73.16	3.68	67.87
T_6	2.60	0.43	2.75	5.60	2.20	6.28	3.10	6.04	3.80	19.62	5.73	18.58
T_7	1.95	0.88	2.25	28.38	2.25	16.5	2.15	5.33	2.93	14.87	3.46	31.37
T_8	1.10	0.79	3.08	5.32	2.05	4.08	4.60	5.26	2.46	11.37	5.13	69.50
CD (P=0.05)	1.21	NS	0.54	6.92	0.36	1.91	0.33	4.44	0.71	1.62	0.91	3.03

*treatment details are given in Table 1; ** = glucose (mg 100^{-1} g fresh tuber weight)

The French fry grade tubers were also stored in small quantity (5kg) at room temperature to study the physiological losses in terms of sprouting and total weight loss. There was no significant effect of different treatments on these two parameters upto 90 days of storage (data not shown). However minimum weight loss after 90 days of storage in numerical terms was obtained in treatment T_8 (13.4%) and maximum in T_1 and T_3 treatments (20.4%). Sandhu *et al.*, (2014) also reported the similar pattern of physiological weight loss for Indian potato processing variety *Kufri Chipsona-1* under Amritsar conditions.

Conclusions

The treatment T_8 (cut seed pieces of 30 g treated with 0.2% mancozeb, 0.2% carbendazim and 0.5% dusting of plaster of Paris was found best over other treatments with respect to French fry grade tuber numbers, yield, quality at harvest and after storage, net retunes, and benefit:cost ratio for variety *Kufri Frysona*. This treatment also saves the seed requirement by 50%, which is most critical and expensive input for the potato farming.

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