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Research Paper

Efficiency of different incubating material for phosphate rich organic manure in wheat (*Triticum aestivum*)

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ABSTRACT

A field experiment was conducted at Centre for Research on Integrated Farming Systems, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during 2018–19 to 2020–21 to study the efficiency of different incubating material for phosphate rich organic manure (PROM) in wheat. A total of fourteen treatments such as T_1 : Control, T_2 : DAP @ 60 kg P_2O_5/ha, T_3 : Rock phosphate @ 40 kg P_2O_5/ha incubated with vermicompost, T_4 : Rock phosphate @ 60 kg P_2O_5/ha incubated with vermicompost, T_5 : Rock phosphate @ 40 kg P_2O_5/ha incubated with FYM, T_6 : Rock phosphate @ 60 kg P_2O_5/ha incubated with FYM, T_7 : Rock phosphate @ 40 kg P_2O_5/ha incubated with compost, T_8 : Rock phosphate @ 60 kg P_2O_5/ha incubated with compost, T_9 : Rock phosphate @ 40 kg P_2O_5/ha incubated with vegetable waste, T_{10} : Rock phosphate @ 60 kg P_2O_5/ha incubated with vegetable waste, T_{11} : Rock phosphate @ 40 kg P_2O_5/ha incubated with green algae, T_{12} : Rock phosphate @ 60 kg P_2O_5/ha incubated with green algae, T_{13} : Rock phosphate @ 40 kg P_2O_5/ha incubated with cow urine and T_{14} : Rock phosphate @ 60 kg P_2O_5/ha incubated with cow urine were evaluated based on growth parameters, yield attributes and yield. The pooled result of three years experiment indicated that phosphorus source of DAP in wheat (60 kg P_2O_5/ha) can be replaced with Udaipur rock phosphate (31% P_2O_5) @ 198 kg/ha incubated for 30 days with FYM or vermicompost or compost or vegetable waste (each of 593 kg) or cow urine (593 L) in the ratio of 1:3 ratio as basal for obtaining higher yield and net returns.

Key words: Cow urine, Farm Yard Manure, Green algae and Vermicompost

Wheat is the second most important crop in India and a principal source of calorie intake. It has been under cultivation in the Indian subcontinent from pre-historic times and is an integral part of the country's economy and food security. Systematic research in the crop has started in India way back in 1960s through the coordinated system of multi-location research to cater the needs of diverse population. The country achieved rapid strides in wheat production during the last four decades resulting in self-sufficiency and surplus production. This has enabled the country to meet domestic demand from its own production and reduce dependence on wheat imports. In 1978, for the first time in the post-independence period, India emerged as a net exporter of wheat (Chand, 2001). However, feeding burgeoning population through the next 25 years remains an uphill task. Increasing domestic and international demand owing to population growth should meet the future challenges of food and nutritional security. The country will have to feed about 1.30 billion people by 2020 requiring 5-6 million tons of additional food grains every year. India by 2030, will require approximately 100 million tons of wheat to cover an estimated demand of 345 million tons of food grains (Annual Report, 2011-12). The country as per the national policy on agriculture has set a target of 4 per cent growth rate for which high growth in wheat production becomes a mandate owing to its importance in food basket. The growth rate can be achieved by increasing the production and bridging the existing yield gap. Regional surveys reveal large variation in yield across research farm, farmers and fields attributed to management, site and season differences. Punjab and Haryana recorded 4.3 and 4.2 t/ha, respectively in wheat production and the yield gap between farm and potential yield was about 45 and 35 per cent, respectively in those states (Fischer, 2009). Bhattacharya (2011) estimated 28.22 per cent yield gap I (difference between potential yield and national average yield) in India and 57.01 per cent yield gap II (difference

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between potential yield and state average yield) and 0.98 per cent yield gap III (difference between potential yield and on-farm yield) in Uttar Pradesh. Aggarwal *et al.* (2008) found that wheat registered a yield gap of 70 kg/ha between research farm and farmer's field.

Phosphorus (P) fertilizers are critical to crop production and global food security. Strengthening intensive agricultural production will also increase the demand for P fertilizers. China produces and consumes 34.0% and 22.5% of global P fertilizer. The output of high-concentration P fertilizer accounts for 95.9% of the total P fertilizer production, mainly as ammonium P fertilizer. However, the P supply capacity of different soils varies significantly due to soil properties, P fractions and P fertilizer types, resulting in different soil types requiring different P fertilizer types. In calcareous soils, due to the high content of calcium carbonate in the soil, the fixation effect of calcium carbonate on P is the main factor. In contrast, P is mainly fixed by a large amount of amorphous iron oxide and alumina in acid soils. From this, P fertilizer is easily fixed and accumulated after being applied to the soil. As a result, the availability is reduced, resulting in the average in-season P use efficiency (PUE) being 3.0–21.2%. (Meyer *et al.,* 2020) In addition, to maximize the effectiveness of all P fertilizer types, corresponding fertilization measures should be taken according to the characteristics of different P fertilizer types. Therefore, strategies are needed to improve fertilizer PUE by matching the soil types—P fertilizer type—cropping system in P nutrient management. Phosphorus deficiency can be corrected by applying phosphatic fertilizers, but recovery of applied P is notoriously low due to its rapid conversion to sparingly soluble compounds in soils. Rock phosphate is a raw material for phosphatic fertilizer industry. Several reports have shown that some species such as wheat, oil seed crops and legumes are particularly efficient in using P from rock phosphate through the release of H^+ (Salim *et al.,* 2013). In the present study a rock phosphate incubated with different organic media was used to identify the best inoculated media under P-limiting conditions, against their P utilization efficiencies from rock phosphate.

MATERIALS AND METHODS

A field experiment was conducted at Centre for Research on Integrated Farming Systems, S. D. Agricultural University, Sardarkrushinagar, Gujarat, India, during *rabi* season of 2018-19 to 2020-21 to study the different incubating material for Phosphorus Rich Organic Manure (PROM) in wheat. The experimental soil was loamy sand in texture, alkaline in reaction (pH 7.76), 0.310% organic carbon, 146 kg/ha available nitrogen and 31 kg/ha P_2O_5 and 226 kg/ha K_2O. Total fourteen treatments with different source were used, namely *viz.,* T_1 : Control, T_2 : DAP @ 60 kg P_2O_5 /ha, T_3 : Rock phosphate @ 40 kg P_2O_5/ha incubated with vermicompost, T_4 :Rock phosphate @ 60 kg P_2O_5/ha incubated with vermicompost, T_5 : Rock phosphate @ 40 kg P_2O_5/ha incubated with FYM, T_6 : Rock phosphate @ 60 kg P_2O_5/ha incubated with FYM, T_7 : Rock phosphate @ 40 kg P_2O_5/ha incubated with compost, T_8 : Rock phosphate @ 60 kg P_2O_5/ha incubated with compost, T_9 : Rock phosphate @ 40 kg P_2O_5/ha incubated with vegetable waste, T_{10} : Rock phosphate @ 60 kg P_2O_5/ha incubated with vegetable waste, T_{11} : Rock phosphate @ 40 kg P_2O_5/ha incubated with green algae, T_{12} : Rock phosphate @ 60 kg P_2O_5/ha incubated with green algae, T_{13} : Rock phosphate @ 40 kg P_2O_5/ha incubated with cow urine and T_{14} : Rock phosphate @ 60 kg P_2O_5/ha incubated with cow urine were tried in randomized block design with three replications on fixed site. *Rabi* wheat seeds was treated with *Azotobactor* @5 ml/kg seed. Common dose of 120 kg/ha nitrogen was applied for all treatments except T_1.

Udaipur rock phosphate (URP, 31%) used for the experiment was grained and sieved to get size of 74 micron before incubation. After that, these grained Udaipur rock phosphate was incubated with FYM/vermicompost/compost/green algae and vegetable waste with the ratio of 1:3 (W/W) and with cow urine (1:3 W/V) for the period of 30 days before application under shade. Watering was done twice in the day and stopped 4 days before using it. This incubated rock phosphate was applied as basal dose to fulfill the requirement of phosphorus. In case of cow urine, incubated material was mixed with sand for easy application at the time of sowing. The representative soil samples were collected and analyzed for organic carbon, available nitrogen, phosphorus and potassium after completion of crop sequence. The cost of cultivation was calculated based on existing input cost. Net return was calculated by subtracting cost of cultivation from gross income of system. The benefit: cost ratio (BCR) was worked out dividing net return by the cost of cultivation. No severe pests and diseases were observed during the crop growth; however, necessary plant protection measures were taken on need basis.

RESULTS AND DISCUSSION

An experiment was conducted during *rabi* seasons of 2018-19 to 2020-2021 at Centre for Research on Integrated Farming Systems, Sardarkrushinagar to study the different incubating material for phosphate rich organic manure (PROM) in wheat. The result and discussion is described on the pooled data of three years.

The plant population found non-significant under different treatments. The data on periodical plant height of wheat as influenced by incubating material of phosphate rich organic manure (PROM) were recorded at 30, 60 DAS and

Table 1. Chemical composition of high-grade Udaipur rock phosphate before incubation

Sr. no.	Parameters	URP (31%)
1	P_2O_5 (%)	31.3
2	Ca O (%)	46.0
3	Mg O (%)	1.4
4	R_2O_3 *(%)	1.6
5	L.O.I. ** (%)	5.5
6	Al *** (%)	-
7	Particle size	74 micron

* R_2O_3-Fe_2O_3+Al_2O_3+Cr_2O_3+Other oxides (Source: Soni and Aery, 2002. RSMM Ltd, UDR)
** L.O.I.-Loss on Ignition
*** AI-Acid in soluble

90 DAS are presented in the Table 2. Increase in plant height was rather slow up to 30 DAS, thereafter; it increased linearly up to 90 DAS. Different incubating material for PROM was fails to exert its significant effect on plant height at 30 DAS, but application of DAP @ 60 kg P_2O_5/ha (T_2) recorded significantly highest plant height (54.4 cm) at 60 DAS. At 90 DAS, treatment T_2 recorded significantly higher plant height (70.0 cm), which was at par with T_6, T_{10} and T_{14}. Number of tillers, spike length, number of grain per ear head recorded significantly higher under application of DAP @ 60 kg P_2O_5/ha (T_2), which was found at par with T_4, T_6, T_8, T_{10}, T_{12} and T_{14}. Data presented in the Table 2 indicated that different incubating material PROM exhibited their significant influence on test weight. An application of DAP @ 60 kg P_2O_5/ha (T_2) registered significantly higher test weight (38.50 g), which was at par with T_4, T_5, T_6, T_7, T_8, T_{10}, T_{12} and T_{14}. This was due to higher phosphorus availability near root zone area which increased number of tillers and effective tillers per meter row length. The results are in close conformity with the findings of Ditta *et al*. (2015), Rajeew *et al.* (2018) and Chaudhari *et al.* (2019).

The data presented in Table 3 revealed that wheat grain yield was significantly affected due to different incubating material for PROM during individual years and also in pooled results. Significantly the higher grain yield and straw yield of 4,411 kg/ha and 5595 kg/ha, respectively were recorded under application of DAP @ 60 kg P_2O_5/ha (T_2) over different incubating material for PROM, which was at par with T_4 (4032 kg/ha and 5131 kg/ha) and T_6 (4,121 kg/ha and 5325 kg/ha), T_8 (3,863 kg/ha and 4860 kg/ha), T_{10} (3873 kg/ha and 4,950 kg/ha) and T_{14} (3807 kg/ha and 4905 kg/ha), respectively. Whereas, significantly the lowest grain yield of 2,044 kg/ha and 2465 kg/ha were observed under control (T_1). Significantly the higher gross profit (99,411 ₹/ha) was registered application of DAP @ 60 kg P_2O_5/ha (T_2) over different incubating material for PROM, which was at par with T_4 (90,909 ₹/ha), T_6 (93,072 ₹/ha), T_8 (86978 ₹/ha), T_{10} (87361 ₹/ha) and T_{14} (85947 ₹/ha). Whereas, significantly the lowest gross profit of 45813 ₹/ha were recorded under control (T_1). Same trend was observed for net profit. Significantly the higher net profit was registered with T_2 (58,690 ₹/ha) over different incubating material, which was at par with T_4 (48,907 ₹/ha), T_4 (48,907 ₹/ha), T_6 (53,737 ₹/ha), T_8 (48,236 ₹/ha), T_{10}

Table 2. Effect of different incubating material for PROM on growth and yield attributing characters of wheat. (Pooled of 3 years)

Treatments	Plant population at initial (metre row length)	Plant height (cm) at 30 DAS	Plant height (cm) at 60 DAS	Plant height (cm) at 90 DAS	Number of tillers (No.)	Spike length (cm)	Number of grains/ spike	Test weight (g)
T_1	31.5	15.0	34.9	49.5	52.2	4.58	29.8	29.5
T_2	32.6	20.4	54.4	70.0	81.7	8.02	42.8	38.5
T_3	31.4	15.0	41.7	60.5	66.2	6.41	37.7	35.9
T_4	31.8	15.7	44.4	66.0	75.9	7.16	40.0	37.7
T_5	31.6	15.3	43.0	61.6	70.5	6.94	38.4	36.6
T_6	32.0	16.0	46.2	67.2	76.8	7.62	41.3	37.9
T_7	31.2	15.2	42.3	62.6	68.0	6.58	37.0	36.6
T_8	31.6	15.9	44.5	64.9	73.3	7.18	39.0	37.8
T_9	32.0	15.3	42.8	62.9	70.2	6.69	38.7	35.9
T_{10}	31.6	15.8	45.3	68.3	73.2	7.19	39.5	37.4
T_{11}	31.1	15.1	41.1	57.2	68.4	6.62	37.6	34.8
T_{12}	31.7	15.7	44.1	64.6	74.7	7.05	39.4	36.5
T_{13}	31.4	15.3	43.5	62.5	72.0	6.67	38.2	35.4
T_{14}	31.4	16.7	47.0	68.6	78.7	7.50	42.0	38.2
S.Em.±	0.447	0.47	1.32	1.75	3.06	0.36	1.24	0.69
CD at 5 %	NS	NS	3.71	4.95	8.90	1.04	3.60	2.01
CV %	4.68	8.89	8.98	8.32	7.75	8.26	7.27	3.98

Table 3. Effect of different incubating material for PROM on yield and economics of wheat. (Pooled of 3 years)

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Gross return (₹/ha)	Cost of Cultivation (₹/ha)	Net return (₹/ha)	BCR
T_1	2,044	2,465	45,813	36,031	9,782	1.27
T_2	4,411	5,595	99,411	40,721	58,690	2.44
T_3	3,341	4,251	75,328	40,523	34,806	1.86
T_4	4,032	5,131	90,909	42,001	48,907	2.16
T_5	3,416	4,444	77,198	38,745	38,453	1.99
T_6	4,121	5,325	93,072	39,335	53,737	2.37
T_7	3,160	4,126	71,441	38,350	33,091	1.86
T_8	3,863	4,860	86,978	38,742	48,236	2.25
T_9	3,484	4,464	78,604	40,128	38,476	1.96
T_{10}	3,873	4,950	87,361	41,409	45,952	2.11
T_{11}	3,141	4,123	71,060	40,128	30,932	1.77
T_{12}	3,436	4,596	77,899	41,409	36,490	1.88
T_{13}	3,164	4,307	71,888	38,547	33,341	1.86
T_{14}	3,807	4,905	85,947	39,038	47,264	2.20
SEm±	209	268	4,679	-	4,679	-
CD (P=0.05)	609	779	13,605	-	13,605	-
CV %	13.09	12.35	12.52	-	24.96	-

BCR = Benefit cost ratio

(45,952 ₹/ha) and T_{14} (47,264 ₹/ha), while highest BCR registered under with application of DAP @ 60 kg P_2O_5/ha (2.44) followed by T_6 (2.37), T_8(2.25), T_{14} (2.20) and T_{10} (2.11) in pooled. It might be due to better nutritional environment for wheat under incubation of rock phosphate with FYM and vegetable waste, which had increased the solubility and availability of phosphorus from rock phosphate and yield attributes of wheat. The results are in close conformity with the findings of Shaktawat *et al.* (2004), Mamun *et al.* (2012), Vyas *et al.* (2013), Sarkar *et al.* (2018), Rajeew *et al.* (2018) and Chaudhari *et al.* (2019).

Data presented in the Table 4 indicated that the mean highest total nutrient uptake by the crop (109.5 nitrogen, 24.0 phosphorus and 99.2 potassium kg/ha) was recorded with the application of DAP @ 60 kg P_2O_5/ha followed by rock phosphate @ 60 kg P_2O_5/ha incubated with FYM (103.9, 22.5 and 96.0 kg/ha, respectively). Data presented in the Table 5 revealed that, significantly higher soil organic carbon (0.364%) was recorded with the application rock phosphate @ 60 kg P_2O_5/ha incubated FYM, which was at par with T_4, T_8, T_{12}, T_5, T_7, T_9, T_{14} and T_{13}. In case of available nitrogen (154 kg/ha) and available potash (236 kg/ha) were recorded maximum with application of rock phosphate @ 60 kg P_2O_5/ha incubated with FYM and cow

Table 4. Effect of different incubating material for PROM on nutrient uptake (kg/ha) by wheat

Treatment	Grain uptake			Straw uptake			Total uptake		
	N	P	K	N	P	K	N	P	K
T_1	37.09	6.47	12.63	12.99	3.27	31.31	50.08	9.74	43.94
T_2	79.68	15.41	27.17	29.83	8.60	72.01	109.51	24.01	99.18
T_3	60.99	11.14	20.72	22.26	5.88	54.56	83.25	17.02	75.28
T_4	73.63	14.29	24.97	27.28	7.89	67.21	100.91	22.18	92.18
T_5	62.63	11.60	21.35	23.30	6.25	58.69	85.93	17.85	80.04
T_6	75.84	14.52	25.86	28.05	8.03	70.16	103.89	22.55	96.02
T_7	58.29	10.94	19.75	20.88	5.85	55.18	79.17	16.79	74.93
T_8	71.26	13.76	24.56	24.36	7.49	65.47	95.62	21.25	90.03
T_9	64.41	11.88	22.12	23.54	6.45	60.24	87.95	18.33	82.36
T_{10}	71.07	13.46	24.15	26.22	7.58	68.20	97.29	21.04	92.35
T_{11}	57.31	10.42	19.40	21.94	5.85	56.20	79.25	16.27	75.60
T_{12}	60.95	11.81	20.53	24.52	7.10	63.94	85.47	18.91	84.47
T_{13}	57.06	11.10	19.83	23.22	6.48	60.72	80.28	17.58	80.55
T_{14}	69.70	13.54	23.53	25.00	7.78	65.92	94.70	21.32	89.45
SEm±	3.89	0.71	1.30	1.50	0.41	3.91	5.26	1.08	5.09
CD (P=0.05)	11.30	2.07	3.80	4.37	1.19	11.38	15.28	3.14	14.79
CV %	13.55	12.84	13.33	13.67	12.75	12.61	12.39	11.36	11.73

Table 5. Effect of different incubating material for PROM on soil fertility status after harvest

Treatment	SOC (%)	Available nutrients (kg/ha)			pH	EC (dSm^{-1})
		N	P_2O_5	K_2O		
T_1	0.252	127	24.37	224	7.78	0.138
T_2	0.308	147	40.18	224	7.61	0.140
T_3	0.336	148	36.55	227	7.63	0.138
T_4	0.357	154	39.54	236	7.71	0.140
T_5	0.343	149	38.47	227	7.73	0.138
T_6	0.364	152	39.54	233	7.73	0.134
T_7	0.329	149	37.62	224	7.80	0.132
T_8	0.357	153	39.32	233	7.61	0.133
T_9	0.329	149	37.41	230	7.44	0.136
T_{10}	0.336	151	38.69	230	7.45	0.132
T_{11}	0.308	147	38.05	227	7.59	0.137
T_{12}	0.35	151	38.9	230	7.56	0.137
T_{13}	0.322	150	37.83	230	7.46	0.133
T_{14}	0.343	154	40.82	233	7.45	0.135
SEm±	0.019	8.3	2.23	9.6	0.09	0.005
CD (P=0.05)	0.054	NS	6.49	NS	0.25	NS
Initial status	0.310	146	31.00	226	7.76	0.138
CV %	9.76	9.62	10.27	7.3	1.94	6.490

Rate of produce and inputs used in wheat

1	Selling price of wheat seed	₹ 20/kg	6	Labour charge	₹ 260/day	11	Compost	₹ 0.5/kg
2	Selling price of wheat straw	₹ 2/ kg	7	Chlorpyriphos	₹ 450/litre	12	Green algae	₹ 5/kg
3	Urea	₹ 5.88/ kg	8	Rock phosphate (31 %)	₹ 6/kg	13	Cow urine	₹ 1/kg
4	DAP	₹ 24/ kg	9	FYM	₹ 1.5/kg	14	Vegetable waste	₹ 5/kg
5	Pendimethalin	₹ 540/litre	10	Vermicompost	₹ 6/kg			

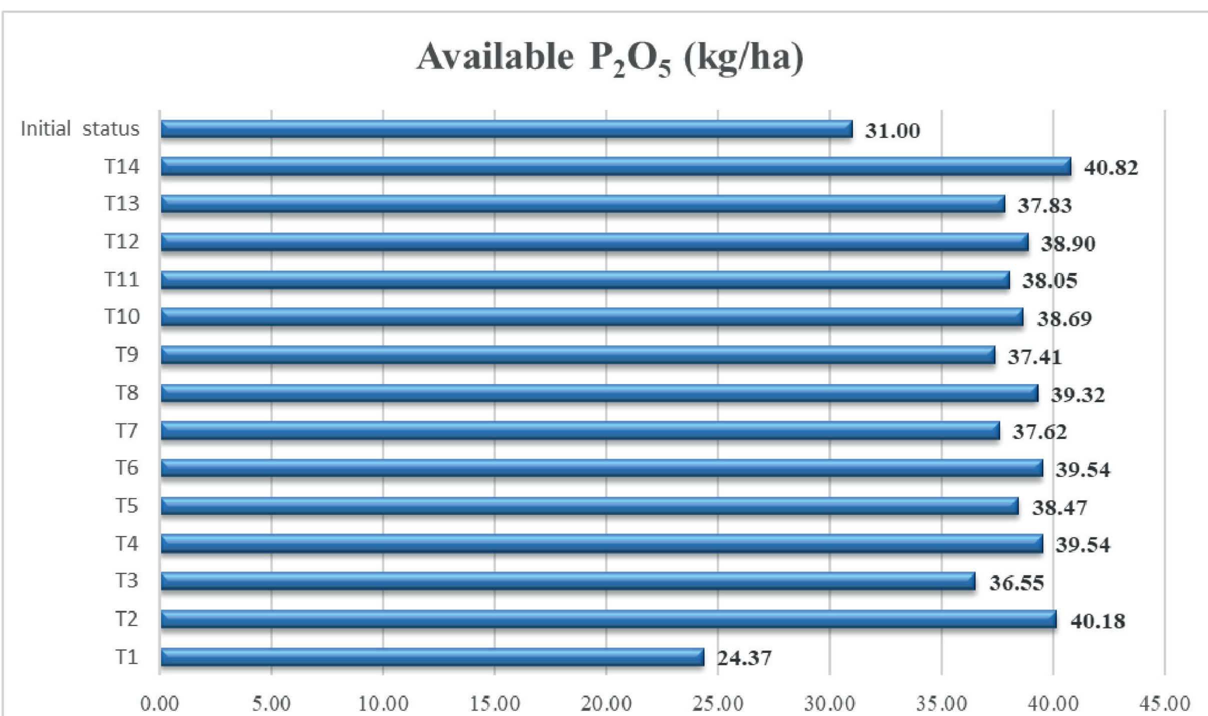

Fig. 1. Effect of available phosphorus on initial soil status and different treatments.

urine, while available phosphorus was significantly higher with the application of rock phosphate @ 60 kg P_2O_5/ha incubated with cow urine (40.82 kg/ha), which was at par with treatment T_2 to T_{13}. Soil pH (7.44) was observed lowest under T_9, while EC (0.132 dS/m) was lowest under T_{10}.

It can be concluded that the diammonium phosphate (DAP) (60 kg P_2O_5/ha) can be replaced with Udaipur rock phosphate (31 per cent P_2O_5) @ 198 kg/ha incubated for 30 days with FYM or vermicompost or compost or vegetable waste (each of 593 kg) or cow urine (593 L) in the ratio of 1:3 for obtaining higher yield and net returns.

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