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Research Paper

Effect of row proportions, organic and inorganic nutrient sources on growth and yield of potato (*Solanum tubersoum*) cultivars

AJAY KUMAR[1], V.S. VERMA[2], DINESH KUMAR SHARMA[3] AND ANIL KUMAR MISHRA[4]

Amar Singh College, Lakhaoti, Bulandshahr, Uttar Pradesh 203 407

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ABSTRACT

The effects of row proportions and nutrient management was studied in potato (*Solanum tubersoum* L.) + Indian mustard [*Brassica juncea* (L.) Czernj.] intercropping system during 2014–15 and 2015–16 at Amar Singh College Farm, Lakhaoti (Bulandshahr), Uttar Pradesh. The field experiment was laid out in a split-split plot design with 3 replications. The main plot treatments consisted of 3 varieties, viz. 'Kufri Pukhraj', 'Kufri Anand' and 'Chipsona 3', and subplots comprised row proportions of 2 : 1 potato : Indian mustard (P : M), 4 : 1 P : M, potato sole and Indian mustard sole and the sub-subplot treatments consisted of 3 nutrient sources 100% organic (FYM), 100% inorganic and 50% organic + 50% inorganic. The maximum fresh weight of tubers (450.33 g), total tuber dry weight (56.99 g), total number of tubers/plant (15.40) as well as total biological yield (49.14) were recorded in 'Kufri Pukhraj' both for A - grade and total tuber yield. Row ratio of 2 : 1 (P : M) recorded higher fresh weight of haulms/plant (191.48), while higher dry weight/plant of potato (119.70) was recorded in the sole crop. Number of tuber/plant, fresh and dry weight of tubers were significantly higher under sole potato than row ratio of 4 : 1 however, row ratio of 4 : 1 was slightly superior to row ratio of 2 : 1. Sole potato and row ratio of 4 : 1 resulted in significantly higher total biomass than row ratio of 2 : 1. Yield of different grades and total tubers was recorded significantly higher in sole crop than that for row ratio of 4 : 1 and 2 : 1, though variations were observed nominal in case of C-grade tubers. Significantly higher potato yield (2.85 t/ha) was observed with the application of nutrients through 50% organic + 50% inorganic fertilizer application.

Key words: Grade of tubers, Organic and inorganic, Potato, Row proportions, Varieties

Potato (*Solanum tuberosum* L.) is a low cost and good source of carbohydrates, protein, fat etc. On an average, 100 g potato contains 18–20 g carbohydrates, 1.6–2.0 g protein, 0.1 g fat, 20 mg magnesium, 10 mg calcium, 0.7 mg iron, besides Vitamin B, C and it also contains good amounts of essential amino acids like leucine, tryptophane and isolucine. India produced 53.11 million tonnes potato from 2.25 million ha area, with an average productivity of 23.6 m tonnes/ha (MoA&FW, 2020). In uttar Pradesh, potato is grown in an area of 0.65 mha, with an annual production of 15.91 mt and average productivity of 24.47 t/ha (MoA&FW, 2020). It is grown in almost all the states in India and under different agroclimatic conditions. It involves high cost of cultivation due to its heavy requirements of seed, fertilizers and other management practices.

Though the productivity under inorganic farming is high, the produce possesses long-term negative effect on soil, environment and human health. However, organic farming, is good to improve the soil, environment and human health. Hence, there is a need to report the effect of integration of inorganic and organic farming system for yield of different crops. The nutritional requirement of the crop is much more for its high bulking rate. A major benefit of intercropping is the increase in production per unit area compared to sole cropping through the effective use of resources, including water, nutrients and solar energy (Nasri *et al*., 2014).

Indian mustard [*Brassica juncea* (L.) Czernj.] is a widely spaced crop, its inter-row space could profitably be utilized for other crops, particularly in the winter season. This approach may increase the possibility to generate the yield recovery of such system. Intercropping sequence of Indian mustard with potato results in additional yield of Indian mustard to the extent of 15–20 q/ha, with a marginal reduction of 8–10% in tuber yield without any additional

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[1]Corresponding author's Email: ajaypandit005@gmail.com

[1]Ph.D. Scholar, [4]Pricnaipal Scientist, Water Technology Centre, ICAR-Indian Agricultural Research Institute, New Delhi 110 012; [2]Ex-Dean and Professor, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh 208 002; [3]Ph.D. Scholar, Sardar Vallabhai Patel University, Meerut, Uttar Pradesh 250 110

crop area, inputs or expenditure Verma, (1981). In intercropping sowing of Indian mustard in the alternate trenches of potato (Kufri Chandramukhi) is superior to sowing in every trench, and sowing of Indian mustard has been recommended in place of every 4th ridge of potato but potato, in larger area, is planted by 2 or 4 ridge tractor-drawn planters. In this situation, it is essential to compare the row proportions of 2 : 1 and 4 : 1 of potato: Indian mustard for getting higher yields and profits.

Mueller (2012) recommended that proper fertilization (manuring-cum-chemical fertilizers application), and plant spacing are the pre-requisites for quality production of potatoes, besides the other cultural practices. He emphasized that, efficient production of potato is more location-specific rather than general practices. Organic manures like farmyard manure (FYM) and vermicompost (VC) play an important role in potato productivity. These sources can reduce the mining of soil nutrient and improve soil organic matter, humus and overall soil productivity. The use of organics in association with chemical fertilizers is superior to improve the grain yield, straw yield and post-harvest soil nutrient status probably owing to better balanced nutrient supply because of organics that resulted in better crop growth and yield attributes.

MATERIALS AND METHODS

The field experiment was conducted during the winter (*rabi*) season of 2014–15 and 2015–2016 at Farm of Amar Singh College, Lakhaoti, Bulandshahr, (28.4° N, 77.1°E, 245.83 m above mean sea-level), Uttar Pradesh. This tract has sub-tropical climate with extreme of weather conditions, having a hot dry summer, very cold winter and mild to heavy rains. The mean maximum temperature during the hottest months of May and June varies from 35ºC to 46ºC, while the minimum temperature during the coldest month of January and/or December, frost being common during these months. The mean weekly maximum temperature varied from 20.4 and 34.1ºC and 20.9 and 35.4ºC during 2014–15 and 2015–2016 respectively. The minimum temperature was 9.8–7.6ºC during 2014–15 and 9.1–21.1ºC during 2015–16. The soil was low in organic carbon (0.41 and 0.43%) sandy loam, having *p*H 7.3 and 7.2 with available nitrogen 218.2 and 224.8 kg/ha, available phosphorus and potassium medium during 2014–15 and 2015–16 respectively. The field experiment was laid out in a split-split plot design with 3 replications. The main plot treatments consisted of 3 varieties, viz. 'Kufri Pukhraj', 'Kufri Anand' and 'Chipsona 3; and subplot comprised row proportions of 2 : 1 potato: Indian mustard (P : M), 4 : 1 P : M, potato sole and Indian mustard sole; and the sub-subplot treatments consisted of 3 nutrient sources, viz. 100% organic (FYM), 100% inorganic and 50% organic + 50% inorganic. Uniform doses of nitrogen, phosphorus and potassium @ 150–80 and 120 kg/ha were applied through organic and inorganic sources as per treatments. In case of organic source, full dose of phosphorus and half of nitrogen were applied basal and the remaining nitrogen was applied in 2 equal splits just before earthing. In the treatments of 100% organic source, FYM was applied before sowing and it was thoroughly incorporated into soil. Organic and inorganic sources in the row ratio of 50 : 50% were applied as per the procedures adopted above in both the cases. The crop of potato was planted first in the desired ridges as per treatments, maintaining a space of 15 cm between tubers. Indian mustard sole as well as intercrop were sown in shallow furrows. The analysis of variance was done by following the methods suggested by Gomez and Gomez (1984), to statistically analyse the data. The significance of different sources of variations was tested by Error mean square of Fisher Snedecors F test at probability level (P=0.05).

RESULTS AND DISCUSSION

Varieties

The varietal differences was non-significant with respect to length of haulms, whereas significant variations were observed for fresh and dry weight of haulm/plant (Table 1). Pooled data showed that, 'Kufri Pukhraj' showed the maximum (59.00 cm) length of haulm, higher fresh weight (191.48 g), dry-matter accumulation (119.70 g), while 'Chipsona 3' the lowest fresh and dry weight of haulm. Since dry weight is the more precise measurement than fresh weight, there were relatively more variations in the dry weight of haulm/plant. The maximum fresh weight of tubers (450.53 g), total tuber dry weight (56.99 g), total number of tubers/plant (15.40) as well as total biological yield (49.14 t/ha) was recorded in 'Kufri Pukhraj' (Table 2). Total biomass is the resultant of different growth parameters like length of haulm, fresh and dry weight of haulms/plant, fresh and dry weight of tubers/plant, tubers/plant and successive increases in these parameters resulted in variations in the total biomass/plant. On the basis of total biomass, 'Kufri Pukhraj' was found significantly superior to 'Kufri Anand', whereas 'Kufri Anand' was numerically superior to 'Chipsona 3'. The results are in agreement with the findings of Kumar *et al*., (2012).

Yield of different grades and total tubers yield were significantly varied among the varieties of potato. Results showed that, wide variations were observed in A- grade and total tuber yield as compared to the yield of B-grade and C-grade tubers. On the basis pooled data of A – grade and total tuber yield, variety 'Kufri Pukhraj' was found superior to 'Kufri Anand' and 'Chipsona 3'. Yield of B-grade tubers of 'Kufri Pukhraj' was also numerically higher

than the remaining 2 varieties. Cultivar 'Kufri Pukhraj', belonging to short-duration maturity group, has higher yield as well as an excellent source of vitamin C, potassium and fibre (Sarangi *et al.*, 2020). Potato crop first grains a required quantity of aerial growth and even smaller improvements in the aerial growth results into higher tuber yield. Vegetative growth and tuber fresh yield and tuber number of 'Kufri Pukhraj' were higher than 'Kufri Anand' and 'Chipsona 3' which resulted in higher total yield of tuber, especially A-grade, accompanied by B-grade tubers, which all together contributed to the total tuber yield of this variety. These results partially confirm the findings of Muthoni and Nyamongo (2009).

Plant geometry-cum-row proportions

Accommodating Indian mustard rows after certain ridges of potato provided vacant space especially in early stages of growth and this vacant space, helped the growth of potato plants however, few growth attributes were better in sole crop of potato may be due to plot-to-plot variations and also due to adverse effect of mustard over potato in the intercropping while there was no adverse effect in potato sole. That is why, row of proportions in the ratio of 4:1 (P:M) followed by potato sole proved significantly superior to 2:1 ratio with respect to length of haulm. Fresh weight of haulm/plant of potato was recorded maximum and significantly higher in the row ratio of 2 : 1 (P : M), while higher dry weight/plant of potato was found in sole crop. Number of tubers/plant and fresh and dry weight of tubers were significantly higher under sole potato than row ratio of 4 : 1, the row ratio of 4 : 1 was slightly superior to row ratio of 2 : 1. The biometric observations based on per unit area showed a different trend than observations on per plant basis. Total biomass of sole potato followed by row ratio of 4 : 1 was significantly higher than row ratio of 2 : 1. Yield of different grade and total tubers was significantly higher in sole crop than row ratios of 4 : 1 and 2 : 1, though variations were observed nominal for C-grade tubers.

Nutrient management

Data pertaining to haulm length and fresh weight of haulms/plant by nutrient sources were not significant but nutrient source 50% organic plus 50% inorganic was better than 100% inorganic as well as 100% organic source. Nutrient sources 50 : 50% organic plus inorganic showed significant differences in the dry weight of haulms/plant followed by 100% inorganic source DAP, urea and MoP was superior to 100% organic source. The results emphasized the need of integrated use of 50% through inorganic and remaining 50% through organic sources for producing highest growth characters of potato plant under north India condition. Growth enhancement owing to the above-mentioned treatments is in agreement with the results reported by Gawish *et al.,* (2012), Kumar *et al.,* (2012) and Atul Jayapal *et al.* (2016) on potato. The increase in plant growth parameters by organic sources may not only be nutritional, but also due to its content of biologically active plant growth-influencing substances (Warman and

Table 1. Length of haulm, fresh and dry weight of haulms/plant (g) at different stages of potato varieties as influenced by row proportions and nutrients

Treatment	Length of haulm (cm)			Fresh weight of haulms/plant (g)			Dry weight of haulms/plant (g)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Varieties									
'Kufri Pukhraj'	59.61	58.39	59.00	192.43	190.53	191.48	121.08	118.32	119.70
'Kufri Anand'	56.84	55.68	56.26	188.10	186.30	187.20	114.53	111.73	113.13
'Chipsona 3'	58.76	57.68	58.22	185.06	183.36	184.21	93.17	90.06	91.62
SEm±	0.57	1.04	0.65	1.27	1.30	1.11	0.49	0.18	0.20
CD (P=0.05)	NS	NS	NS	4.97	5.08	4.35	1.93	0.71	0.79
Row proportions									
2 : 1 P : M	54.17	53.04	53.61	193.52	191.72	192.62	100.44	97.65	99.05
4 : 1 P : M	61.35	60.18	60.77	189.50	187.70	188.60	113.85	110.91	112.38
Potato sole	59.69	58.53	59.11	182.56	180.76	181.66	114.48	111.54	113.01
SEm±	0.20	0.31	0.25	1.80	1.68	1.33	1.27	1.18	0.73
CD (P=0.05)	0.60	0.96	0.76	5.55	5.16	4.03	3.92	3.66	2.29
Nutrient sources									
100% Organic	58.47	56.70	57.59	185.80	184.00	184.90	96.42	93.53	94.97
100% Inorganic	57.85	57.31	57.58	188.73	186.93	187.83	109.89	107.00	108.44
50% Organic + 50%	58.90	57.74	58.32	191.06	189.26	190.16	122.47	119.58	121.03
SEm±	0.79	0.64	0.71	2.44	2.70	1.61	1.28	1.29	0.70
CD (P=0.05)	NS	NS	NS	NS	NS	NS	3.67	3.71	2.01

Table 2. Fresh and dry weight of tubers per plant (g) and total biomass (t/ha) of potato varieties as influenced by row proportions and nutrient

Treatment	Fresh weight of tubers/plant (g)			Dry weight of tubers/plant (g)			Tubers/plant			Total biomass (t/ha)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Varieties												
'Kufri Pukhraj'	452.71	447.95	450.33	58.37	55.61	56.99	16.10	14.70	15.40	49.69	48.59	49.14
'Kufri Anand'	444.64	439.84	442.24	54.34	51.54	52.94	15.20	13.60	14.40	46.76	45.36	46.06
'Chipsona 3'	420.63	415.52	418.08	48.63	45.52	47.08	14.30	12.70	13.50	45.21	43.61	44.41
SEm±	4.49	3.89	2.39	0.38	0.24	0.11	0.18	0.14	0.06	0.78	0.71	0.72
CD (P=0.05)	17.53	15.17	9.32	1.49	0.95	0.42	0.70	0.55	0.25	3.06	2.79	2.82
Row proportions												
2 : 1 P : M	426.61	421.82	424.22	49.43	46.64	48.03	14.31	12.80	13.50	44.04	42.68	43.36
4 : 1 P : M	443.24	438.30	440.77	55.36	52.42	53.89	14.70	13.20	13.90	48.19	46.83	47.51
Potato sole	448.13	443.19	445.66	56.55	53.61	55.08	16.53	15.00	15.80	49.42	48.05	48.74
SEm±	4.39	3.68	2.93	0.71	0.95	0.39	0.06	0.12	0.04	0.48	0.37	0.38
CD (P=0.05)	13.53	11.33	5.95	2.17	2.91	1.22	0.19	0.38	0.13	1.49	1.13	1.16
Nutrient sources												
100% Organic	435.43	430.54	432.98	48.70	45.81	47.25	13.90	12.30	13.10	43.35	41.98	42.66
100% Inorganic	436.42	431.53	433.98	54.36	51.47	52.92	15.90	13.60	14.30	47.92	46.55	47.24
50% Organic + 50%	446.13	441.24	443.69	58.28	55.39	56.84	16.60	15.00	15.80	50.40	49.03	49.71
SEm±	5.22	4.80	3.27	0.72	0.59	0.37	0.23	0.17	0.11	0.70	0.63	0.65
CD (P=0.05)	NS	NS	9.38	2.05	1.71	1.06	0.65	0.49	0.32	2.01	1.81	1.85

Table 3. Different grades of tuber yield and total tuber yield (t/ha) of potato varieties as influenced by row proportions and nutrient

Treatment	A-grade tuber yield (t/ha)			B-grade tuber yield (t/ha)			C-grade tuber yield (t/ha)			Total tuber yield (t/ha)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Varieties												
'Kufri Pukhraj'	18.60	17.67	18.14	20.03	19.43	19.73	2.93	2.77	2.85	41.56	39.87	40.72
'Kufri Anand'	16.82	15.82	16.32	18.59	18.09	18.34	3.76	3.60	3.68	39.17	37.52	38.34
'Chipsona 3'	16.31	15.91	16.11	17.93	18.53	18.23	3.80	4.01	3.91	38.04	38.45	38.24
SEm±	0.10	0.04	0.06	0.09	0.09	0.03	0.05	0.05	0.06	0.49	0.32	0.34
CD (P=0.05)	0.40	0.15	0.21	0.35	0.34	0.12	0.21	0.21	0.22	1.92	1.26	1.32
Row proportions												
2 : 1 P : M	15.21	14.21	14.71	15.33	15.16	15.24	3.23	3.19	3.21	33.77	32.56	33.16
4 : 1 P : M	17.31	16.65	16.98	19.28	19.11	19.19	3.15	3.11	3.13	39.74	38.87	39.31
Potato sole	19.21	18.54	18.88	21.95	21.79	21.87	4.11	4.07	4.09	45.27	44.40	44.84
SEm±	0.13	0.27	0.15	0.26	0.37	0.17	0.03	0.03	0.03	0.31	0.27	0.28
CD (P=0.05)	0.39	0.83	0.46	0.80	1.13	0.53	0.09	0.08	0.09	0.94	0.82	0.86
Nutrient sources												
100% Organic	14.39	13.39	13.89	16.26	16.10	16.18	3.27	3.23	3.25	33.92	32.72	33.32
100% Inorganic	18.07	17.40	17.73	20.24	20.07	20.16	3.58	3.54	3.56	41.89	41.02	41.45
50% Organic + 50%	19.28	18.61	18.94	20.05	19.88	19.97	3.64	3.60	3.62	42.97	42.10	42.53
SEm±	0.24	0.19	0.10	0.21	0.19	0.08	0.04	0.04	0.05	0.52	0.62	0.63
CD (P=0.05)	0.69	0.55	0.29	0.61	0.54	0.23	0.10	0.13	0.14	1.48	1.79	1.81

AngLopez, 2010).

Significantly higher fresh, dry weight of tubers/plant and total biomass/ha was were recorded with the integrated application of nutrients applied through 50% organic + 50% inorganic fertilizer. The superiority of these characters obtained under integrated use of 50% recommended dose of fertilizer (RDF) through inorganic fertilizers and remaining 50% RDF through organic sources (FYM) could be attributed to the beneficial effect in precise proportions that led to increased nutrient availability through enhanced microbial activity, conversion of unavailable to available forms and improved physical chemical and biological conditions of soil (Singh and Kushwah, 2006).

Combined application of organic and inorganic had positive effect on potato productivity, tubers/plant and different grade of tubers as well as total yield/ha varied significantly over 100% organic or inorganic fertilizer application (Table 3). Tuber/plant and as total tuber yield were increased with the application of 50% organic + 50% inorganic source through than 100% inorganic and also proved superior to 100% organic. Supply of nutrients through the combination of 50% organic + 50% inorganic was significantly superior to 100% inorganic source and 100% organic source with respect to total biomass of potato. Application of nutrients through 50% organic + 50% inorganic source followed by 100% inorganic source increased the tuber yield especially of A-grade, B-grade and total tuber yield. Organic manures showed beneficial effect on tuber yield, as also reported by Chettri *et al.,* (2002). In addition to these ingredients, FYM also supplies plant growth hormones, enzymes, antibiotics and vitamins to the crop plants (Bhawalker, 1991). The result showed that, the increase in tuber number and tuber yield was owing to organic sources of nutrients which have high porosity, aeration, drainage and water-holding capacity that has effects on tuber development and total yield (Joshi *et al.,* 2015).

Economics

Gross returns, net profit and benefit: cost ratio were recorded significantly higher with 100% organic source than the other 2 sources (Table 4). Combination of 50 : 50% organic plus inorganic also proved superior to 100% inorganic source in respect of these parameters.

CONCLUSION

On the basis pooled data, Variety 'Kufri Pukhraj' proved superior to 'Kufri Anand' and 'Chipsona 3', in respect of A – grade tubers and total tuber yield. Yield attributes and total tubers yield were higher in row ratio of 4 : 1 than 2 : 1 ratio.

Based on the 2-year data, it may be concluded that potato requires adequate nutrition under North Indian condition and may be achieved by judicious and balanced use of organic and inorganic sources of nutrients. The combined application of inorganic (50% recommended dose) and remaining 50% recommended dose through organic manures are recommendable practices for higher growth characters, tubers quality and tuber yield.

Table 4. Economic aspects of cultivation of potato varieties as influenced by row proportions and nutrient sources during 2014–15, 2015–16 and pooled

Treatment	Gross return (000'₹/ha)			Net profit (000'₹/ha)			Benefit: cost ratio		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Varieties									
'Kufri Pukhraj'	249.37	239.21	244.29	169.79	159.63	164.71	2.13	2.00	2.07
'Kufri Anand'	235.03	225.10	230.06	155.44	145.51	150.48	1.95	1.83	1.89
'Chipsona 3'	228.25	230.69	229.47	148.66	151.10	149.88	1.86	1.90	1.88
SEm±	5.66	7.30	0.63	5.66	7.30	0.63	0.07	0.09	0.008
CD (P=0.05)	15.72	NS	1.45	15.72	NS	1.45	0.19	NS	0.018
Row proportions									
2:1 P : M	202.59	195.37	198.98	126.78	119.56	123.17	1.68	1.59	1.63
4:1 P : M	238.44	233.22	235.83	158.38	153.16	155.77	1.98	1.92	1.95
Potato sole	271.62	266.40	269.01	188.73	183.51	186.12	2.28	2.22	2.25
SEm±	7.32	7.97	0.74	7.32	7.97	0.74	0.09	0.10	0.009
CD (P=0.05)	15.96	17.37	1.52	15.96	17.37	1.52	0.19	0.21	0.019
Nutrient sources									
100% Organic	203.51	196.29	199.90	121.82	114.60	118.21	1.48	1.39	1.44
100% Inorganic	251.33	246.11	248.72	172.30	167.08	169.69	2.17	2.10	2.14
50% Organic + 50%	257.80	252.59	255.20	179.78	174.56	177.17	2.30	2.23	2.26
SEm±	4.81	4.92	0.47	4.81	4.92	0.47	0.06	0.06	0.006
CD (P=0.05)	9.77	10.00	0.93	9.77	10.00	0.93	0.12	0.12	0.012

REFERENCES

MoA&FW. 2020. Ministry of Agriculture and Farmers Welfare, 2020–21.

Jayapal, Atul, Swadija, O.K. and Anju, V.S. 2016. Impact of organic management on yield, quality and economics of Chinese potato (*Plectranthus rotundifolius*). *Indian Journal of Agronomy* **61**(1): 127–130.

Bhawalker, U.S. 1991. Vermiculture technology for LEISA. (In) *Seminar on Low External Input Sustainable Agriculture,* held at Amsterdam, Netherland.

Chettri, M., Mondal, S.S. and Roy, B. 2002. Influence of potassium and sulphur with or without FYM on growth, productivity and disease index of potato in soils. *Journal of Indian Potato Association* **29**(1–2): 61–65.

FAO 2019. FAO statistical databases FAOSTAT. http://faostat3.fao.org.

Gawish, Ragaa A., Ali, F.A., Midan, Sally A. and Taha, M.A. 2012. Effect of organic compost and mineral N fertilizers applied individually or in different combination rates along with seaweed extract on vegetative growth, tuber development, dry weight and growth analysis of potato plants. *Menofia Journal of Agricultural Research,* **37**(1): 183–201.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures in Agricultural Research*, edn 2, pp. 680. New York, Chichester etc. Wiley, paperback.

Joshi R., Singh J. and Vig A.P. 2015. Vermicompost as an effective organic fertilizer and biocontrol agent: Effect on growth, yield and quality of plants. *Reviews in Environmental Science and Bio Technology* **14**: 137–159.

Kumar, M., Baishaya, L.K., Ghosh, D.C., Gupta, V.K., Dubey, S.K., Das, Anup and Patel, D.P. 2012. Productivity and soil health of potato (*Solanum tuberosum* L.) field as influenced by organic manures, inorganic fertilizers and biofertilizers under high altitudes of Eastern Himalayes. *Journal of Agricultural Science* **4**(5): 223–234.

Kumar, P., Kumar, Rajeev, Singh, S.V. and Pandey, S.K. 2012. Standardizing fertility and crop geometry requirements of potato chipping variety *Kufri* 'Chipsona 4' for higher chip grade yield, quality and profitability. *Indian Journal of Horticulture* **72**(2): 239–243.

Mueller, R. 2012. Features: Fine points of nutrients affect potato yields and quality. *Wisconsin State Farmer News,* 29 November 2012 issue: 1–2.

Muthoni, J. and Nyamongo, D.O. 2009. A review of constraints to ware Irish potatoes production in Kenya. *Journal of Horticulture and Forestry* **1**(7): 98–102.

Nasri, R., Kashani, Barary, M., Paknejad, F. and Vazan, S. 2014. Nitrogen uptake and utilization efficiency and the productivity of wheat in double cropping system under different rates of nitrogen. *International Journal of Biosciences* **4**: 184–193.

Sarangi, S.K., Maji, B., Sharma, P.C., Digar, S., Mahanta, K.K., Burman, D., Mandal, U.K., Mandal, S. and Mainuddin, M. 2020. Potato (*Solanum tuberosum* L.) cultivation by zero tillage and paddy straw mulching in the saline soils of the Ganges Delta. *Potato Research* **64**(2): 277–305. https://link.springer.com/article/10.1007%2Fs11540-020-09478-6.

Singh, S.P. and Kushwah, V.S. 2006. Effect of integrated use of organic and inorganic sources of nutrients on potato (*Solanum tuberosum* L.) production. *Indian Journal of Agronomy* **51**(3): 236–38.

Taha, Mohamed, Malik T.P., Bhatia, A.K. and Deswal, Sumit. 2017. Tuber growth and quality of potato var. 'Kufri Bahar' as affected by FYM, vermicompost and neem cake under Western Haryana conditions, India. *International Journal of Current Microbiology Appied Sciences* **6**(12): 4,118–4,125.

Verma, V.S. 1981. Intercropping of mustard (*Brassica juncea* Coss.) with potato for additional production of oil. Paper presented at *Silver Jublee Conference*. *Indian Society of Agronomy* held at Haryana Agriculture University, Hisar, Haryana.

Warman, P.R. and AngLopez, M.J. 2010. Vermicompost derived from different feedstocks as a plant growth medium. *Bioresource Technology* **101**: 4,479–4,483.