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Assessment of potato (*Solanum tuberosum* L.) – onion (*Allium cepa* L.) cropping sequence under lower Gangetic plains of West Bengal

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ABSTRACT

Field experiments were conducted during 2017-18 and 2018-19 at Bardhaman, West Bengal India to assess the feasibility of potato (Solanum tuberosum L.) –onion (Allium cepa L.*) cropping sequence under lower Gangetic plains of West Bengal. The experiment was laid out in a split plot design with six treatment combinations viz. 3 dates of sowing (D1-10 days before optimum i.e.,15th Nov; D2-optimum, i.e.,25th Nov. and D3-10 days after optimum, i.e.,5th Dec.) in main plots and two dates of harvesting (H1-80 and H2-90 days after planting), each replicated four times; immediately after harvesting of potato crop onion seedlings were transplanted. It was revealed that the potato variety Kufri Jyoti planted at optimum date (25th November) recorded the highest tuber yield (28.15 t ha^{-1}). The results also revealed that dates of planting in potato, dates of harvesting in potato and interaction of these two factors significantly influenced the yield of onion bulbs grown as a subsequent crop in the rotation. Highest onion bulb yield (24.88 t ha^{-1}) of variety N53 were recorded with planting of potato 10 days after optimum (5th December) and harvesting it at 90 days after planting (DAP). The highest system productivity (57.73 t ha^{-1}) in potato - transplanted onion sequence and system net return (Rs. 371047.50) were recorded with the treatment planting potato 10 days after optimum date (5th December) and harvesting it at 90 DAP.*

Keywords: Cropping sequence, economics, potato, pre kharif onion, yield

West Bengal is the second largest potato growing state in India with a production of 10.1 million tonnes from an area of 4.4 lakh hectares, with productivity of 22.72 t ha^{-1} (Anon., 2018). The state accounts for one-third of the country's total potato production. Potato is the most popular crop in West Bengal next to the cereals. Whereas, India ranks next to China, accounting for 26.8 per cent of world area and 19.9 per cent of onion production. Onion is one of the most important commercial vegetable cum spice crop grown in India. In West Bengal onion is cultivated in an area of 21.68 thousand hectares producing 465.45 thousand metric tonnes of bulbs (Anon., 2018). Onion is a major bulbous vegetable crop with high domestic and export demand, has become an important crop of West Bengal. In West Bengal Onion is traditionally cultivated during *rabi* (winter) season and to some extent during *kharif* (Rainy season) season now-a-days. Onion is a photo-thermo sensitive crop and hence time of planting varies from region to region. In West Bengal and Odisha transplanting of *kharif* onion is done during August to September. Optimum transplanting dates have vital role in maximizing growth, bulb yield and quality of onion (Sharief *et al*., 2013). The farmers of West Bengal are not familiar with pre *kharif* season onion still now. It was a new initiative to introduce onion just after harvesting potato. If the farmers can cultivate onion during *pre kharif* season (March to June) just after harvesting potato with appropriate varieties they can fetch a good return out of it because at the time of harvesting of this off season onion the selling price remains higher than the traditional rabi onion in the market. A good harvest in pre *kharif* season can reduce the gap between demand and supply of onion during the dearth period. Keeping the above facts in view this experiment was initiated with the objective to introduce onion during pre *kharif* season (as a off season crop) just after harvesting potato to assess the suitability, feasibility and profitability of potato (*Solanum tuberosum* L.) – pre *kharif* onion (*Allium cepa* L.) cropping sequence under lower Gangetic plains of West Bengal.

MATERIALS AND METHODS

Field experiments were conducted during 2017-18 and 2018-19 at Siptai, Jamalpur, Bardhaman, West Bengal under AICRP on Potato, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal, India to assess the feasibility of potato (*Solanum tuberosum* L.) – pre *kharif* onion (*Allium cepa* L.) cropping sequence under lower Gangetic plains of West Bengal. The experiment was laid out in a split plot design with six treatment combinations *viz*. 3 dates of sowing (D1-10 days before optimum i.e.,15th Nov; D2-optimum, *i.e*.,25th Nov. and D3-10 days after optimum, *i.e*.,5th Dec.) in main plots and two dates of harvesting (H1-80 and H2-90 days after planting) in sub plots, each replicated four times; with a plot size of 5 x 3m in case of potato and immediately after harvesting of potato crop onion seedlings were transplanted. The soil of the experimental

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Table 1: Effect of treatments on grade wise and total tuber yield (t ha^{-1}) of potato (pooled)

Treatment	Grade-wise tuber yield (t ha^{-1})				Total
	0-25g	25-50g	50-75g	>75g	
Dates of Planting					
D1	0.67	2.32	4.06	15.81	22.82
D2	0.63	3.48	4.68	19.37	28.15
D3	0.64	3.11	4.37	18.42	26.52
SEm (±)	**0.03**	**0.17**	**0.18**	**0.24**	**0.36**
LSD (0.05)	**NS**	**0.51**	**NS**	**0.72**	**1.08**
Dates of Harvesting					
H1	0.65	2.84	3.98	16.89	24.56
H2	0.63	2.65	4.75	18.84	27.09
SEm (±)	**0.02**	**0.15**	**0.15**	**0.19**	**0.28**
LSD (0.05)	**NS**	**NS**	**0.45**	**0.57**	**0.84**

field was sandy clay loam in texture and slightly alkaline in reaction (pH 7.6) having an organic carbon content of 0.57%, 196.25 kg available N ha^{-1}, 19.8 kg available P_2O_5 ha^{-1} and 141 kg available K_2O ha^{-1}. Potato variety Kufri Jyoti was used in the experiment. Tubers weighing 30-40 g each were planted in the furrows with 3-4 cm depth of planting and a spacing of 60 x 20 cm and finally covered with soil. The recommended dose of fertilizer was 200, 150, 150 kg N, P_2O_5, K_2O ha^{-1} which were applied through urea, single super phosphate and muriate of potash, respectively. Half of nitrogen, full dose of phosphorus and potassium were applied as basal. Rest half N was top dressed at 30 days after planting (DAP) followed by earthing up. Pre-emergence application of Sencor (Metribuzin) @ 0.75 kg a.i. ha^{-1} was done at 3 DAP followed by 1 hand-weeding at 20 DAP to promote early crop growth. As a prophylactic measure, spraying (twice) with Dithane M-45 (Mancozeb 80% WP) @ 0.2% at 40 and 60 DAP was done against late blight. Imidacloprid 17.8 SL @0.03% was also sprayed (thrice) at 30, 40 and 60 DAP for controlling aphids and other sucking insects. Dehaulming was done 10 days before harvesting and harvesting was done as per treatment details. Potato tubers were dug out from each plot manually. Onion seedlings of Variety N 53 was raised for 51 days in a nursery bed and transplanted immediately after harvesting potato with a spacing of 15 x 10 cm. The dose of fertilizer applied to onion was 120, 60, 60 kg N, P_2O_5, K_2O ha^{-1} which were applied through urea, single super phosphate and muriate of potash, respectively. Half of nitrogen, full dose of phosphorus and potassium were applied as basal. Rest half N was top dressed at 30 days after transplanting. Data on grade wise tuber yield and total tuber yield of potato and onion bulb yield were recorded at harvest from each net plot area of 9 m^2. The system productivity was calculated by converting onion bulb yield to potato equivalent yield and by adding it with potato yield for each treatment by using the formula of crop equivalent yield (CEY). CEY= $C_y + C_{1y} X P_{c1}/P_c$, where, C_y is yield of first crop and C_{1y} is yield of second crop and P_c and P_{c1} are their respective prices. The economic parameters (cost of cultivation, gross return and net returns) were worked on the basis of prevailing market prices of inputs and outputs. Analysis of variance of the data in the experimental design and comparison of means at $p \leq 0.05$ were carried out, using MSTAT-C software.

RESULTS AND DISCUSSION

Effect on grade wise and total tuber yield of potato

The results of the experiment revealed that dates of planting and harvesting had a significant influence upon the yield of potato tubers. Planting at optimum date (25th November) recorded significantly higher grade wise tuber yield and total tuber yield (28.15 t ha^{-1}) of potato variety Kufri Jyoti under West Bengal situation (Table 1) during both the years of study followed by planting at 10 days after optimum (5th December). This finding was corroborated with the findings of Konar *et al.* (2001), Paul and Konar (2003) and Kahar *et al.* (2016). Harvesting at 90 DAP was found to record significantly higher total tuber yield (27.09 t ha^{-1}) over harvesting at 80 DAP might be due to accumulation of higher photosynthates. Among the interaction effects planting of Kufri Jyoti at optimum date and harvesting at 90 days after planting (DAP) recorded highest total tuber yield (29.21 t ha^{-1}). It was also revealed that harvesting at 90 days significantly increased the 50-75g grade and > 75 g grade tuber yields over harvesting at 80 days but dates of harvesting had no significant effect on production of small sized tubers. In West Bengal planting potato variety Kufri Jyoti at optimum date (25th November) recorded highest tuber yield still now under changing climatic situation.

Effect on onion growth parameters

Results revealed that plant height and number of leaves per plant of onion were not significantly

Table 2: Effect of treatments on growth parameters and yield of onion (pooled)

Treatment	Plant Height (cm)			No. of leaves plant^{-1}			Neck thickness (cm)			Bulb diameter (cm)			Weight of bulb (g)			Bulb yield (t ha^{-1})		
	H1	H2	Means	H1	H2	Means	H1	H2	Means	H1	H2	Means	H1	H2	Means	H1	H2	Means
D1	38.2	38.4	38.3	6.40	6.30	6.35	1.10	1.12	1.11	3.15	3.85	3.50	44.3	50.2	47.3	16.30	18.35	17.33
D2	38.5	39.3	38.9	6.30	6.40	6.35	1.12	1.22	1.17	3.99	4.56	4.28	51.9	56.1	54.0	19.13	21.09	20.11
D3	38.8	39.5		6.30	6.50		1.21	1.30		4.62	4.98		58.6	61.4		23.04	24.88	
Means	38.5	39.1	39.2	6.33	6.40	6.40	1.14	1.21	1.26	3.92	4.46	4.80	51.6	55.9	60.0	19.49	21.44	23.96
LSD D (0.05)		**NS**	**0.15**	**0.35**											**4.90**			**1.35**
LSD H (0.05)		**NS**	**0.10**	**0.28**											**3.15**			**0.93**
LSD DXH (0.05)		**NS**	**0.12**	**0.30**											**4.20**			**1.92**

influenced by the dates of planting and harvesting in potato and their interactions but the treatments significantly influenced the onion neck thickness, bulb diameter and weight of bulb (Table 2). Highest neck thickness (1.26 cm), bulb diameter (4.80 cm) and weight of bulb (60 g) were recorded when potato was planted at 10 days after optimum date (5th December). It was also evident from the table that highest onion neck thickness (1.21 cm), bulb diameter (4.46 cm) and weight of bulb (55.9 g) were recorded when potato was harvested at 90 days. Among the interaction effects highest onion neck thickness (1.30 cm), bulb diameter (4.98 cm) and weight of bulb (61.4 g) were recorded when potato was planted at 10 days after optimum (5th December) and harvested at 90 DAP and onion was transplanted immediately after harvesting potato as in this situation onion bulb development took place at a favorable climatic situation though the variety N-53 has got some heat tolerance character compared to traditional *rabi* season onion varieties but it could resist heat up to certain extent. Das *et al.* (2015) and Sharma and Jarial (2017) reported that the onion variety N53 performed well over different planting dates during *kharif* season in West Bengal. Still now there is no such data available regarding performance of pre kharif onion under lower Gangatic plains of West Bengal.

Effect on onion bulb yield

The results revealed that dates of planting in potato, dates of harvesting in potato and interaction of these two factors significantly influenced the yield of onion bulbs (Variety- N 53) grown during pre *kharif* season (Table 2) under West Bengal situation. Planting of potato 10 days after optimum date (5th December) recorded highest bulb yield (23.96 t ha^{-1}) in succeeding crop pre *kharif* onion might be due to higher net photosynthate accumulation in onion and higher bulb weight at lower maximum temperature, lower soil temperature and lesser respiration rate during bulb development stage of onion which took place during the first week of June. Harvesting of potato at 90 DAP recorded significantly higher onion bulb yield (21.44 t ha^{-1}) over harvesting potato at 80 DAP which might be due to similar reason. Among the interaction effects highest onion bulb yield (24.88 t ha^{-1}) of variety N 53 was recorded with planting of potato 10 days after optimum (5th December) and harvesting it at 90 DAP in both the years and immediately after harvesting of potato crop onion seedlings were transplanted. The reason behind this higher onion bulb yield might be due to higher net photosynthate accumulation in onion bulbs at lower maximum ambient temperature, lower soil temperature with a lesser respiration rate of onion plant during bulb development stage of onion which resulted in higher bulking and bulb weight, as in this case onion bulb development took place during first week of June but when potato was planted

Table 3: Production economics of the system

Treatments	System productivity (t ha^{-1})	Cost of cultivation (Rs.ha^{-1})	Gross Return (Rs.ha^{-1})	Net returns (Rs.ha^{-1})	B:C ratio
D_1H_1	40.83	148574	367470	218896	2.48
D_1H_2	47.16	148574	424440	275866	2.86
D_2H_1	50.46	148574	454095	305521	3.06
D_2H_2	54.98	148574	494820	346246	3.33
D_3H_1	53.86	148574	484740	336166	3.27
D_3H_2	57.73	148574	519570	370996	3.50

earlier and harvested at 80 DAP the onion bulb development coincided with scorching heat of the sun and higher maximum ambient temperature during the months of April-May with a higher respiration rate and lesser net accumulation of photosynthates in onion bulb which produced lower individual bulb weight though the variety N-53 has got some heat tolerance character but it could resist heat to a certain extent.

Effect on system productivity

The highest system productivity (57.73 t ha^{-1}) in Potato - Transplanted Onion sequence was recorded (Table 3) with the treatment planting potato 10 days after optimum date (5th December) and harvesting it at 90 DAP in both the years and immediately after harvesting of potato crop onion seedlings of variety N53 were transplanted. The lowest system productivity (40.83 t ha^{-1}) in Potato - Transplanted Onion sequence was recorded with the treatment planting potato 10 days before optimum date (15th November) and harvesting it at 80 DAP.

Economics

The highest system net return (Rs. 370996) and B:C ratio (3.50) in Potato - Transplanted Onion sequence was recorded (Table 3) with the treatment planting potato 10 days after optimum date (5th December) and harvesting it at 90 DAP and immediately after harvesting of potato crop onion seedlings of variety N53 were transplanted. The lowest system net return (Rs. 218896) and B:C ratio (2.48) in Potato - Transplanted Onion sequence was recorded with the treatment planting potato 10 days before optimum date (15th November) and harvesting it at 80 DAP and immediately after harvesting of potato crop onion seedlings were transplanted.

Thus, based on two years data it can be concluded that, for getting highest potato yield, planting at optimum date (25th November) was found best still now under changing climatic situation. For getting highest yield of pre *kharif* onion planting of potato 10 days after optimum date (5th December) and harvesting it at 90 days followed by onion seedling transplanting was found best. For getting highest system productivity (Potato - Transplanted *pre kharif* Onion sequence) and economics planting of potato 10 days after optimum date (5th December) and harvesting it at 90 days and immediate transplanting of onion seedlings thereafter found best.

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