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Standardizing fertility and crop geometry requirements of potato chipping variety Kufri Chipsona-4 for higher chip grade yield, quality and profitability

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ABSTRACT

Field study was conducted at Central Potato Research Institute Campus, Modipuram to standardize the fertilizer and crop geometry requirements of newly released potato chipping variety Kufri Chipona-4 for higher chip grade tuber yield with good quality and higher profitability. Growth traits as well as chip grade tuber number did not influence due to different fertility levels and intra-row spacing treatments. Average tuber number/plant was higher under wider spacing. Highest chip grade, total and net tuber yield was recorded with highest fertility dose tested in the study (270 N + 80 P_2O_5 + 150 K_2O kg/ha). Graded as well as net tuber yield was statistically similar under different crop geometry treatments. All the chipping quality parameters remained unaffected due to different fertility levels and crop geometry treatments except tuber dry matter content, which increased significantly in response to wider spacing and was maximum under 67.5 cm × 25 cm crop geometry (22.36%). Average chip grade tuber weight, which decides the peeling losses increased significantly in response to higher fertility levels and wider spacing. Maximum net returns (Rs. 95,937/ha) and B:C ratio (2.16) was recorded with fertilizer dose of 270 N + 80 P_2O_5 + 150 K_2O kg/ha. Among crop geometry treatments the net returns was statistically similar, but the B:C ratio was statistically higher under 67.5 cm × 25 cm crop geometry (2.20). Therefore, chipping variety Kufri Chipsona-4 may be fertilized with 270 N + 80 P_2O_5 + 150 K_2O kg/ha, along with 67.5 cm × 25 cm crop geometry (seed size 50 g) for achieving higher chipping grade tuber yield with good chipping quality and profits to the farmers.

Key words: Chip grade tuber yield, chipping quality, crop geometry, Kufri Chipsona-4, fertility levels.

INTRODUCTION

Development of the Chipsona varieties has proved a boon to the potato processing industry in India; however, industry still feels a crunch of raw material during the months of September to January. Presently during September to November, the industry depends heavily on the fresh produce from the *kharif* crop of Karnataka especially from Hassan and Chickmagalur districts, where predominant variety is Kufri Jyoti, which has poor chipping qualities besides susceptible to dreaded disease late blight. Most of the potatoes in India are grown during *rabi* season and its harvesting starts from February month especially of processing varieties which has longer crop span (110-120 days). Similarly, West Bengal is becoming a hub of potato processing industries, but raw material availability is a problem as prevalent variety Kufri Jyoti is not suitable for chipping and exotic cultivar Atlantic is highly susceptible late blight. Due to harvest of paddy crop in November, shorter window is available for potato; there is also need of an early maturing and late blight resistant variety. Because of changing climatic conditions and requirements of the industry, early maturing potato varieties are also required in Malwa region of Madhya Pradesh. Therefore, variety Kufri Chipsona-4 was released in year 2010, which was tested in the present study as MP/01-916, has all the required traits for chipping and matures within 90 days (Kumar *et al.*, 6). This can be an apt replacement of Kufri Jyoti in Karnataka, West Bengal and Madhya Pradesh, besides has potential to supply the raw material to the chip making industry during January month from northern and central plains zone. Processing of potatoes into chips requires certain minimum quality attributes that include round to oblong tubers (> 45 mm) with shallow eyes and low peeling losses for higher recovery of finished product. The tubers need to have 20% or more dry matter with glucose content as low as possible (preferably below 35 mg/ 100 g fresh tuber weight) to yield crisp and light coloured chips (Gould, 2; Sowokinos, 13). A number of factors influence potato yield and tuber size distribution, which include spacing (inter-row or intra-row), nutrient management, water management, seed size, cultivar, geographic location and climatic conditions. Variation in intra-row spacing can also affect tuber size distribution, therefore, for any given potato cultivar information on intra-row spacing is required to optimize yields of marketable size

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tubers (Kumar *et al.*, 10). There is also evidence of reduced tuber specific gravity and higher incidence of hollow heart at wider intra-row spacing; however no effect of intra-row spacing on chip colour has been observed (Zebarth *et al*., 14; Kumar *et al*., 10). It is well documented that fertilizer regimes or doses affect tuber quality besides tuber yield in different grades (Kumar *et al*., 8). Every potato cultivar has specific nutritional requirements as evident in case of cvs Kufri Chipsona-1, Kufri Chipsona-2 and Kufri Chipsona-3, which require 50% higher N and K compared to ware varieties for realizing full yield potential with acceptable processing quality at harvest and during long term storage as well (Kumar *et al*., 11, 12). Therefore, the objective of this experiment was to standardize the NPK level and crop geometry (intra-row spacing) requirements of new potato chipping variety Kufri Chipsona-4 for higher tuber yield (chipping grade and total), better chipping quality and maximum profits to the growers.

MATERIALS AND METHODS

The field experiment was conducted with newly released chipping variety Kufri Chipsona-4 (MP/01-916) on sandy loam soil (Typic Ustochrept) during 2008-2011 at Central Potato Research Institute Campus, Modipuram, India (29° 4' N, 77° 46' E, 237 m above mean sea level) in Factorial Randomized Block Design with three replications. The treatment combination consisted of three fertility levels (F_1 = 180 + 80 +100; F_2 = 225 + 80 + 125 and F_3 = 270 + 80 + 150, N + P_2O_5 + K_2O kg/ha) and three crop geometry treatments (67.5 × 15, 67.5 × 20 and 67.5 × 25 cm^2). Chemical analysis of the soil (0-15 cm) showed neutral pH (7.33), medium organic carbon content (0.68%) and low alkaline $KMnO_4$-N (212.9 kg/ha), high Olsen's (0.5 M $NaHCO_3$ extractable) P (50.8 kg/ha) and medium 1N ammonium acetate extractable K (175.9 kg/ha). Half N, full P (52.4 kg/ha) and full K were applied at the time of planting as per treatment. The remaining half N 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 18 and 19 October during the two years, respectively. Well-sprouted seed tubers (about 50 g weight and 35-40 mm seed size) were planted in plots of 4.05 m × 4.0 m size. The experimental crop was raised under assured irrigation using the furrow method. Dehaulming as well as harvesting was done manually at 90 days after planting (DAP) to simulate the supply of fresh potatoes to the chipping industry during the month of January. Observations on growth parameters, such as stem number, plant height and compound leaf number were recorded at 45 DAP. Total and chip grade tuber yield and number were recorded at harvest, tubers of >45 mm in diameter were considered as chip grade. To calculate net tuber yield, seed tuber used was deducted from the total tuber yield. To estimate tuber dry matter content five chip 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*., 9). Tuber specific gravity was measured by the hydrometer method by taking 3.632 kg of processing grade potato tubers from each plot (Gould, 2). Five chip grade tubers were selected randomly from each plot and used for estimating the chip colour score. Potato chips were prepared in laboratory which involved peeling the tubers in abrasive peeler, slicing in 1.75 mm thick slices with an automatic slicer, washing and drying on paper towel. Dried slices were fried in refined sunflower oil in a thermostatically controlled deep fat fryer at 180°C till bubbling stopped. Fried chips were then evaluated for chip colour on a scale of 1-10, subjectively with the help of colour cards (Ezekiel *et al*., 1), where 1 denotes a highly acceptable colour, 10 denotes a dark brown and unacceptable colour, and chips with colour range of up to 3.0 were considered acceptable. The glucose content in potato tubers was quantified using YSI Biochemistry analyzer as described by Sowokinos (13). To calculate economic variables the price of the chip grade potato tubers was taken as Rs. 6,000/t (price paid by the processors to their contract growers during those years) and the price for small size potato tubers was taken as Rs. 4,000/t (the prevailing market price for that quality of potato tubers). The price of seed tuber was taken as Rs. 10,000/t. Data of each character collected from the experiments were statistically analyzed using standard procedures of variance analysis with the help of statistical software CROPSTAT 7.2 (IRRI, 4). Critical difference (CD) values at P=0.05 were used to determine the significance of differences between means.

RESULTS AND DISCUSSION

No interaction was observed between fertility levels and crop geometry treatments therefore main effects of the both the factors are discussed in this section. Final plant emergence as well as growth traits (plant height, stem and compound leaf number/plant) remained statistically similar under different levels of fertility and crop geometry treatments (Table 1). Kumar *et al.* (7, 8, 11) also reported that plant height; stem number and leaf number did not influenced for processing cultivars Kufri Chipsona-1 and Kufri Chipsona-2 under different crop geometry and fertilizer treatments under similar conditions. Chlorophyll content slightly increased in response to higher N and K dose and wider intra-row spacing, however, the increase was insignificant. Maximum chip grade and total tuber number were recorded with fertility level F_2, but the differences were non-significant with other fertility levels (Table 1). The numerically higher tuber numbers under F_2 can be attributed to higher average tuber number/plant (7.43). Similar findings have been reported by Kumar *et al*. (9) for chipping cultivar Kufri Chipsona-3. It is well documented that tuber setting/number is mainly governed by the genetic makeup of the cultivar (Horton, 3). Small size tuber number decreased with increased fertilizer dose and found minimum under fertility level F_3. Chip grade, small size as well as total tuber number decreased in response to increased intra-row spacing, whereas, average tuber number/plant was higher under wider spacing. The reduction in tuber number with increased intra-row spacing may be attributed to reduced plant density; even having higher tuber number/plant the total tuber number could not be compensated. The similar findings have earlier been reported for French fry variety Kufri Frysona (Kumar *et al*., 10).

In the present study only N and K doses were varied while the dose of P was kept constant because of higher P content in the native soils. Highest chip grade, total and net tuber yield was recorded with highest fertility dose tested in the study (F_3: 270 N + 80 P_2O_5 + 150 K_2O kg/ha), which was statistically higher than F_1, which is the fertilizer dose (180 N+ 80 P_2O_5 + 100 K_2O kg/ha) recommended for table potato varieties in the region, and at par with F_2 treatment (Table 2). An increase of potato tuber yield by N and K fertilization has also been on records (Kumar *et al*., 9, 11). Percent chip grade was also maximum under F_3 treatment (84.3%). Inspite of having lower tuber numbers under F_3 treatment the higher chip grade and total yield can be ascribed to the fact that mean chip grade tuber weight improved significantly with response to higher fertilizer dose under F_3 treatment (93.1 g) than F_1 (86.2 g) and F_2 (78.5 g) treatments. This is very important character for chipping industry as peeling losses are negatively correlated with the average chip grade tuber weight (Kumar *et al*., 10). Graded as well as net tuber yield was statistically similar under different crop geometry treatments; however, total tuber yield was statistically higher under 67.5 cm × 15 cm crop geometry than 67.5 cm × 25 cm. This was due to lesser tuber number under wider spacing because 40% higher seed rate was

Table 1. Effect of fertility levels and crop geometry treatments on growth and graded tuber number of cv. Kufri Chipsona-4 (pooled data).

Fertility level N : P_2O_5: K_2O (kg/ha)	Plant density (× 10^3/ha)	Seed rate (t/ha)	Emergence (%)	Plant height (cm)	Stem No./ plant	Leaf No./ plant	Chlorophyll content (SPAD value)	Tuber No. (thousand/ha)			Tuber No. plant
								Chip grade (>45 mm)	Small (<45 mm)	Total	
F_1 = 180 -80 -100	77.4	3.87	92.6	50.2	4.27	46.8	45.9	268.5	245.7	514.2	7.37
F_2 = 225 - 80 - 125	77.4	3.87	93.2	54.6	4.08	46.8	46.6	328.4	204.1	532.5	7.43
F_3 = 270 - 80 - 150	77.4	3.87	93.4	54.4	3.72	45.6	47.2	286.0	198.4	484.4	6.90
CD at 5%	-	-	NS	NS	NS	NS	NS	NS	45.5	NS	NS
Crop geometry (cm)											
67.5 × 15	98.8	4.94	90.8	54.9	4.11	48.1	44.7	339.7	242.6	582.3	6.49
67.5 × 20	74.1	3.71	93.7	53.5	4.11	47.2	47.4	287.9	213.6	501.4	7.22
67.5 × 25	59.3	2.97	94.8	50.9	3.86	43.9	47.6	255.4	192.0	447.3	7.96
CD at 5%	-	-	NS	NS	NS	NS	NS	NS	45.5	99.2	1.25

Table 2. Effect of fertility levels and crop geometry treatments on graded tuber yield, chipping quality and profitability of cv. Kufri Chipsona-4 (pooled data).

Fertility level	Tuber yield (t/ha)				Mean chip grade tuber wt. (g)	Tuber dry matter content (%)	Specific gravity	Chip colour score	Glucose (mg/100 g FW)	Net returns (Rs./ha)	B: C ratio
N : P_2O_5: K_2O (kg/ha)	Chip grade (>45 mm)	Small (<45 mm)	Total	Net							
F_1 = 180 - 80 -100	23.15 (79.0)	6.13	29.28	25.41	86.2	22.06	1.081	2.77	14.4	79682	1.97
F_2 = 225 - 80 - 125	25.78 (83.5)	5.04	30.82	26.95	78.5	21.48	1.079	2.92	32.5	91122	2.09
F_3 = 270 - 80 - 150	26.63 (84.3)	4.98	31.61	27.74	93.1	21.61	1.079	2.89	26.6	95937	2.16
CD at 5%	2.71 (4.1)	1.10	2.27	2.27	6.8	NS	NS	NS	NS	14217	0.17
Crop geometry (cm)											
67.5 × 15	26.52 (82.5)	5.51	32.04	27.10	78.1	21.08	1.079	2.79	16.3	86793	1.92
67.5 × 20	25.14 (82.2)	5.41	30.56	26.85	87.3	21.72	1.080	2.96	39.8	90410	2.10
67.5 × 25	23.89 (82.1)	5.23	29.12	26.15	93.5	22.36	1.080	2.83	17.3	89538	2.20
CD at 5%	NS	NS	2.27	NS	6.8	1.11	NS	NS	NS	NS	0.17

*In parenthesis percent chip grade

used under 67.5 cm ×15 cm spacing than 67.5 cm × 25 cm treatment. On the other hand mean chip grade tuber weight increased significantly in response to wider spacing. Like our studies, Zebarth *et al.* (14) also reported that under wider intra-row spacing mean tuber weight increased, whereas, total tuber yield decreased by 12% when intra-row spacing was increased from 20 to 40 cm.

Tuber specific gravity and dry matter content directly influence the chip yield and crispiness, while chips colour score decides the consumer acceptance. A chip colour of < 3 and glucose content of < 35 mg/100 g fresh tuber weight are considered ideal and acceptable by the chipping industry (Gould, 2; Sowokinos, 13). Higher glucose levels are also related to formation of potentially carcinogenic compound acryl amide upon frying (Kumar *et al.*, 5). Therefore, lower levels of glucose are desirable in fried potato products. In our study all the chipping quality parameters (tuber dry matter content, specific gravity, chip colour score and glucose content) remained unaffected due to different fertility levels and were in acceptable limits of the chipping industry (Table 2). Kumar *et al.* (9) also observed that all the above stated chipping traits remained uninfluenced up to fertility regime of 270 N + 80 P_2O_5 + 150 K_2O kg/ha in chipping variety Kufri Chipsona-3, but fertilizer dose above this resulted in deterioration of processing quality. Among the crop geometry treatments the tuber dry matter content increased significantly in response to wider spacing and was maximum under 67.5 × 25 cm treatment (22.36%). This is a very significant finding from chipping industry point of view because higher dry matter will help in reducing the oil consumption on one hand and will make the chips crispier on the other hand. Kumar *et al.* (10) also reported slight increase in tuber dry matter content at 67.5 cm × 25 cm crop geometry than 67.5 cm × 20 cm in processing variety Kufri Frysona. Specific gravity, chip colour score and glucose content remained unaffected due to crop geometry treatments. Similar findings have earlier been reported by Kumar *et al.* (7) for chipping cultivars Kufri Chipsona-1 and Kufri Chipsona-2.

Maximum net returns and B:C ratio was estimated with fertility regime F_3 (270 N + 80 P_2O_5 + 150 K_2O kg/ha), which was statistically higher than F_1 and at par with F_2 treatment (Table 2). This was due to the higher chipping and total tuber yield realized at higher fertility regimes. The same fertilizer dose have also been found best for processing cultivars Kufri Chipsona-1, Kufri Chipsona-2 and Kufri Chipsona-3 (Kumar *et al.*, 9,11). Among crop geometry treatments the net returns was statistically similar, but the B:C ratio was statistically higher under 67.5 cm × 25 cm crop geometry (2.20) than 67.5 cm ×15 cm (1.92) and at par with 67.5 cm × 20 cm (2.10) crop geometry. This can be attributed to low cost of cultivation because of 40% lower seed cost at 67.5 cm × 25 cm than 67.5 cm × 15 cm crop geometry. To realize the higher chipping grade tuber yield with maximum mean chip grade tuber weight with good chipping quality along with profitability the chipping variety Kufri Chipsona-4 may be fertilized with 270 N + 80 P_2O_5 + 150 K_2O kg/ha along with 67.5 cm × 25 cm crop geometry (seed size of 50 g or 35-40 mm).

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