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Effect of Phosphorus, Boron and Rhizobium inoculation on productivity and profitability of chickpea

Sudhir Pal, SB Pandey, Anshul Singh, Satyaveer Singh, Ravindra Sachan and Ankit Yadav

Abstract
Field experiments were conducted to Studies effect of Phosphorus, Boron and Rhizobium inoculants on yield attributes and yield of chickpea during rabi season 2018-19 and 2019-20 at students instructional farm, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur. The experiment comprised of eighteen treatments viz. T_1: P_0B_0, T_2: P_0B_1, T_3: P_0B_2, T_4: P_1B_0, T_5: P_1B_1, T_6: P_1B_2, T_7: P_2B_0, T_8: P_2B_I, T_9: P_2B_2, T_{10}: P_0B_0+Rhizobium, T_{11}: P_0B_1+Rhizobium, T_{12}: P_0B_2+Rhizobium, T_{13}:P_1B_0+Rhizobium, T_{14}:P_1B_1+Rhizobium,T_{15}: P_1B_2+Rhizobium,T_{16}:P_2B_0+Rhizobium,T_{17} :P_2B_1 +Rhizobium, T_{18}: P_2B_2 +Rhizobium and replicated thrice. Results of the experiment reflected that yield attributes like of chickpea crop significantly increased with the use of phosphorus, boron and rhizobium inoculation. Maximum number of pods plant^{-1} 68.65, number of grains pods^{-1} 1.79, 100 grains weight 20.55 gm and harvest index 44.29% were recorded under T_{18} ((P_{90} +B_2 + rhizobium). The crop yield of chickpea significantly increased due to phosphorus and boron application @ 60 kg P_2O_5 ha^{-1} and 1.0 kg ha^{-1} respectively. Rhizobium inoculation significantly increased yield, both grain 18.52 q ha^{-1} and stover 24.44 q ha^{-1} recorded under T_{14} (P_1B_1+Rhizobium) of chickpea crop during both the years of the experimentation. The maximum gross return Rs. (125546), net return Rs. (86846) and B:C ratio (2.24) were recorded under T_{18} ((P_{90} +B_2 + rhizobium). Combined application of phosphorus, boron and rhizobium inoculation. The present study showed that application of phosphorus, boron and rhizobium inoculation along with recommended nitrogen and potassium could be an effective option for enhancing chickpea yield attributes, yield and economic return.

Keywords: Chickpea, Yield attributes, Yield, Economics, Phosphorus, Boron and *Rhizobium*, Uday

Introduction

Pulses play a pivotal role and occupy a unique position in Indian agriculture by virtue of their inherent capacity to grow on marginal lands. It is an easily available source of protein in the rural heart of India. Pulses provide significant nutritional and health benefits and are known to reduce several non- communicable diseases such as colon cancer and cardio-vascular diseases (Jukanti *et al.* 2012) [10]. India is the largest producer and consumer of pulses in the world. Chickpea mainly cultivated in the cool, dry season of the semi-arid tropical region. The plant is well adapted to tropical climates with moderate temperatures and is successfully cultivated under irrigation in the cool season of many tropical countries (Bejiga and Van der Maesen, 2006) [3]. Many attractive dishes viz – sweets, snacks and namkeen are also prepared from its floor called besan. Also eaten as whole fried or boiled and salted. Fresh green leaves (sag) are used as vegetables and green grains as hare chhole or chholia. Straw of gram is an excellent fodder while both husk and bits of 'Dal' are valuable cattle feed. Leaves consist of mallic and citric acid and are very useful for stomach ailments and blood purifier.Today, Chickpea is the third most important pulse crop in the world after dry bean and pea.

Phosphorus is one of the essential nutrients for legume growth and BNF (Mhango *et al.*, 2008) [15]. Phosphorus deficiency can limit nodule number, leaf area, and biomass and grain development in legumes. Symbiotic nitrogen fixation has a high P demand because the process consumes large amounts of energy (Schulze *et al.*, 2006) [23] and energy generating metabolism strongly depends upon the availability of P (Plaxton, 2004) [18]. P fertilization stimulates root growth, photosynthesis and increases hydraulic conductibility of roots. Phosphorus is used in numerous molecular and biochemical plant processes, particularly in energy acquisition, storage and utilization (Epstein and Bloom, 2005) [6].

The role of boron in cell wall integrity, cell division, plasma membranes, phenol metabolism, and its requirement for the nitrogen fixation and in the reproductive growth of plants. Boron is recognized as an essential micronutrient for vascular plants and is believed to be involved in nucleic acid metabolism, sugar biosynthesis and translocation, active nutrient absorption, regulation of rate of photosynthesis and nodulation process (Prajapati *et al.* 2017) [19]. Boron is very important in cell division and in pod and seed formation. Boron ranks third place among micronutrients in its concentration in seed and stem as well as its total amount after zinc (Shil *et al.* 2007) [25].

Rhizobium are symbiotic bacteria that facilitate formation of nodules on the roots of legume hosts, within which the bacteria fix atmospheric nitrogen into ammonia. Symbiotic nitrogen fixation is the main route for sustainable input of nitrogen into ecosystems.

Materials and methods

Field experiments were conducted during the rabi season 2018-19 and 2019-20 at students instructional farm, Chandra Shekhar Azad university of Agriculture & Technology, Kanpur. Initial soil properties of experimental field had sandy loam texture, low in organic carbon 0.35% alkaline pH 7.97 and electrical conductivity 0.36 dsm^{-1}. Available N 197.25 kg ha^{-1}, P_2O_5 12.14 kg ha^{-1}, K_2O 265.15 kg ha^{-1},and B 0.33 mg ha^{-1}. The soil samples was analysed for pH, EC by (Jackson 1973) [8] and organic carbon by the method described by (Walkley and Black, 1934) [31]. Available N was determining by alkaline per magnate method as described by Subbiah and Asija (1956) [27]. Available phosphorus was extracted with 0.5 M NaHCO3 (Olsen *et al.* 1954) [17]. The available K was determined by flame photo meter (Jackson 1973) [8]. Available boron was determined by Azomethine-H method (Chopra and kanwar 1991) [5]. The plant samples were also analyse for N, P, K and B. Nitrogen was determined by Kjeldahl's method (Jackson 1973) [8] Phosphorus was estimated by vanadomolybdo phosphoric yellow colour method (Jackson 1973) [8]. Potassium was estimated by flame photometric method. Boron was estimated by Azomethine-H method as described by (Chopra and kanwar 1991) [5]. The experiment was laid out in factorial randomized block design with three replications. Chickpea cultivar uday was sown in row 45 cm apart on 20 November in 2018 and 21 November in 2019 and harvested on 10th April 2019 and 11th April in 2020 repectivly. Full dose of nitrogen and potash were applied at the time of sowing uniformaly. Phosphorus, boron and rhizobium were applied as per treatments. N, P, K and B were applied through urea, SSP, muriate of potash and borax respectively. The crop received two uniform irrigations (pre sowing and pre flowring). The number of pods $plant^{-1}$, number of grains $pods^{-1}$, 100 grains weight in gm and harvest index, grain and straw yield were recorded as per standard procedure. The net return of chickpea grown under various treatments was calculated by substracting cost of cultivation of individual treatments from gross returns of respective treatments and finally the benefit cost ratio was calculated.

Results and discussion

Yield attributes and yield - the data pertaining to yield attributes and yield of chickpea were presented in table 1 and 2. :Experimental results reaveled that number of pods $plant^{-1}$, number of grains pod^{-1}, test weight (100 grains weight gm) and harvest index % significantly increased due to application of phosphorus, boron and rhizobium inoculation. The number of pods $plant^{-1}$ Varied from 48.85- 67.25, number of grains $pods^{-1}$ 1.32- 1.77, 100 grains weight 17.08 to 20.37 and harvest index 41.68 to 44.26 % on the pooled basis. The highest values of number of pods $plants^{-1}$ 68.65, number of grains pod^{-1} 1.79, 100 grains weight 20.55 gm and harvest index 44.29 % were recorded under T_{18} (P_{90} +B_2 + rhizobium) and respective minimum were 48.20, 1.30, 16.96 gm and 41.67 % respectively under T_1 (P_0 +B_0) during first year.

This increased might be due to essentiality of phosphorus for legume growth. Phosphorus always play role in increasing nodule number, biomass and grains development. Symbiotic nitrogen fixation has more phosphorus demand like phosphorus boron is essential micronutrient and essential for cell wall integrity, cell division, nitrogen fixation. Rhizobium is symbiotic bacteria which facilitase nodules formation on the root of legume crop. On the whole all three factors increased yield attributes of chickpea. This finding supported by Meena *et al*. (2001) [13], Umar *et al*. (2001), Malik *et al*. (2002) [12], Bhat *et al*. (2005) [4], Shekhawat and Shivay (2012) [24], Rahman *et al*. (2014) [21], Prajapati *et al*. (2017) [19], Ullah *et al*. (2018) [28], Kumar *et al*. (2019) [11], Meleta and Girma (2019) [19] and Rathor *et al*. (2020).

Grain, straw and biological yield of chickpea significantly increased due to phosphorus (60 kg P_2O_5 ha^{-1}) and boron (1 kg B ha^{-1}) over their controls. Inoculation of rhizobium further increased grain & stover yield of chickpea significantly over without inoculation. Combine use of phosphorus 60 kg P_2O_5 ha^{-1} and boron 1 kg ha^{-1} alone with rhizobium significantly increased grain 18.52 q ha^{-1}, stover 24.44 q ha^{-1} and biological yield 42.96 q ha^{-1} of chickpea recorded under T_{14} (P_{60} +B_1 + rhizobium) over other treatments during second year. It may due to rhizobium which fix atmospheric nitrogen and increased the supply of other nutrients to plants and ultimately increased grain and stover yield of chickpea. This finding supported by Jena *et al.* (2009) [9], Singh *et al.* (2014) [26], Alam and Islam (2016) [1], Alam *et al.* (2017) [2], Quddus *et al.* (2018) [20], Kumar *et al.* (2019) [11], Meleta and Girma (2019) [19] Neha *et al.* (2019) [16] and Rathor *et al.* (2020).

Profibility: The maximum gross return Rs. 125546, net return Rs. 86866 and benefit cost ratio 2.24 was found with T_{18}(P_{90} +B_2+ *rhizibium*) during second year. The application of phosphorus, boron and *rhizobium* enhanced the gross return with the magnitude of 58.54 percent, net return 45.35 percent and benefit cost ratio 50.34 percent. The minimum gross return Rs.72643, net return Rs. 40919 and benefit cost ratio 1.28 recorded under T_1(P_0 +B_0) during first year showed the table number 3. Similar finding of increased the crop yield and profitability with combined application of phosphorus, boron and *rhizobium* inoculation has been reported by Meleta and Girma (2019) [19], Verma *et al.* (2019) [30].

Conclusions

The current study demonstrate the benefit of phosphorus, boron and *rhizobium* alone with recommended N K for achieving higher productibity and profitability by chickpea crop. Application of phosphorus, boron and rhizobium inoculation increased yield attributes, yield and economics of chickpea crop. Finally it can be concluded that the treatment T_{14} (P_{60} +B_1+ *rhizobium*) is a best option for improving productivity and profitability of chickpea crop.

Table 1: Effect of treatments on yield attributes of chickpea crop.

Treatments	No. of pods plant^{-1}			No. of grains pod^{-1}			100 grains wt. in gm			Harvest index		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	48.20	49.50	48.85	1.30	1.34	1.32	16.96	17.20	17.08	41.67	41.68	41.68
T_2	50.30	50.80	50.55	1.41	1.43	1.42	17.25	18.15	17.70	41.77	41.81	41.79
T_3	51.80	52.10	51.95	1.45	1.48	1.47	17.45	18.40	17.93	41.90	41.93	41.92
T_4	54.10	57.20	55.65	1.49	1.50	1.495	17.32	17.83	17.57	42.37	42.45	42.41
T_5	58.35	62.35	60.35	1.58	1.62	1.60	19.05	19.25	19.15	42.83	42.93	42.88
T_6	60.55	64.40	62.48	1.62	1.67	1.65	19.45	19.64	19.55	43.38	43.44	43.41
T_7	55.40	59.00	57.20	1.50	1.52	1.51	17.40	17.85	17.63	43.67	43.71	43.69
T_8	59.45	63.35	61.40	1.59	1.64	1.62	19.13	19.32	19.23	43.89	44.07	43.98
T_9	61.85	65.40	63.63	1.64	1.68	1.66	19.75	19.73	19.74	44.15	44.27	44.21
T_{10}	49.40	51.20	50.30	1.50	1.58	1.54	16.99	17.47	17.23	41.70	41.72	41.71
T_{11}	54.50	54.70	54.60	1.56	1.64	1.60	17.89	18.90	18.40	41.79	41.84	41.82
T_{12}	55.70	56.20	55.95	1.59	1.67	1.67	17.99	18.98	18.49	41.90	42.02	41.96
T_{13}	55.40	59.10	57.25	1.60	1.62	1.61	17.45	17.99	17.72	42.46	42.61	42.54
T_{14}	63.45	66.40	64.93	1.69	1.71	1.70	19.85	19.97	19.91	42.99	43.10	43.04
T_{15}	65.35	67.85	66.60	1.73	1.77	1.75	20.15	20.49	20.32	43.39	43.57	43.48
T_{16}	57.20	61.20	59.20	1.61	1.64	1.63	17.52	18.02	17.77	43.73	43.87	43.80
T_{17}	64.55	67.55	66.05	1.71	1.73	1.72	19.92	20.02	19.97	44.05	44.09	44.07
T_{18}	65.85	68.65	67.25	1.75	1.79	1.77	20.20	20.55	20.37	44.23	44.29	44.26
Overall mean	57.30	59.83	58.57	1.57	1.61	1.59	18.43	18.88	18.65	42.88	42.97	42.93
SEm±	P 0.82 B 0.82 Rh 0.67	P 0.95 B 0.95 Rh 0.78	P 0.62 B 0.62 Rh 0.50	P 0.04 B 0.04 Rh 0.03	P 0.04 B 0.04 Rh 0.03	P 0.03 B 0.03 Rh 0.02	P 0.27 B 0.27 Rh 0.22	P 0.32 B 0.31 Rh 0.26	P 0.20 B 0.20 Rh 0.16	P 0.16 B 0.16	P 0.16 B 0.16	P 0.12 B 0.12
C.D. at 5%	P 1.66 B 1.66 Rh 1.35	P 1.93 B 1.93 Rh 1.58	P 1.25 B 1.25 Rh 1.02	P 0.08 B 0.08 Rh 0.06	P 0.09 B 0.09 Rh 0.07	P 0.06 B 0.06 Rh 0.05	P 0.56 B 0.56 Rh0.46	P 0.64 B 0.64 Rh 0.52	P 0.42 B 0.42 Rh 0.35	P 0.32 B 0.32	P 0.33 B 0.33	P N.S. B N.S.

T_1: $P_0B_0Rh_0$ (0kg P_2O_5+0 kg B ha^{-1} without *Rhizobium*), T_2 : $P_0B_1Rh_0$ (0 kg P_2O_5+1 kg B ha^{-1} without *Rhizobium)*, T_3 : $P_0B_2Rh_0$ (0 kg P_2O_5+2 kg B ha^{-1} without *Rhizobium*), T_4 : $P_1B_0Rh_0$ (60 kg P_2O_5+0 kg B ha^{-1} without *Rhizobium*), T_5: $P_1B_1Rh_0$ (60 kg P_2O_5+1 kg B ha^{-1} without *Rhizobium*), T_6: $P_1B_2Rh_0$ (60 kg P_2O_5+2 kg B ha^{-1} without *Rhizobium*), T_7: $P_2B_0Rh_0$ (90 kg P_2O_5+0 kg B ha^{-1} without *Rhizobium*), T_8: $P_2B_1Rh_0$ (90 kg P_2O_5+1 kg B ha^{-1} without *Rhizobium*), T_9: $P_2B_2Rh_0$ (90 kg P_2O_5+2 kg B ha^{-1} without *Rhizobium*), T_{10}: $P_0B_0Rh_1$ (0 kg P_2O_5+0 kg B ha^{-1} with *Rhizobium*), T_{11}: $P_0B_1Rh_1$ (0 kg P_2O_5+1 kg B ha^{-1} with *Rhizobium*), T_{12}: $P_0B_2Rh_1$ (0 kg P_2O_5+2 kg B ha^{-1} with *Rhizobium*), T_{13}: $P_1B_0Rh_1$ (60 kg P_2O_5+0 kg B ha^{-1} with *Rhizobium*), T_{14}: $P_1B_1Rh_1$ (60 kg P_2O_5+1 kg B ha^{-1} with *Rhizobium*), T_{15}: $P_1B_2Rh_1$ (60 kg P_2O_5+2 kg B ha^{-1} with *Rhizobium*), T_{16}: $P_2B_0Rh_1$ (90 kg P_2O_5+0 kg B ha^{-1} with *Rhizobium*), T_{17}: $P_2B_1Rh_1$ (90 kg P_2O_5+1 kg B ha^{-1} with *Rhizobium*), T_{18}: $P_2B_2Rh_1$ (90 kg P_2O_5+2 kg B ha^{-1} with *Rhizobium*).

Table 2: Effect of treatments on grain, straw and biological yield of chickpea crop.

Treatments	Yield (q ha^{-1})								
	Grain			Stover			Biological		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	12.07	12.40	12.24	16.88	17.34	17.11	28.94	29.74	29.34
T_2	13.92	14.10	14.01	19.40	19.62	19.51	33.32	33.38	33.35
T_3	14.85	15.10	14.98	20.59	20.91	20.75	35.44	36.01	35.73
T_4	14.37	14.65	14.51	19.54	19.86	19.70	33.91	34.51	34.21
T_5	16.65	16.90	16.78	22.22	22.46	22.34	38.87	39.36	39.11
T_6	17.71	17.89	17.80	23.11	23.29	23.20	40.82	41.18	41.00
T_7	15.68	15.82	15.75	20.22	20.37	20.30	35.90	36.17	36.04
T_8	17.95	18.13	18.04	22.94	23.00	22.97	40.87	41.13	41.01
T_9	18.51	18.72	18.62	23.41	23.56	23.48	41.92	42.28	42.10
T_{10}	13.42	13.85	13.64	18.76	19.34	19.05	32.19	33.19	32.69
T_{11}	15.15	15.80	15.47	21.10	21.96	31.53	36.25	37.76	37.00
T_{12}	16.05	16.30	16.18	22.21	22.49	22.35	38.26	38.79	38.53
T_{13}	16.92	17.05	16.99	22.92	22.96	22.94	39.84	40.01	39.92
T_{14}	18.15	18.52	18.33	24.06	24.44	24.25	42.21	42.96	42.59
T_{15}	19.05	19.33	19.19	24.76	25.03	24.89	43.81	44.36	44.09
T_{16}	17.82	18.03	17.93	22.93	23.16	23.05	40.75	41.19	40.97
T_{17}	19.00	19.32	19.16	24.13	24.49	24.31	43.13	43.81	43.47
T_{18}	19.65	19.90	19.78	24.77	25.94	25.35	44.42	44.93	44.67
Overall Mean	16.50	16.76	16.63	21.89	22.23	22.06	38.38	38.93	38.66
SEm±	P 0.55 B 0.55 Rh0.45	P 0.61 B0.61 Rh0.50	P 0.40 B 0.40 Rh 0.32	P 0.69 B 0.69 Rh 0.56	P 0.89 B 0.89 Rh 0.72	P 0.54 B 0.54 Rh 0.42	P 0.82 B 0.82 Rh 0.67	P 0.93 B0.93 Rh 0.76	P 0.61 B 0.61 Rh 0.52
C.D. at 5%	P 1.12 B 1.12 Rh 0.92	P 1.24 B1.24 Rh1.01	P 0.82 B 0.82 Rh0.67	P 1.39 B 1.39 Rh 1.13	P 1.79 B1.79 Rh 1.46	P 1.11 B 1.11 Rh 0.87	P 1.66 B 1.66 Rh 1.35	P 1.89 B 1.89 Rh 1.51	P 1.24 B 1.24 Rh 1.06

T_1: $P_0B_0Rh_0$ (0kg P+0 kg B ha^{-1} without *Rhizobium*), T_2 : $P_0B_1Rh_0$ (0 kg P+1 kg B ha^{-1} without *Rhizobium)*, T_3 : $P_0B_2Rh_0$ (0 kg P+2 kg B ha^{-1} without *Rhizobium*), T_4 : $P_1B_0Rh_0$ (60 kg P+0 kg B ha^{-1} without *Rhizobium*), T_5: $P_1B_1Rh_0$ (60 kg P+1 kg B ha^{-1} without *Rhizobium*), T_6: P_1B_2

Rh_0 (60 kg P+2 kg B ha^{-1} without *Rhizobium*), T_7: P_2B_0 Rh_0 (90 kg P+0 kg B ha^{-1} without *Rhizobium*), T_8: P_2B_1 Rh_0 (90 kg P+1 kg B ha^{-1} without *Rhizobium*), T_9: P_2B_2 Rh_0 (90 kg P+2 kg B ha^{-1} without *Rhizobium*), T_{10}: P_0B_0 Rh_1 (0 kg P+0 kg B ha^{-1} with *Rhizobium*), T_{11}: P_0B_1 Rh_1 (0 kg P+1 kg B ha^{-1} with *Rhizobium*), T_{12}: P_0B_2 Rh_1 (0 kg P+2 kg B ha^{-1} with *Rhizobium*), T_{13}: P_1B_0 Rh_1 (60 kg P+0 kg B ha^{-1} with *Rhizobium*), T_{14}: P_1B_1 Rh_1 (60 kg P+1 kg B ha^{-1} with *Rhizobium*), T_{15}: P_1B_2 Rh_1 (60 kg P+2 kg B ha^{-1} with *Rhizobium*), T_{16}: P_2B_0 Rh_1 (90 kg P+0 kg B ha^{-1} with *Rhizobium*), T_{17}: P_2B_1 Rh_1 (90 kg P+1 kg B ha^{-1} with *Rhizobium*), T_{18}: P_2B_2 Rh_1 (90 kg P+2 kg B ha^{-1} with *Rhizobium*).

Table 3: Effect of treatments on economics of various treatments of chickpea crop.

Treatment	Total cost of cultivation (₹ ha-1)	Gross income (₹ ha-1)		Net return (₹ ha-1)		Benefit cost ratio (B:C)	
	2018-19 and 2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
T_1	31724	72643	79187	40919	47463	1.28	1.49
T_2	32864	83710	90319	50846	57455	1.54	1.74
T_3	34004	89197	96613	55193	62609	1.62	1.84
T_4	34724	85929	93264	51205	58540	1.47	1.68
T_5	35864	99143	107093	63279	71229	1.76	1.98
T_6	37004	104930	112832	67926	75828	1.83	2.04
T_7	36220	92661	99529	56441	63309	1.55	1.74
T_8	37360	105869	113683	68509	76323	1.83	2.04
T_9	38500	108926	117176	70426	78676	1.83	2.04
T_{10}	31924	80760	88792	48836	56868	1.52	1.78
T_{11}	33064	91093	101181	58029	68117	1.75	2.06
T_{12}	34204	96316	104201	62157	69997	1.81	2.04
T_{13}	34924	101090.00	108374	66166	73450	1.89	2.10
T_{14}	36064	107913.00	117169	71849	81105	1.99	2.24
T_{15}	37204	112771.00	121766	75567	84562	2.03	2.27
T_{16}	36420	105258	113372	68838	76952	1.89	2.11
T_{17}	37560	111910	121124	74350	83564	1.97	2.22
T_{18}	38700	115553	125546	76853	86846	1.98	2.24
Overall mean	35463	98093	106179	62633	70716	1.75	1.98
SEm±		P 471.53 B 471.53 Rh 385.00	P 483.97 B 483.97 Rh 395.16	P 668.09 B 668.09 Rh 545.50	P 561.72 B 561.72 Rh 458.64	P 0.046 B 0.046 Rh0.037	P 0.062 B 0.062 Rh0.051
C.D. at 5%		P 974.19 B 974.19 Rh 995.42	P 999.89 B 999.89 Rh 816.60	P 1380.29 B 1380.29 Rh 1127.00	P 1160.52 B 1160.52 Rh 947.65	P 0.095 B 0.095 Rh0.077	P 0.129 B 0.129 Rh0.105

T_1: P_0B_0 Rh_0 (0kg P+0 kg B ha^{-1} without *Rhizobium*), T_2 : P_0B_1 Rh_0 (0 kg P+1 kg B ha^{-1} without *Rhizobium)*, T_3 : P_0B_2 Rh_0 (0 kg P+2 kg B ha^{-1} without *Rhizobium*), T_4 : P_1B_0 Rh_0 (60 kg P+0 kg B ha^{-1} without *Rhizobium*), T_5: P_1B_1 Rh_0 (60 kg P+1 kg B ha^{-1} without *Rhizobium*), T_6: P_1B_2 Rh_0 (60 kg P+2 kg B ha^{-1} without *Rhizobium*), T_7: P_2B_0 Rh_0 (90 kg P+0 kg B ha^{-1} without *Rhizobium*), T_8: P_2B_1 Rh_0 (90 kg P+1 kg B ha^{-1} without *Rhizobium*), T_9: P_2B_2 Rh_0 (90 kg P+2 kg B ha^{-1} without *Rhizobium*), T_{10}: P_0B_0 Rh_1 (0 kg P+0 kg B ha^{-1} with *Rhizobium*), T_{11}: P_0B_1 Rh_1 (0 kg P+1 kg B ha^{-1} with *Rhizobium*), T_{12}: P_0B_2 Rh_1 (0 kg P+2 kg B ha^{-1} with *Rhizobium*), T_{13}: P_1B_0 Rh_1 (60 kg P+0 kg B ha^{-1} with *Rhizobium*), T_{14}: P_1B_1 Rh_1 (60 kg P+1 kg B ha^{-1} with *Rhizobium*), T_{15}: P_1B_2 Rh_1 (60 kg P+2 kg B ha^{-1} with *Rhizobium*), T_{16}: P_2B_0 Rh_1 (90 kg P+0 kg B ha^{-1} with *Rhizobium*), T_{17}: P_2B_1 Rh_1 (90 kg P+1 kg B ha^{-1} with *Rhizobium*), T_{18}: P_2B_2 Rh_1 (90 kg P+2 kg B ha^{-1} with *Rhizobium*).

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