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Studies on Integrated Nutrient Management and Growth Regulator Application on Production, Productivity, Quality and Economics of Processing Potato (*Solanum tuberosum* L.)

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ABSTRACT

A field experiment was conducted at the Students' Research Farm, Khalsa College, Amritsar during *rabi* season of 2021-22. The experiment was laid out in Randomized Block Design (RBD) with ten treatments viz., T_1 (Control), T_2 (100% RDF), T_3 (70% RDF + 30% FYM), T_4 (70% RDF + 30% Compost), T_5 (70% RDF + 30% Poultry manure), T_6 (70% RDF + 30% FYM + Mepiquat chloride @ 1250 ml/ha), T_7 (70% RDF + 30% Compost + Mepiquat chloride @ 1250 ml/ha), T_8 (70% RDF + 30% Poultry manure + Mepiquat chloride @ 1250 ml/ha), T_9 (33.3% FYM + 33.3% Compost + 33.3% Poultry manure) and T_{10} (25% RDF + 25% FYM + 25% Compost + 25% Poultry manure + Mepiquat chloride @ 1250 ml/ha) with three replications. The data obtained revealed that treatment T_2 (100% RDF) obtained higher number of stems/hill being statistically identical with all the treatments except T_{10}, T_9 and T_1. Maximum plant height, LAI and haulm DMA were recorded in T_2 which was statistically at par with T_3, T_4 and T_5 and significantly superior to the rest of the treatments. The yield attributes and yield viz., number of tubers/plant, average tuber weight, processable tuber grade and total tuber yield was recorded significantly higher in T_2 than all other treatments but remained statistically at par with T_6, T_7 and T_8. Regarding the quality parameters, all the treatments showed non-significant variation except tuber dry matter content which was found significantly higher in T_1 and lower in T_2. The highest gross returns, net returns and B:C ratio were also obtained in treatment T_2 followed by T_8.

Keywords Inorganic fertilizers, Mepiquat chloride, Organic manures, Potato, Yield.

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INTRODUCTION

Potato is the most important food crop in the world after wheat, rice and maize in terms of production and human consumption (Burke 2016). Worldwide India ranks second in potato production after China with total production of 53.58 million metric tonnes from an area of 2.2 million hectare with an average

yield of 24.35 t/ha (Anonymous 2022). The crop is adapted well for the commercial cultivation under sub-tropical conditions. Punjab is the third largest potato producing state with a total production of 29.4 lac tonnes from an area of 1.07 lac hectares with an average yield of 27.5 t/ha (Anonymous 2021). The crop has occupied an important place in agricultural economy of Punjab and is a suitable alternative crop to diversify the rice-wheat cropping system. At present in India, potato consumption is divided into three sectors i.e., table (68%), seed (8.5%) and processing industry (7.5%) and remaining (16%) goes as wastage due to inadequate, expensive and unevenly distributed refrigerated storage facilities. Under the existing circumstances, diversion of potatoes into various processed products is a viable option which can help to extend the shelf-life, save the wastage of precious food during gluts, solve the problem of storage as well as increase the per capita consumption in the country. Certain tuber morphological and biochemical attributes are considered necessary for processing industry. The processing genotypes should possess high dry matter (>20%), low reducing sugars (<0.5%) and acceptable chip/french fry color (Marwaha *et al*. 2010).

Agronomic requirements especially fertilizer application is necessary to increase the yield and quality of processing varieties. Potato is a heavy feeder of nutrients and requires large amounts of fertilizers to produce much more dry matter in its shorter life cycle. As there is no single source capable of supplying all the required amount of plant nutrients, integrated use of organic and inorganic fertilizers is essential to supply balanced nutrition to the crop which should be aimed at increasing yield, quality, nutrient deficiencies, improving lasting soil fertility and productivity that has been degraded by exploitive use of chemical fertilizers alone. Higher fertility status may increase the above ground foliage in potato which is not desirable. To check the excessive vegetative growth, the application of growth retarding chemicals at grand growth phase will be a practical approach for effective translocation of photosynthesis into developing tubers. Mepiquat chloride (MC), also known as 1,1 dimethylpiperidinium chloride, is one of the most widely used plant growth regulator for crops like cotton, onion and potato around the world to control the excessive vegetative development and to improve production (Gencsoylu 2009). It decreases the rate of cell division and cell expansion by inhibiting the manufacture of gibberellic acid (Srivastava 2002).

Therefore, the current investigation was undertaken to evaluate the response of processing potato (*Solanum tuberosum* L.) under integrated nutrient management practices and growth regulator application and in order to generate suitable agronomic practices for successful cultivation under Punjab conditions.

MATERIALS AND METHODS

Study location

A field experiment was carried out during *rabi* season of 2021-2022 at the Students' Research Farm, PG. Department of Agriculture, Khalsa College, Amritsar, Punjab, India. Geographically, the experimental site falls under semi-arid, tropical climate and is located at 31^0-63' North latitude and 74^0-83' East longitudes on an elevation of about 234 meters above sea level. The weakly mean meteorological observation during the crop period is represented in Fig. 1. Amritsar region receives a mean annual precipitation of about 541.9 mm. The soil of the experimental field was sandy loam in texture with normal pH (7.8) and EC (0.4 dsm^{-1}), lower in available nitrogen (168.5 kg/ha) and medium in organic carbon (0.4%), available phosphorus (16.6 kg/ha) and available potassium (255.0 kg/ha).

Experimental details

The experiment was laid out in Randomized Block Design (RBD) with ten treatments viz., T_1 (Control), T_2 (100% RDF), T_3 (70% RDF + 30% FYM), T_4 (70% RDF + 30% Compost), T_5 (70% RDF + 30% Poultry manure), T_6 (70% RDF + 30% FYM + Mepiquat chloride @ 1250 ml/ha), T_7 (70% RDF + 30% Compost + Mepiquat chloride @ 1250 ml/ha), T_8 (70% RDF + 30% Poultry manure + Mepiquat chloride @ 1250 ml/ha), T_9 (33.3% FYM + 33.3% Compost + 33.3% Poultry manure) and T_{10} (25% RDF + 25% FYM + 25% Compost + 25% Poultry manure + Mepiquat chloride @ 1250 ml/ha) with three replications. The

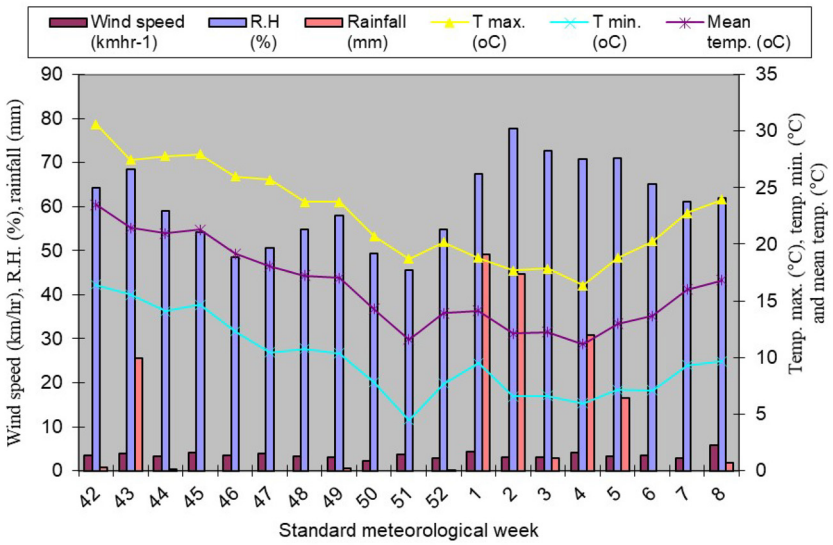

Fig. 1. Weakly mean meteorological observations during crop period (*rabi* 2021-22).

recommended dose of NPK was 187.5: 62.5: 62.5 kg/ha. Full dose phosphorus, potassium and half nitrogen were applied as basal in furrows according to treatments at time of planting, while the remaining nitrogen was top dressed at the time of earthing up. FYM, compost and poultry manure were applied to the plots as per different treatments and incorporated thoroughly into the soil before making ridges. Sowing of seed tubers (cv Cardinal) was done ridges at spacing of 60 cm × 20 cm in each plot (3.0 m × 3.0 m). First post sowing irrigation was given immediately after sowing and next irrigation after a week. Later on, timely irrigations, normal cultural operations and plant protection measures were used to ensure healthy crop. Haulm cutting was done 15 days before digging of potatoes and tubers were harvested at 1st week of February.

All the growth parameters were observed from the three randomly selected tagged plants from each plot. Plant emergence was calculated by counting the number of plants emerged at 30 DAP and the percentage of plants emergence per plot was calculated mathematically.

$$\text{Emergence (\%)} = \frac{\text{Number of plants emerged}}{\text{Number of seed tuber planted}} \times 100$$

Tuber initiation was recorded from 20th to 30th days after planting by digging three plants from the gross plot of each treatment. Observations on number of stems per hill, plant height, leaf area index and haulm dry matter accumulation were recorded at 90 DAP from the three tagged plants and average values were calculated. The yield and yield attributing characters viz., number of tubers, average tuber weight, processable (40-75mm), non processable (<40 and >75mm) and total tuber yield and haulm yield were recorded at harvest. Three tubers were selected randomly from each plot for estimating the quality parameters viz., tuber dry matter content, reducing sugars, sucrose content, chip color and chip recovery. Tuber dry matter was determined by oven drying 100 g cut tubers at 70°C was worked out by using formulae:

$$\text{Tuber dry matter content (\%)} = \frac{\text{Dry weight of tuber}}{\text{Fresh weight of tuber}} \times 100$$

The amount of reducing sugars was determined by Nelson-Somogyi method (Pearson 1976), while sucrose content was estimated by anthrone colorimetric method provided by Handel (1968). Chip color score was according to the reference chart given by Ezekiel *et al.* (2003), given numerical scores between 1-10, such that 1 being the lightest and highly acceptable and 10 being the darkest and

highly unacceptable. Chip recovery was calculated by using formulae:

$$\text{Chip recovery (\%)} = X \times \frac{\text{Peel weight}}{\text{Tuber weight}}$$

$$\text{Where, } X = \frac{\text{Weight of 30 fried chips}}{\text{Weight of 30 raw chips}} \times 100$$

The amount of N, P and K uptake by the crop was determined from the dried and grounded plant samples (tuber and haulm) collected from each treatment plot. Nitrogen content was determined using micro-kjeldahl apparatus (Sharma and Sud 1978). Phosphorus content was estimated from the extract by using spectrophotometer after developing yellow color with Barton solution and potassium content was estimated by using flame photometric method as described by Jackson (1967). Thereafter, the amount of nutrient uptake by the crop was calculated using formula:

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Dry yield (tuber or haulm)} \times \text{nutrient content (\%)}}{100}$$

Additional cost involved and return obtained with different treatments was worked out on the basis of market rate of all the applied inputs and then cost benefit analysis was computed for all the treatments.

The data on various parameters were statistically analyzed by using CPCS-1 (Cochran and Cox 1967). The comparisons were made at 5% level of significance.

RESULTS AND DISCUSSION

Growth parameters

Different nutrient management practices had showed significant effect on all the growth parameters except emergence percent and days taken to tuber initiation (Table 1). This might be due to the reason that well sprouted healthy tubers were planted which provided favorable conditions for emergence and also initial growth of potato depends on storage of food material inside the tubers (Barman *et al.* 2018). Application of 100% RDF through inorganic fertilizers had registered higher number of stems per hill (7.8) which was significantly superior over 25% RDF + 25% FYM + 25% Compost + 25% Poultry manure + Mepiquat chloride @ 1250 ml/ha (6.0), 33.3% FYM + 33.3% Compost + 33.3% Poultry manure (5.7) and control (4.0) but remained statistically at par with rest of the treatments.

Similarly, plant height and leaf area index were recorded significantly higher (44.1 cm and 2.62) in 100% RDF than all other treatments but remained at par with 70% RDF + 30% Poultry manure (43.3 cm and 2.53), 70% RDF + 30% FYM (40.6 cm and 2.46) and 70% RDF + 30% Compost (39.7 cm and 2.38),

Table 1. Effect of integrated nutrient management and growth regulator application on growth parameters in processing potato.

Treatments	Emergence (%)	Days taken to tuber initiation	No. of stems/ hill	Plant height (cm)	Leaf area index (LAI)	Haulm DMA (g/plant)
T_1-Control	89.6	25.9	4.0	25.4	1.33	7.1
T_2-100% RDF	94.0	24.6	7.8	44.1	2.62	11.9
T_3-70% RDF + 30% FYM	93.8	25.7	7.0	40.6	2.46	10.9
T_4-70% RDF + 30% Compost	92.8	25.2	6.8	39.7	2.38	10.8
T_5-70% RDF + 30% PM#	94.8	24.8	7.3	43.3	2.53	11.6
T_6-70% RDF + 30% FYM + MC @ 1250 ml/ha*	93.5	25.6	7.2	35.8	2.33	10.6
T_7-70% RDF + 30% Compost + MC @ 1250 ml/ha	92.5	25.3	6.8	35.2	2.30	10.5
T_8-70% RDF + 30% PM + MC @ 1250 ml/ha	94.2	25.0	7.7	37.1	2.36	10.7
T_9-33.3% FYM + 33.3% Compost + 33.3% PM	92.3	25.2	5.7	30.6	1.99	9.0
T_{10}-25% RDF + 25% FYM + 25% Compost + 25% PM + MC @ 1250 ml/ha	90.5	25.4	6.0	31.4	2.08	9.4
CD (p=0.05)	NS	NS	1.1	4.5	0.25	1.2

*Mepiquat chloride @ 1250 ml/ha at 55 days after planting, # Poultry manure.

Table 2. Effect of integrated nutrient management and growth regulator application on yield attributes and yield in processing potato.

Treatments	No. of tubers/ plant	Av tuber weight (g)	Tuber yield (q/ha) Processable	Non processable	Total	Haulm yield (q/ha)
T_1-Control	6.1	20.2	63.2	27.0	90.2	28.2
T_2-100% RDF	9.9	28.8	146.9	57.1	204.0	70.2
T_3-70% RDF + 30% FYM	9.0	27.3	126.3	46.6	172.9	67.3
T_4-70% RDF + 30% Compost	8.9	27.1	124.0	46.4	170.4	64.7
T_5-70% RDF + 30% PM#	9.1	27.4	129.1	47.6	176.7	69.0
T_6-70% RDF + 30% FYM + MC @ 1250 ml/ha*	9.3	28.2	135.8	52.8	188.6	53.5
T_7-70% RDF + 30% Compost + MC @ 1250 ml/ha	9.2	28.0	133.7	51.9	185.6	52.3
T_8-70% RDF + 30% PM + MC @ 1250 ml/ha	9.6	28.4	137.0	54.2	191.2	55.3
T_9-33.3% FYM + 33.3% Compost + 33.3% PM	8.0	25.0	97.8	35.5	133.3	46.3
T_{10}-25% RDF + 25% FYM + 25% Compost + 25% PM + MC @ 1250 ml/ha	8.2	25.6	110.9	42.6	153.5	50.2
CD (p=0.05)	0.8	1.4	14.1	8.4	22.6	5.7

*Mepiquat chloride @ 1250 ml/ha at 55 days after planting, #Poultry manure.

respectively. The haulm dry matter accumulation was also in line with plant height and LAI with maximum value (11.9 g/plant) recorded in 100% RDF.

The better results with the application of 100% RDF alone might be due to quick availability of nitrogen in inorganic form, which has profound effect on vegetative growth. Similar results were reported by Sandhu *et al*. (2014). Similarly, Singh *et al.* (2018) reported organic manures when applied with mineral fertilizers increased the efficiency of nitrogen and phosphorus which assimilates more photosynthates and better translocation resulting in higher vegetative growth. On the other hand, prominent variation among the growth attributes (plant height, LAI and haulm DMA) was observed with application of mepiquat which might be due to delayed cell division and elongation of plant aerial parts as well restrict gibberellin biosynthesis, thereby resulting in reduced internodal length and vegetative growth (Lopezvalencia *et al.* 2002). Similar results were also obtained by Pal *et al.* (2018) and Ali and Nagaa (2019).

In contrary, lower value for growth parameters was obtained under control throughout the crop growth period.

Yield attributes and yield

Nutrient management practices and growth regulator application exerted a significant effect on yield attributes and yield (Table 2). Significantly higher number of tubers per plant and average tuber weight i.e., 9.9 and 28.8g, respectively was recorded in 100% RDF being statistically identical with 70% RDF + 30% Poultry manure + Mepiquat chloride @ 1250 ml/ha (9.6 and 28.4 g), 70% RDF + 30% FYM + Mepiquat chloride @ 1250 ml/ha (9.3 and 28.2 g) and 70% RDF + 30% Compost + Mepiquat chloride @ 1250 ml/ha (9.2 and 28.0 g) than rest of the treatments. This might be attributed to quick availability of nutrients from inorganic fertilizers alone especially phosphorus at tuber initiation stage, which would have increased translocation of photosynthates for maximum tuber set (Davis *et al.* 2014). Trehan and Singh (2013) stated maximum potassium availability promotes large sized tubers by increasing water accumulation in tubers. The results are in support with findings Dangi *et al.* (2018).

The different graded tuber yield, total tuber yield and haulm yield were recorded significantly higher in all the treatments than control. Maximum processable (146.9 q/ha), non processable (57.1 q/ha) and total tuber yield (204.0 q/ha) was recorded in 100% RDF followed by 70% RDF + 30% Poultry manure + Mepiquat chloride @ 1250 ml/ha, 70% RDF + 30% FYM + Mepiquat chloride @ 1250 ml/ha and 70% RDF + 30% Compost + Mepiquat chloride @ 1250 ml/ha with same statistical rank. The percent increase

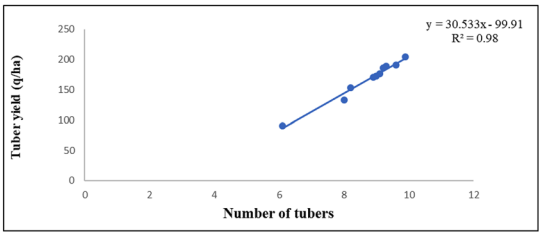

Fig. 2. Relationship between number of tubers plant and tuber yield.

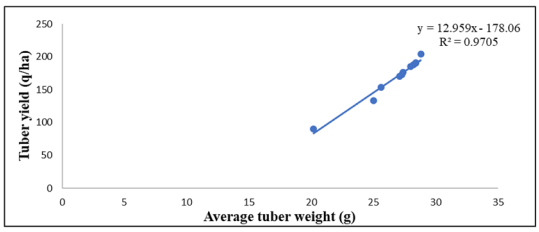

Fig. 3. Relationship between average tuber weight and tuber yield.

in total tuber yield with 100% RDF over control was 126.1%. This might be attributed to the positive response of the crop to readily availability of the nutrients from inorganic forms which has resulted in increased number of tubers, average tuber weight and ultimately total tuber yield. These results were in line with the findings of Deshmukh and Badgujar (2018). Singh *et al.* (2018) reported application of organic manures in conjunction with inorganic fertilizers provide balanced nutrition to plants, which increased the nutrient use efficiency, through modification of soil physical condition for better absorption of nutrients. Similar results were also reported by Kumar *et al.* (2011). On the other hand, treatments applied with mepiquat chloride (T_6, T_7 and T_8) gave 8.2 to 9.0% increase in total tuber yield over untreated plots (T_3,

Table 3. Effect of integrated nutrient management and growth regulator application on quality, NPK uptake and economics in processing potato.

Treatments	Tuber DMC (%)	Reducing sugars (mg/100g FW)	Sucrose (mg/ 100g FW)	Chip color score	Chip recovery (%)	Nitrogen (kg/ha)	Phos-phorus (kg/ha)	Potassium (kg/ha)	Cost of cultiva-tion (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C
T_1-Control	24.4	26.2	332.0	1.9	32.7	48.2	4.5	37.3	100335	102840	2505	1.02
T_2-100% RDF	21.1	28.4	344.4	2.8	30.1	104.2	14.4	80.7	108385	233380	124995	2.15
T_3-70% RDF + 30% FYM	22.1	27.9	341.6	2.6	31.0	91.4	11.5	70.5	117169	198160	80991	1.69
T_4-70% RDF + 30% Compost	22.4	27.3	337.1	2.4	31.4	90.3	11.0	69.4	117169	195200	78031	1.66
T_5-70% RDF + 30% PM#	21.8	28.2	343.2	2.7	30.4	94.2	11.7	73.1	112689	202520	89831	1.79
T_6-70% RDF + 30% FYM + MC @ 1250 ml/ha*	22.3	27.6	342.1	2.5	31.3	97.0	12.1	75.0	119444	215760	96316	1.80
T_7-70% RDF + 30% Compost + MC @ 1250 ml/ha	22.5	26.8	336.7	2.3	31.6	96.1	11.6	73.7	119444	212340	92896	1.77
T_8-70% RDF + 30% PM + MC @ 1250 ml/ha	21.9	28.1	343.0	2.7	30.7	97.5	12.6	75.4	114964	218600	103636	1.90
T_9-33.3% FYM + 33.3% Compost + 33.3% PM	24.0	26.4	333.2	2.0	32.5	69.3	7.7	53.8	132655	152860	20205	1.15
T_{10}-25% RDF + 25% FYM+ 25% Compost + 25% PM+MC @ 1250 ml/ha	23.4	26.7	334.6	2.3	32.0	77.2	9.2	60.0	128801	175680	46879	1.36
CD (p=0.05)	1.5	NS	NS	NS	NS	14.0	3.5	11.4	-	-	-	-

*Mepiquat chloride @ 1250 ml/ha at 55 days after planting, #Poultry manure.

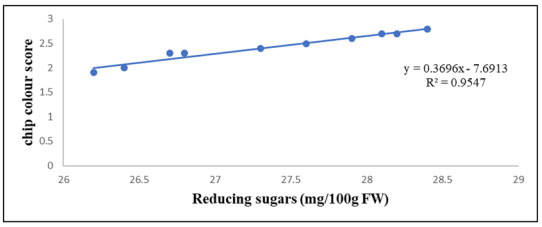

Fig. 4. Relationship between reducing sugars and chip color score.

T_4 and T_5), respectively which might be attributed to better utilization of photosynthates from aerial parts to the tubers. This is in agreement with the findings of Pal *et al.* (2018). Maximum haulm yield (70.2 q/ha) might be attributed to increased growth characters (plant height, stems/hill and leaf area index) in 100% RDF due quick availability of nutrients particularly nitrogen, which has profound effect on vegetative growth.

Results of the linear regression analysis among the studied variables with tuber yield are shown in Figs. 2–3. The dependent variable was tuber yield and the independent variables were number of tubers per plant and average tuber weight. The linear regression model indicated that the tuber yield was positively correlated with its affilated variables. The R^2 value indicated 98% and 97% variation in tuber yield was caused by the number of tubers per plant and average tuber weight, respectively among the different nutrient management practices.

Quality parameters

Data presented in Table 3 indicated that tuber dry matter content was recorded maximum in control (24.4%) and minimum in 100% RDF (21.1%). The reduction in tuber dry matter content with increased nutrient availability might be due to higher transformation of starch from potato leaves to tubers that promotes large sized tubers by increasing water accumulation in tubers resulting in lowering of dry matter content (Mishra 2018). Similar results were also obtained by Manolov *et al*. (2016). Tuber dry matter content directly influences the chip recovery, while chip color decides the consumer acceptance. In the present study, the processing attributes like reducing sugars, sucrose content, chip color score and chip recovery were not influenced by different nutrient management practices. However, direct and positive impact between reducing sugars and chip color has been reported among the treatments (Fig. 4).

Significantly higher N, P and K uptake by the crop i.e., 104.2, 14.4 and 80.7 kg/ha, respectively was recorded in 100% RDF which was significantly superior to 25% RDF + 25% FYM + 25% Compost + 25% Poultry manure + Mepiquat chloride @ 1250 ml/ha, 33.3% FYM + 33.3% Compost + 33.3% Poultry manure and control, but remained at par with rest of the treatments. This might be attributed to increased soil nutrient availability due to improved physical and chemical properties with inorganic fertilizers and organic manures, which lead to development of extensive root system for uptake of maximum nutrients from soil. The results are in conformity with the findings of Kumar *et al*. (2011) and Islam *et al.* (2013).

Economics

Maximum gross returns (233380 Rs./ha), net returns (124995 Rs/ha) and B:C ratio (2.15) were obtained under 100% RDF followed by 70% RDF + 30% Poultry manure + Mepiquat chloride @ 1250 ml/ha. This might be due to maximum processable and total tuber yield under these treatments.

CONCLUSION

The study revealed that among the various treatments, 100% RDF (187.5 kg N: 62.5 kg P_2O_5: 62.5 kg K_2O/ha) through inorganic fertilizers was superior in achieving the highest total tuber yield and processable tuber grade with the highest gross returns, net returns, and benefit-cost ratio. However, considering the adverse effects of inorganic fertilizers on the environment and to reduce the use of inorganic fertilisers, 70% RDF through inorganic fertilizers + 30% RDF from organic manures (FYM, compost, and chicken manure) combined with growth regulator application might be an alternative for the cultivation of the potato variety Cardinal under Punjab circumstances in order to obtain higher processable tuber yield with permissible quality attributes.

REFERENCES

Ali SMH, Nagaa A (2019) Effect of Mepiquat chloride and potassium sources on growth and yield of potato plants (*Solanum tuberosum* L.). *J Agric Sci* 27(1): 27-35.

Anonymous (2021) Package of practices for cultivation of vegetables, pp 1-2, Punjab Agricultural University, Ludhiana.

Anonymous (2022) https://www.statista.com/statistics/1038959/india-production-of-potato/#statisticContainer

Bansal KK, Sandhu KS, Bharti V, Saha A, Srivastava H, Nesar NA, Attri M (2022) Influence of varieties and spacings on growth, Yield attributes and productivity of pigeonpea. *Ind J Agric Res* 1: 6.

Barman KS, Kumar A, Kasera S, Ram B (2018) Integrated nutrient management in potato (*Solanum tuberosum* L.) cv Kufri ashoka. *J Pharmacog Phytochem* SPI: 1936-1938.

Burke JJ (2016) Growing of potato crop. Vita. Equity House, Upper Ormond Quay, Dublin 7, Ireland, pp 73-238. https://www.food.gov.uk/multimedia/pdfs/cropguide potatodec06.pdf.

Cochran WG, Cox GM (1967) Experiment Designs. Asia publishing house, New Delhi, India.

Dangi RS, Singh SP, Gaur D, Dixit JP, Sharma S, Patidar R (2018) Response of potato (*Solanum tuberosum* L.) to nitrogen levels under different cultural practices. *Int J Chem Stud* 6(4): 1589-1593.

Davis JD, Davidson RD, Essah SYC (2014) Fertilizing Potatoes. Colorado State University Extension. Fort Collins, Co80523 (970) 491-5061. USA

Deshmukh M, Badgujar C (2018) Effect of different fertilizer doses on yield and its attributes in potato. *World J Biol Biotechnol* 2(3): 175-177.

Ezekiel R, Singh B, Kumar D (2003) A reference chart for potato chip color for use in India. *Potato J* 30 (3-4): 259-265.

Gencsoylu I (2009) Effect of plant growth regulators on agronomic characteristics, lint quality pests and predators in cotton. *J Pl Growth Regul* 28: 147-153.

Handel VE (1968) Direct micro- determination of sucrose. *Anal Biochem* 22: 280-283.

Islam MM, Akhter S, Majid NM, Ferdous J, Alam MS (2013) Integrated nutrient management for potato (*Solanum tuberosum*) in grey terrace soil (Aric Albaquipt). *Aust J Crop Sci 7*(9): 1235-1241.

Jackson ML (1967) Soil chemical analysis. Prentice hall India Pvt Ltd., New Delhi, pp 498.

Kumar M, Baishya LK, Ghosh DC, Ghosh M, Gupta VK (2011) Yield and quality of potato tubers as influenced by nutrient sources under rainfed conditions of Meghalaya. *Ind J Agron* 56(3): 260-266.

Lopezvalencia M, Sanchezdel CF, Contreras ME (2002) Effect of cycocel and B9 on tomato plants pruned to two clusters. *Revista Chapin Serie Hort* 8(2): 161-170.

Manolov L, Neshev N, Chalova V (2016) Tuber quality parameters of potato varieties depend on potassium fertilizer rate and source. *Agric Sci Procedia* 10: 63-66.

Marwaha RS, Pandey SK, Kumar D, Singh SV, Kumar P (2010) Potato processing scenario in India: Industrial constraints, future projections, challenges ahead and remedies. *J Food Sci Technol* 47(2): 137-156.

Mishra N (2018) Effect of fertilizers on growth and productivity of potato- A review. *Int J Agric Sci* 10(4): 5183-5186.

Pal SK, Singh SP, Yadav KS, Kumar R, Kumar A (2018) Effect of mepiquat chloride on growth and yield of onion. *Ann Pl Soil Res* 19(4): 377-380.

Pearson D (1976) The chemical analysis of food 7th Educational Churchill Livingston, Edinburgh, pp 126.

Sandhu AS, Sharma SP, Bhutani RD, Khurana SC (2014) Effect of planting date and fertilizer dose on plant growth attributes and nutrient uptake of potato. *Int J Agric Sci* 4(5): 196-202.

Sharma RC, Sud KC (1978) Influence of organic manures and nitrogen levels on nutrient status, translocation, yield and tuber quality in four potato-based cropping systems. *J Ind Potato Ass* 19(1-2): 12-15.

Singh G, Kumar A, Singh G, Kaur M, Jatana MS, Rani S (2018) Effect of integrated nutrient management on growth and yield attributes of potato (*Solanum tuberosum* L). *Int J Curr Microbiol Appl Sci* 7(06): 2051-2056.

Srivastava LM (2002) Gibberellins: Plant development academic press, New York, USA pp 172-181.

Trehan SP, Singh BP (2013) Nutrient efficiency of different crop species and potato varieties in retrospect and prospect. *Potato J* 40: 1-21.