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Evaluating Growth and Yield of Potato by Intercropping and Humic Acid Application

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ABSTRACT: The field experiment was conducted at Student's Research Farm, Khalsa College, Amritsar, Punjab, during *Rabi* season of 2022-23 to investigate the effect of intercropping and humic acid application on the productivity of potato. The experiment was laid out as a split plot design (SPD) with replicated three times *viz.* Four intercropping treatments (sole potato, potato + coriander, potato + lettuce, potato + methi) and six fertility treatments (HA_0 (Control), HA_1(Soil application of HA @7.5kg/ha), HA_2(Foliar application of HA @7.5kg/ha in three splits at 25, 40 and 55 DAP), HA_3 (Soil application of HA @15kg/ha), HA_4 (Foliar application of HA @15kg/ha in three splits at 25, 40 and 55 DAP), HA_5 (Soil application of HA @7.5kg/ha + Foliar application of HA @7.5kg/ha in three splits at 25, 40 and 55 DAP) were tried. All the intercropping treatment doesn't show any significant effect on the growth parameter of the potato. The fertility treatments significantly affect growth parameters except days taken to plant emergence, emergence percentage and days taken to tuber initiation. The data revealed that the maximum growth parameters *viz.*, plant height, stems/hill, leaf area index and total tuber yield were obtained in treatment HA_3 (Soil application of HA @15kg/ha).

Keywords: Growth, Humic Acid, Intercropping, Potato, Yield.

INTRODUCTION

Potato (*Solanum tuberosum* L.*)* is a popular stable food crop belonging to *Solanaceae* family. Leucine, tryptophan, and isoleucine are the necessary amino acids found in potato, along with 20.6% carbohydrates, 2.1% protein, 0.3% fat, 1.1% crude protein, and 0.9% ash (Singh *et al*., 2008). After rice, wheat, and maize, potato is produced and consumed in fourth place. India comes in second to China in terms of potato output. With an average yield of around 24.3 tonnes per hectare and a production area of about 2.2 million hectares, India produces about 53.6 million metric tonnes (Anonymous, 2022). An estimated area about 107 thousand hectares in Punjab are planted with potato, producing 2948.5 thousand tonnes with an average yield of 275.3 quantal per hectare (Anonymous, 2020-21).

In India, the weather does not always stay the same all year round. The frost conditions have a significant impact on the potato production. Crop failure is quite likely when there is frost or freezing temperatures. The most impressive way for reducing the danger of crop failure is intercropping of processed potato with other compatible crops like coriander, lettuce, and methi, which offers additional benefits. Because there is an increased supply of these green vegetables in the market raises farmer income, boosts per capita availability and acts as a bio fence.

Generally, in order to boost production, farmers often apply a very high rate of fertilizers to the processed potato crop. However, it is seriously harmful to human health, pollutes the environment, and its aftereffects on the soil reduce soil fertility. Therefore, it is crucial to adopt more environmentally friendly and financially viable alternative materials that limit fertilizer waste and maximize its utilization. Humic acid application may be used to attain this goal. Humic acid is an organically charged biostimulant that has a considerable impact on plant growth and development. Humic acid effects including enhancing soil's physical and chemical qualities and promoting plant development are mostly caused by the -COOH and -OH functional groups (Nardi *et al.*, 2021). This reduces the need for excessive fertilizers.

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

MATERIAL AND METHODS

A field experiment was carried out during *Rabi* season of 2022-2023 at the Students' Research Farm, P.G. Department of Agriculture, Khalsa College, Amritsar, Punjab, India. Geographically, the experimental site falls under a semi-arid, tropical climate and is located at 31°-63′ North latitude and 74°-86′ East longitudes on an elevation of about 229 meters above sea level. The soil of the experimental field was sandy loam in texture with normal pH (7.9) and EC (0.36 dsm^{-1}), lower in available nitrogen (169.6 kg/ha) and organic carbon (0.4%) and medium in available phosphorus (24.4 kg/ha) and available potassium (253.4 kg/ha). The experiment was laid out in Split Plot Design. The experiment included twenty-four treatments *viz.*, four intercropping treatments (sole potato, potato+coriander, potato+lettuce, potato+methi) as the main plot and six fertility treatments (HA_0 (Control), HA_1(Soil application of HA @7.5kg/ha), HA_2 (Foliar application of HA @7.5kg/ha in three splits at 25, 40 and 55 DAP), HA_3(Soil application of HA @15kg/ha), HA_4 (Foliar application of HA @15kg/ha in three splits at 25,40 and 55 DAP), HA_5 (Soil application of HA @7.5kg/ha+Foliar application of HA @7.5kg/ha in three splits at 25, 40 and 55 DAP) as the subplot. The recommended dose of NPK was 187.5: 62.5: 62.5 kg/ha. Full dose phosphorous, 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 (25DAP). Humic acid was applied @ 7.5 kg/ha and 15 kg/ha to the soil during seedbed preparation by mixing with the soil according to treatment. Foliar application of humic acid was applied @7.5 kg/ha and 15 kg/ha in three splits at 25, 40, 55 DAP (days after planting). Sowing of seed tubers (*cv.* Atlantic) was done with ridges at the spacing of 60 cm × 20 cm in each plot (6.0 m × 2.6 m). First post sowing irrigation was given immediately after sowing and next irrigation after a week. All the growth parameters were observed from the five randomly selected tagged plants from each plot. Observations on the number of stems per hill, plant height and leaf area index were recorded at 30 and 60 days after planting (DAP) from the five tagged plants and mean values were calculated. Tubers were harvested at 2nd week of February and observation on total tuber yield was done at harvest and converted into quintals per hectare.

A. RESULT AND DISCUSSION

Days taken to plant emergence. Among the intercropping treatments, the minimum number of days taken for plant emergence was recorded under sole potato (13.0) as compared to the potato+methi (13.2). Similarly, Rashid *et al.* (2019) also found that there was no significant effect of intercropping on days taken to plant emergence. Among the fertility management, the minimum number of days taken for plant emergence was recorded in treatment HA_3 (12.7) than all other treatments. However, the variation between these treatments was found to be non-significant.

Emergence percentage (%). Among the different intercropping, the maximum tuber emergence percentage was recorded under potato+lettuce (96.5) and the least in potato + coriander (95.8). These treatments were not significantly different because intercropping was done 25 days after potato planting when tuber emergence was already completed. Chapagain *et al.* (2012) also observed similar results. The application of humic acid resulted in maximum tuber emergence with treatment HA_3(96.4) as compared to the other treatments. However, all the treatments were found to be non-significantly variable in nature. This was mainly due to the fact that all the potato tubers have enough food to nourish young sprouts for emergence.

Days taken to tuber initiation. All the intercropping treatments were found to be non-significant. Minimum days taken for tuber initiation were observed in sole potato (26.7) followed by potato+methi (26.8), potato+lettuce (27.0) and potato+coriander (27.0). The minimum day taken for tuber initiation with humic acid application was observed in HA_5 (26.6) as compared to control (27.2). However, all the treatments were found statistically non-significant.

Plant height. Among the intercropping, slightly taller potato plants were recorded under potato+methi followed by sole potato, potato+lettuce and potato+coriander at 30 days after planting. A similar trend was followed at 60 days after the planting. All intercropping treatments were determined to be non-significant because all intercrops were sown after the earthing up of potato, therefore late emergence and slow canopy development of intercrops seem to be less competitive with potato crop. Similarly, Tchapga *et al.* (2022) found that intercropping had no significant difference in plant height.

The effect of humic acid was found to be significant for plant height. At 30 days, maximum plant height was observed in HA_3(26.1) and least in HA_0 (20.4cm). However, treatment $HA_3$and HA_5 were at par with each other. At 60 days after planting, when compared to the earlier growth period, the effects of various treatments on plant height were much more pronounced. The maximum plant height was observed in HA_3 (44.2) as compared to HA_0 (32.3cm). However, the treatment HA_3 with HA_4 and HA_4 with HA_5 were at par with each other. Humic acid application affects cell division and cell elongation as well as physiological function of the cell which consequently affects plant growth. Similarly, Arafa and El- Howeity (2017) also reported maximum plant height with the application of humic acid.

Number of stems per hill. Intercropping did not have any competitive effect on the number of stems per hill. The maximum number of stems per hill was recorded under potato+methi followed by sole potato, potato+lettuce and potato+coriander at 30 days after planting. A similar trend was observed at 60 days after planting. The variation between these intercropping treatments was found to be non-significant due to the

low canopy of all the intercrops during the grand growth period of the potato. Similarly, Singh *et al.* (2015) also found that the effect of intercropping was not significant on the number of stems per hill.

Among all humic acid treatments, the maximum number of stems per hill at 30 days was observed in HA_3 (3.28) and least in HA_0 (2.30). However, treatment HA_3 being at par with HA_1 and HA_5 showed significantly superior results than HA_4, HA_2 and HA_0. At 60 days the maximum and significantly greater number of stems per hill was observed in HA_3 (4.10) as compared to HA_0 (2.80). However, treatments HA_2, HA_3, HA_4 and HA_5 were at par with each other. This might be due to the effect of humic acid which increases the availability of micro and macronutrients that involve in plant bioactivities and leads to growth induction (Abdel-Mawgood *et al.,* 2007). Similarly, Rizk *et al.* (2013) also reported the highest number of stems per hill with the application of humic acid.

Leaf area index (LAI). The maximum leaf area index with the intercropping treatments was recorded under potato+methi and least in potato+coriander at 30 days after the planting. A similar trend was observed at 60 days after planting. However, the variation between these intercropping treatments was found to be non-significant because intercropping impacts were absent at the initial stage of the potato growth period. Similarly, Rezig *et al.* (2013) reported that there was no significant effect of intercropping on the leaf area index of potato.

Higher leaf area index at 30 days with the application of humic acid was recorded in HA_3(1.40) and least in HA_0 (0.70). However, treatment HA_3 being at par with HA_1 and HA_5 showed significantly better results than HA_2, HA_4 and HA_0. At 60 days after the planting, a significant maximum leaf area index was observed in HA_3 (2.65) than HA_0 (1.73). However, treatments HA_2, HA_3, HA_4 and HA_5 were statistically at par with each other. This could be attributed to the increased vegetative growth of plants which leads to more synthesis and translocation of photosynthates for tuber formation. Similarly. Hassan *et al.* (2022) found that the application of humic acid resulted in a maximum leaf area index.

Total Tuber Yield(q/ha). Among the intercropping treatments, the maximum total tuber yield was recorded under potato+methi followed by sole potato, potato+lettuce and potato+coriander. However, variation between these intercropping treatments was found to be non-significant (Table 2). All the intercrops seem to be non-competitive during the grand growing period of potato. All the intercrops produced low foliage initially owing to late emergence and slow growth under very low temperature conditions (first week of January). Similarly, Tchapga *et al* (2022) reported that tuber yield was non significantly affected by intercropping treatment.

The humic acid influenced the total tuber yield of potato significantly as compared with control. Maximum total tuber yield was recorded with HA_3 (205.2) followed by HA_4 (202.8), HA_5 (196.2), HA_2 (193), HA_1 (173.5) and HA_0(154.8q/ha). However, treatment HA_3 was at par with HA_2, HA_4 and HA_5. Percent increase in total potato tuber yield with HA_3 was 31.7, 18.2, 6.3, 1.2, 4.6% than HA_0, HA_1, HA_2, HA_4, and HA_5, respectively. Improvement in total tuber yield might be due to the positive effect of humic acid on the physical and chemical properties of soil and plant growth. Similarly, El-Damarawy *et al.* (2022) also reported an increase in total tuber yield with the humic acid application over control.

Table 1: Effect of intercropping and humic acid on time taken to emergence and tuber initiation.

Treatments	Symbols	Days taken to 100 percent tuber emergence	Tuber emergence percentage (%)	Days taken to tuber initiation
Intercropping				
Sole potato	IC_0	13.0	96.0	26.7
Potato+coriander	IC_1	13.2	95.8	27.0
Potato+lettuce	IC2	13.1	96.5	27.0
Potato+methi	IC3	13.2	95.9	26.8
CD (0.05)		NS	NS	NS
Fertility management				
Control	HA_0	13.3	95.9	27.2
Soil application of HA @7.5kg/ha	HA_1	13.0	96.3	26.8
Foliar application of HA @7.5kg/ha in 3 splits at 25,40 and 55 DAP	HA_2	13.4	95.8	27.0
Soil application of HA @15kg/ha	HA_3	12.7	96.4	26.6
Foliar application of HA @15kg/ha in 3 splits at 25,40 and 55 DAP	HA_4	13.3	95.8	27.0
Soil application of HA @7.5kg/ha+Foliar application of HA @7.5kg/ha in 3 splits at 25,40 and 55 DAP	HA_5	13.1	96.2	26.6
CD (0.05)		NS	NS	NS

Table 2: Effect of intercropping and humic acid on plant height, number of stems per hill, leaf area index and total tuber yield.

Treatments	Symbols	Plant height(cm)		Number of stems per hill		Leaf area index		Total tuber yield (q/ha)
		30DAP	60DAP	30DAP	60DAP	30DAP	60DAP	
Intercropping								
Sole potato	IC_0	23.63	41.24	2.92	3.67	1.15	2.39	188.62
Potato+coriander	IC_1	23.46	41.21	2.77	3.58	1.08	2.31	184.16
Potato+lettuce	IC2	23.56	41.23	2.78	3.65	1.14	2.34	188.37
Potato+methi	IC3	23.68	41.50	2.96	3.73	1.24	2.42	189.36
CD (0.05)		NS	NS	NS	NS	NS	NS	NS
Fertility management								
Control	HA_0	20.42	32.37	2.30	2.80	0.70	1.73	154.88
Soil application of HA @7.5kg/ha	HA_1	23.93	41.15	2.99	3.47	1.26	2.21	173.56
Foliar application of HA @7.5kg/ha in 3 splits at 25,40 and 55 DAP	HA_2	22.48	42.87	2.64	3.84	0.97	2.47	193.0
Soil application of HA @15kg/ha	HA_3	26.05	44.21	3.28	4.10	1.40	2.65	205.25
Foliar application of HA @15kg/ha in 3 splits at 25,40 and 55 DAP	HA_4	23.38	43.86	2.88	3.90	1.18	2.62	202.84
Soil application of HA @7.5kg/ha+Foliar application of HA @7.5kg/ha in 3 splits at 25,40 and 55 DAP	HA_5	25.21	43.36	3.03	3.85	1.35	2.50	196.2
CD (0.05)		0.91	0.54	0.31	0.28	0.21	0.18	17.31

CONCLUSIONS

The study revealed that all three intercrops did not affect the growth parameters of potato negatively. The application of humic acid (soil application of HA @15kg/ha) to soil was more effective than foliar application as well as soil plus foliar application. Humic acid application to soil at the rate of 15 kg/ha improves the growth and yield of potato.

FUTURE SCOPE

Humic acid may significantly boost the potato's growth and yield. Additional research on humic acid at different sites is required and cannot be advised on the basis of a one-year experiment in order to completely understand it and develop management approaches to improve the growth and production of potatoes.

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Conflict of Interest. None.

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