Impact of humic acid-based bio-stimulant ~~(liquid formulation)~~ 'Humetsu' on growth and yield attributes of potato (*Solanum tuberosum L.*)

ABSTRACT

Aims: The current study carried out to examine the impact of humic-acid-based bio-stimulant (liquid formulation) 'Humetsu' on growth and yield attributes of potato variety Kufri Chipsona-4 ~~variety of potato~~.

Study design: The study used a Randomized Block Design with 3 replications and 8 treatments.

Place and Duration of Study: The existing experiment was worked out at Teaching Farm, College of Agriculture under BCKV, Burdwan Sadar during *Rabi,* 2019-20 and *Rabi,* 2020-21.

Methodology: The test product humic-acid based bio-stimulant (liquid formulation) 'Humetsu' was used for seed treatment at the rate of 5 ml/kg ~~of~~ tuber before sowing of potato and 2.5 ml /L ~~of~~ water was sprayed treatment-wise as per protocol using a water volume of 500 liters per ha with knapsack sprayer fitted with flat fan deflector nozzle in potato.

Results: The results elucidated that significantly maximum plant emergence, number of branches per plant and increased available N, P, K and OC in both years were recorded in treatment T_4 (100% NPK + 3 application of 'Humetsu' (Seed treatment @ 5 ml/kg of tuber and 2 foliar sprays @ 2.5ml L^{-1} water at 30 DAS & 55 DAS). The highest plant height, TSS (%), and fewer days to harvest were found in treatment T_7 (80% NPK + 3 application of 'Humetsu' (Seed treatment @ 5ml/kg of tuber and 2 foliar sprays @ 2.5ml L^{-1} water at 30 DAS & 55 DAS) followed by treatment T_4, T_5, and T_6. The maximum number of tubers per plant, total tuber yield, and marketable tuber yield were noticed in the treatment T_7 during both years. The highest microbial population in the soil was noticed in the T_7 during both the years. On the other hand, the least plant height, TSS (%), plant emergence, number of tubers per plant, total tuber yield, marketable yield per ha, more days to harvest, and the least microbial population in soil were observed in (control) treatment (T_8) during both the years.

Conclusion: Application of 80% NPK + 3 application of 'Humetsu' (Seed treatment @ 5ml/kg of tuber and 2 foliar sprays @ 2.5ml l^{-1} water at 30 DAS& 55 DAS) has a significant impact in yield of potato with 20% reduction of the recommended dose of NPK fertilizers.

Keywords: Humestu, Potato, NPK, Humic acid.

1. INTRODUCTION

The potato, ~~or~~ *Solanum tuberosum* L., is a member of the Solanaceae family and is grown in about 150 nations. It is the most prominent tuberous crop in the world, contributing significantly to both food security and the global food chain [1] and is considered as the poor man's friend [2]. After rice, wheat, and maize, it is the fourth-largest crop in the world [3]. The potato is said to have originated in South America's

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Andes and then spread around the world [4]. The Food and Agriculture Organization (FAO) designated potatoes as the crop to address future global food security and poverty reduction in 2008 due to their capacity to generate the highest level of nutrition and dry matter on a per unit area and time basis among major food crops [5]. According to projections, India's domestic potato consumption is expected to reach 125 million metric tonnes by 2050 [6]. Humetsu is a naturally generated organic matter and nutrient blend. It is designed specifically for Indian crops and agro-climatic conditions. Humetsu is developed from a special natural feedstock obtained from Russia's Siberian Leonardites field, which is the result of millions of years of spontaneous fermentation by soil bacteria. Humetsu is quickly absorbed by plants, where it contributes to the nutritional Bio-chemical process as well as the development of intrinsic resistance to unfavorable weather conditions.

2. MATERIAL AND METHODS

The current study was conducted in Rabi, 2019–20 and Rabi, 2020–21 at the Teaching Farm, College of Agriculture under BCKV, Burdwan Sadar, to investigate the effects of the liquid formulation of the humic acid-based bio stimulant "Humetsu" on the growth and yield characteristics of the Kufri Chipsona-4 variety of potato crops. Utilizing a Randomized Block Design with three replications and 8 treatments.

Table 1: The details of treatments

Treatments	Details
T_1	100% NPK + 1 application of 'Humetsu' (Seed treatment @ 5 ml/kg of tuber)
T_2	100% NPK + 1 application of 'Humetsu' (Foliar spray @ 2.5 ml/ l^{-1} water at 30 DAS)
T_3	100% NPK + 2 application of 'Humetsu' (Seed treatment @ 5 ml/kg of Tuber &1 foliar spray @ 2.5ml l^{-1} water at 30 DAS)
T_4	100% NPK + 3 application of 'Humetsu' (Seed treatment @ 5 ml/kg of tuber and 2 foliar spray @ 2.5ml/ l^{-1} water at 30 DAS& 55 DAS)
T_5	100% NPK + 2 application of 'Humetsu' (2 foliar spray @ 2.5 ml / l^{-1} water at 30 DAS & 55 DAS)
T_6	100% NPK + 2 application of 'Humetsu' (Seed treatment @ 5 ml/kg of Tuber& 1 foliar spray @ 2.5 ml/ l^{-1} water at 55 DAS)

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T_7	80% NPK + 3 application of 'Humetsu' (Seed treatment @ 5 ml/kg of tuber and 2 foliar spray @ 2.5ml/-l^{-1} water at 30 DAS& 55 DAS)
T_8	100% NPK (Control)

Data on quantitative and qualitative parameters like plant emergence (%), plant height (cm), no. of branches/plant, days to physiological maturity, no. of tubers /plant, grade of tubers, TSS (%) [^{0}Brix], marketable yield and total yield (t/-ha^{-1}) were recorded.

2.1 Experimental Soil-The soil of the experimental fields wassandy loam to loam in texture with a normal pH and medium fertility status with high water holding capacity. The crop was grown under irrigated condition.

2.2 The climatic condition of the experimental plot- The climate of the *Inceptisol* of West Bengal is typically warm and humid. The average maximum temperature starts falling in June and reaches a minimum in January. The mean monthly rainfall is higher in July-August and lower in December. The average rainfall is 1700 mm per annum of which around 70 % rainfall occurs during June to September. The lowest relative humidity is observed in December while the maximum is in July-August.

3. RESULTS AND DISCUSSION

The analysis of variance showed a significant ($p<0.05$) difference among the treatments in most of the parameters. The application of humic acid-based bio-stimulant significantly influenced the growth, yield and yield-attributing parameters of potato in consecutive two years.

3.1 Growth and quality parameters

Growth parameters of potatoes were evaluated in terms of plant emergence (%), plant height, number of branches/plant, days to physiological maturity and TSS (%) [^{0}Brix]. Significant results for these characters were obtained by the application of humic acid-based bio-stimulant 'Humetsu' (Table-2). The maximum plant emergence (92.41% and 93.11%) and the number of branches/plants (5.92 and 5.97) in both the years (2019-20 and 2020-21) were recorded in treatment T_4. The treatment T_4 was found statistically at par for plant emergence with the treatments T_1, T_3, T_6 and T_7 where seed treatment was done by humic acid @ 5 ml/kg of tuber. The lowest plant emergence was recorded in control T_8 (100% NPK) (84.15% in 2019-20) and T_5 (86.11% in 2020-21) followed by T_2 where tubers were not treated with 'humetsu' before sowing. Similarly, the number of branches per plant was highest in treatment T_4 which was statistically at par with treatment T_7 (5.82 and 5.85 in both consecutive years) and the lowest was recorded in treatment T_1 and T_8 (4.11 in 2019-20 and 2020-21). The highest plant height (62.31 cm in 2019-20 and 62.14 in 2020-21), fewer days to harvest (110.33 and 109.85) and maximum TSS (%)[^{0}Brix] (6.58-6.72) were found in treatment T_7 followed by treatment T_4, T_5 and T_6. On the other hand, least plant height (54.46 cm in 2019-20 and 55.12 cm in 2020-21), more days to harvest (117.24 to 118.85) and minimum TSS(%)[^{0}Brix] (5.53-5.56) was noted from control (T_8) followed by treatment T_1, T_2, and T_3. It was observed that when potato plants get treated with humic acid 3 times or at least 2 times up to 55 DAS showed significantly better results in terms of growth parameters than sole application within 30 DAS. This might be due to the application of humic acid-based bio-stimulant in combination with inorganic fertilizers which increased the nutrient-use efficiency through modification of soil physical condition and

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resulted in higher total uptake of nutrients because of better root penetration leading to better absorption of nutrients and moisture [7].

Table 2. Effect of humic acid based bio-stimulant (liquid formulation) 'Humetsu' on growth attributes of potato

Treatments	Plant emergence (%)		Plant height (cm)		Number of branches/plant		Days to physiological maturity		TSS (%)[^{0}Brix]	
	2019-20	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**
T_1	91.44	91.48	55.35	55.42	4.11	4.18	116.47	117.21	5.76	5.82
T_2	85.24	87.10	56.65	56.32	4.87	4.92	115.99	115.21	5.81	5.84
T_3	90.56	90.70	57.12	57.78	4.67	4.76	114.12	113.82	5.92	5.99
T_4	92.41	93.11	61.95	62.14	5.92	5.97	112.52	111.99	6.49	6.52
T_5	86.28	86.11	59.44	58.99	5.11	5.14	113.14	113.11	6.12	6.23
T_6	91.25	92.10	57.82	58.22	4.96	4.99	115.08	114.95	6.02	6.15
T_7	91.62	92.52	62.31	61.95	5.82	5.85	110.33	109.85	6.58	6.72
T_8	84.15	86.78	54.46	55.12	4.25	4.11	117.24	118.85	5.56	5.53
SEm(±)	1.58	1.73	1.137	1.142	0.24	0.27	1.417	1.531	0.12	0.15
LSD(5%)	4.11	4.25	3.449	3.464	0.74	0.82	4.298	4.644	0.37	0.45

3.2 Yield parameters

Application of humic acid-based bio-stimulant showed a significant positive effect on the number of tubers/plant, grade of tubers and yield of potato (Table 3). During the first year (2019-20) of investigation, the maximum number of tubers per plant (12.68) was observed under the treatment. Though, it was at par with the treatment T_4. The minimum number of tubers per plant (9.28) was counted under treatment T_8 (control). A recitation of the data indicates that a significant maximum number of tubers/plants (13.45) during 2020-21 was counted under the treatment T_7 followed by T_4, T_5 and T_3. The minimum number of tubers per plant was counted in the treatment control (8.99) which was at par with treatment T_1 and T_2. The total tuber yield as well as marketable yield and average processing grade tuber weight were significantly higher during 2020-21 than in 2019-20. Ranking of tubers in terms of grades revealed that the application of humic acid significantly influenced the number of different grades of potato tubers. The increasing levels of humic acid application (3 times in T_4 and T_7) in different stages of crop growth increased the quantity of the large size of tubers. On the other side application of 100% recommended doses of NPK fertilizers alone (T_8) recorded a higher percentage of small-size tubers (<30 g). Noticeable variation was observed among different treatments on total tuber yield and marketable tuber yield. During the first year (2019-20) of investigation, the highest total tuber yield (26.12 t/ha) and second year (2020-21) the highest total tuber yield (27.68 t/ha) was recorded under the treatment T_7 which is statistically

at par with treatment T_4 and T_5. While the lowest total tuber yield (21.26 and 20.95 t/ha) was observed under the treatment T_8 (Control) in both years. The same trend was also observed in the case of marketable tuber yield per ha. Treatment T_7 recorded the highest marketable tuber yield (24.74 t/ha in 2019-20 and 26.22 t/ha in 2020-21) followed by T_4 (24.12 t/ha& 25.56 t/ha), T_5 (23.32 t/ha& 23.51 t/ha) and T_6 (22.11 t/ha & 22.32 t/ha). On the other hand lowest marketable yield per ha was calculated in T_8 (18.99 t/ha in 2019-20 and 18.52 t/ha in 2020-21) which was at par with treatment T_1 and T_2. In the comparison of yield, it was revealed that treatments T_7 and T_4 resulted in 20-22% more yield than T_8 (100% RDF). Table 3 indicates that there is a declining trend of yield in the use of chemical fertilizers continuously. The possible reason for the declining productivity of 100 per cent inorganic treatment may be due to deterioration of soil health (organic carbon and available NPK) [8]. Therefore, on a long-term basis, the combination of humic acid-based bio-stimulant and inorganic fertilizers may be a wise option to sustain the tuber yields in present-day intensive agriculture [9].

Table 3. Effect of humic acid-based bio-stimulant (liquid formulation) 'Humetsu' on yield parameters of potato

Treatments	No. of tubers/plant		A' grade tuber (%)per plot [Diameter >5.0 cm and weight 60- 90 g & above]		B' grade bulb (%) per plot[Diameter 3.0 cm – 5.0 cm and weight 30-60 g]		C' grade bulb (%) per plot[Diameter <3.0 cm and weight < 30 g]		Total tuber yield (t/ha)		Marketable tuber yield (t/ha)	
	2019-20	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**
T_1	9.50	9.55	32.14	32.16	35.12	35.14	32.74	32.70	22.12	22.21	19.44	19.52
T_2	9.78	9.85	36.46	36.56	30.92	30.98	32.62	32.46	22.74	22.85	20.62	20.96
T_3	10.98	11.09	43.16	43.29	30.62	30.77	26.22	25.94	23.67	23.75	22.55	22.83
T_4	12.64	13.40	51.42	51.86	34.55	34.86	14.03	13.28	25.88	27.43	24.12	25.56
T_5	11.48	11.72	46.22	46.75	38.95	39.05	14.83	14.20	25.08	25.13	23.32	23.51
T_6	10.55	10.59	41.55	41.93	35.68	35.89	22.80	22.18	24.22	24.56	22.11	22.32
T_7	12.68	13.45	53.42	53.62	33.16	33.56	13.42	12.82	26.12	27.68	24.74	26.22
T_8	9.28	8.99	30.52	30.49	33.65	33.70	35.83	35.81	21.26	20.95	18.99	18.52
SEm(±)	0.32	0.34	1.91	1.96	0.76	0.83	1.712	1.815	0.81	0.91	1.03	1.13
LSD (5%)	0.96	1.04	5.80	5.95	2.32	2.52	5.193	5.505	2.47	2.76	3.13	3.43

3.3 Soil chemical properties

The nutrient status of nitrogen, phosphorus and potassium in soil were significantly influenced by the effect of humic acid and inorganic source of nutrients on potato (Table 4). The data on chemical properties of post-harvest soil of the experimental field revealed that there were increases in the soil chemical properties in post-harvest soil. The available N, P, K and OC were slightly increased from (360.52kg N; 23.42 kg P, 167.52kg K per ha and 0.52% OC in 2019-20) to (372.41 kg N; 25.04 kg P, 173.12 kg K per ha and 0.56% OC in 2020-21) in T_4 was superior among the treatments (T_7, T_5, T_6, T_3, T_2, T_1) and the control T_8 (351.42 kg N;

21.46 kg P, 160.32 kg K per ha and 0.47% OC in 2019-20 and 350.11 kg N; 21.47 kg P, 158.45 kg K per ha and 0.46% OC in 2020-21). The build-up of available nitrogen, phosphorus, potassium and oxidizable organic carbon in the soil could be due to the organic acids which were released by increased microbial population in soil by the application of humic acid bio-stimulant [10].

Treatments	Nutrient availability in soil after first year (2019-20) crop harvest				Nutrient availability in soil after second year (2020-21) crop harvest			
	N (kg/ha)	P (kg/ha)	K (kg/ha)	Organic Carbon (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Organic Carbon (%)
T_1	352.68	21.87	162.11	0.48	352.66	22.21	161.31	0.48
T_2	352.45	22.05	164.02	0.49	358.66	22.16	166.52	0.51
T_3	353.88	22.63	163.45	0.51	360.42	23.02	167.12	0.53
T_4	360.52	23.42	167.52	0.52	372.41	25.04	173.12	0.56
T_5	358.71	22.36	166.14	0.51	368.42	23.38	172.51	0.55
T_6	354.55	22.65	164.32	0.51	363.44	22.98	167.58	0.54
T_7	359.45	23.31	166.31	0.52	373.54	25.09	171.55	0.56
T_8	351.42	21.46	160.32	0.47	350.11	21.47	158.45	0.46
SEm(±)	1.89	0.19	1.46	0.02	1.92	0.20	1.58	0.021
LSD(5%)	5.74	NS	4.42	NS	5.83	0.65	4.79	0.06

Table 4. Effect of humic acid-based bio-stimulant (liquid formulation) 'Humetsu' on nutrient availability in soil after crop harvest of potato

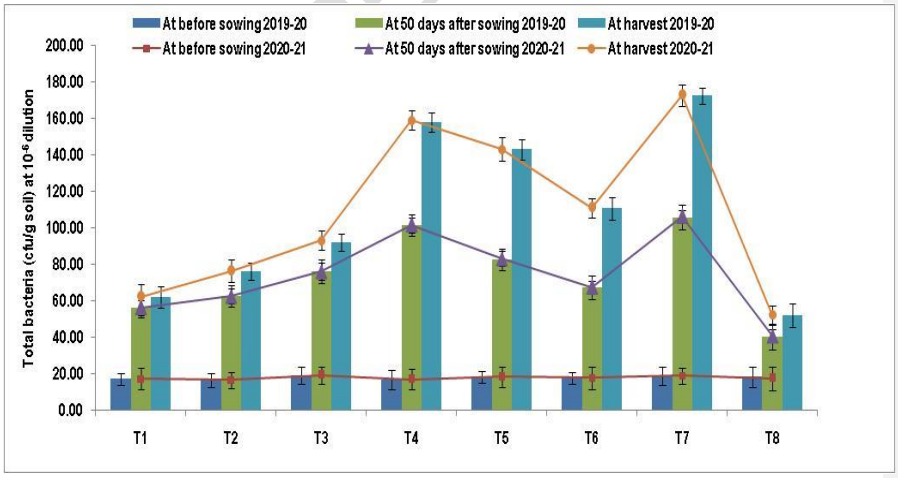

Fig. 1. Effect of humic acid based bio-stimulant (liquid formulation) 'Humetsu' on total bacteria population of soil at different DAS of potato

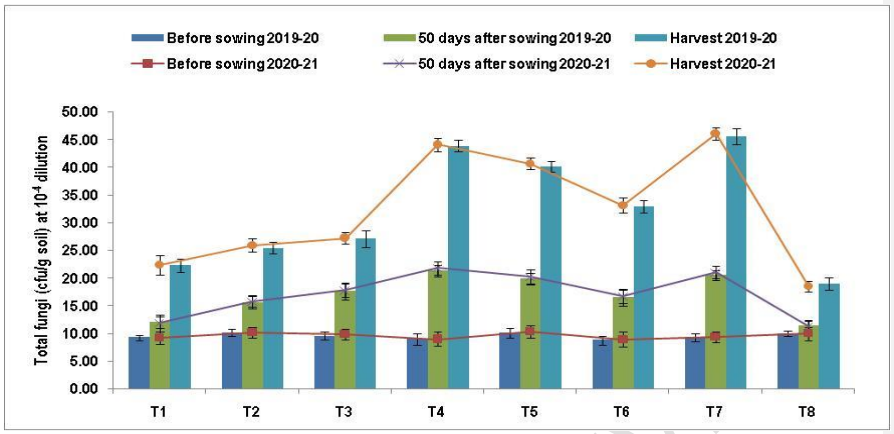

Fig. 2. Effect of humic acid based bio-stimulant (liquid formulation) 'Humetsu' on total fungi population of soil at different DAS of potato

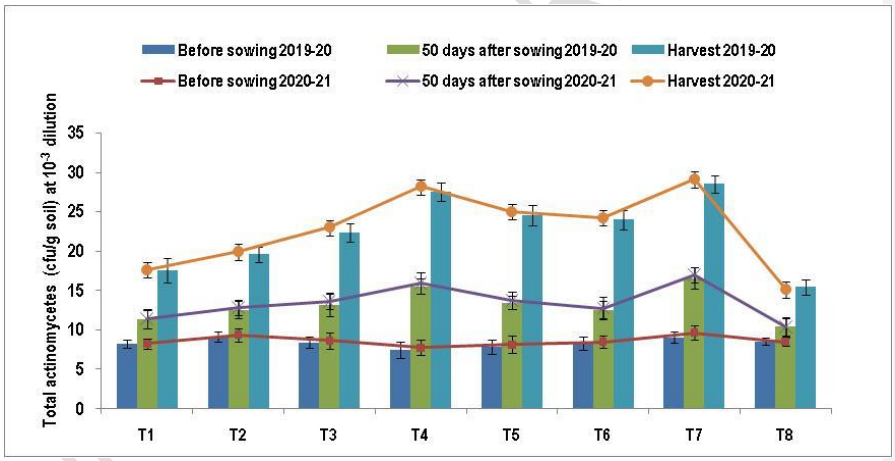

Fig. 3. Effect of humic acid-based bio-stimulant (liquid formulation) 'Humetsu' on total actinomycetes population of soil at different DAS of potato

3.4 Microbial population of soil

Profound dissimilarity in microbial population of soil was found among different treatments of humic acid-based bio-stimulant on potato in both consecutive two years of investigation. The bacterial population at 10^{-6} dilution varied significantly due to different treatments (Figure 1) The higher bacterial population of 105.67 and 172.32 *cfu*/gram soil in first year and 106.11 and 172.65 *cfu*/gram soil in second year were observed under T_7 at 50 DAS and harvesting respectively which was statistically at par with treatment T_4. From the Figure 1 it is clearly

observed that bacterial population increased rapidly in soil after the humic acid-based bio-stimulant application. While, minimum number of cell count was observed in T_8 with 100 % RDF (40.26 and 40.85 *cfu*/g soil in 2019-20 and 2020-21 at 50 DAS) and (52.16 and 52.24 *cfu*/g soil in 2019-20 and 2020-21 at harvesting) at 10^{-6} dilution. All other treatments showed significant variations in bacterial population within them by application of different combination of humic acid-based bio-stimulant. Withregard to total fungus population (Figure 2) in soil at 10^{-4} dilution, the higher fungi biomass of 45.62 (2019-20) and 46.10 (2020-21) *cfu* per gram of soil was noticed in treatment T_7 followed by T_4 and T_5 at harvesting. Whereas it was 9.26 (2019-20) and 9.41 (2020-21) *cfu* per gram of soil in T_7 before the sowing of tubers. On the other hand, treatment T_8 (100% RDF) recorded least number of fungal colonies (18.95 in 2019-20 and 18.54 in 2020-21 *cfu*/g soil at harvesting) at 10^{-4} dilution followed by treatment T_1 and T_2 where humic acid-based bio-stimulant was applied only once. Similarly, the higher actinomycetes biomass (Figure 3) of 28.48 and 29.08 *cfu* per gram of soil at 2019-20 and 2020-21 at 10^{-3} dilution respectively was reported with the application of 80% NPK + 3 application of 'Humetsu' (Seed treatment @ 5ml/kg of tuber and 2 foliar spray @ 2.5ml l^{-1} water at 30 DAS& 55 DAS) (T_7) at harvesting. However, the treatment T_8 (100 % RDF) recorded lowest number of colonies of 15.44 in 2019-20 and 15.12 in 2020-21 *cfu*/gram of soil at 10^{-3} dilution respectively. It is clearly observed from Figure 3 that there are near about 215% and 268% increment of actinomycetes biomass from sowing of tuber to harvesting in treatment T_7 and T_4 where humic acid-based bio-stimulant was applied thrice in different stages of crop. The increase in bacterial, fungus and actinomycetes biomass under these treatments might be due to increased microbial activity and multiplication by application of humic acid [11] based bio-stimulant 'Humetsu'.

4. CONCLUSION

Application of 80% NPK + 3 application of 'Humetsu' (Seed treatment @ 5ml/kg of tuber and 2 foliar sprays @ 2.5ml l^{-1} water at 30 DAS& 55 DAS) (T_7) has a significant impact in yield of potato with 20% reduction of the recommended dose of NPK fertilizers. Application of humic acid increases bacterial, fungus and actinomycetes biomass in the soil it might be due to increased microbial activity and multiplication.

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