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Response of NPK uptake in Mungbean (*Vigna radiata* L.) based rice (*Oryza sativa* L.) cropping system including weed flora

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Abstract
A field experiment was carried out during the two consecutive Zaid and Kharif season in year of 2020-2021 and 2021-2022 at the research farm of Tirhut College of Agriculture, Dholi, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar to study "yield maximization through agronomic management in Mungbean (*Vigna radiate* L.) under a rice-based cropping system''. In seed inoculation with LSMR 1 (*Stenotrophomonas maltophilia*) + RB 3 (Microbial consortia), significantly higher N, P, K uptake of Mungbean and rice were recorded, but in the case of weed management, two-hand weeding at 20 and 40 DAS are observed significantly higher N, P, K uptake of Mungbean and rice as well as Propaquizafop 2.50% + imazethapyr 3.75% ME @ 125g/ha at 15-20 DAS was found at par response with two-hand weeding at 20 and 40 DAS. However, foliar nutrition of 2% 19:19:19 NPK (Flower initiation + Pod initiation) is shown to be significantly higher nitrogen uptake then the other rest of the treatments for Mungbean and rice, but in case weed maximum N, P, K uptake was found in seed inoculation (Rhizobium + PSB (Local) and lowest N, P, K uptake was recorded in LSMR 1 (*Stenotrophomonas maltophilia*) + RB 3 (Microbial consortia). Under weed management in weed check similarly in foliar nutrition in water spray (Flower initiation + Pod initiation) maximum N, P, K uptake was recorded in weed than the rest of treatments in both year (2020-2021) and pooled data respectively.

Keywords: Microbial consortia, *Stenotrophomonas maltophilia,* foliar nutrition, weed management, weedy check, Cropping system

Introduction

Among five Asian countries: India, Pakistan, Nepal, Bangladesh, and China, there are 28.8 million hectares (m ha) under rice-wheat cropping (RWCS). A total of 12 million hectares of RWCS are cultivated in India, accounting for 31% of all food grains produced (Kumar and Yadav 2006). Asia's food requirements are greatly influenced by the RWCS. In spite of this, many people are questioning the sustainability of cereal-cereal cropping systems when they observe that soil fertility deteriorates over time. (Duxbury and Gupta 2000; Ladha *et al.*, 2000; Prasad 2005) [13, 25]. Green gram, or Mung bean (*Vigna radiata* L.), plays a crucial role in Indian food production. Pulses with high nutrients have an advantage over others because they are digestible, non-flatulent, and high in nutrients and Protein-rich edible seeds are the primary reason for their cultivation (Haq 1989) [3]. A winter rainy season that lasts from February to November offers excellent opportunities for the cultivation of short-duration pulse crops before the harvest of the aus rice. During the fallow period Sylhet, Nazrul, and Shaheb (2012b) [28] found that pulse crops can be grown effectively in the fallow land, which produces higher seed yields for Mungbean (var. BARI Mung-6), chickpea (var. BARI Chola-5), and lentil (var. BARI Mosur-6). Cropping patterns using potato-rice and chickpea-rice have been developed to produce crops on fallow land in the Sylhet region (Nazrul *et al.*, 2013; Nazrul and Shaheb, 2012a; Shaheb *et al.*, 2011) [19, 17, 28]. Around 30% of the nitrogen applied as manure is available to crops immediately after application and the rest is available to crops afterward, according to Jamaval *et al.*, 2006: Patel *et al.*, 2020) [7, 22]. It is important to maintain soil fertility to ensure higher and more sustainable yields because nutrients are constantly being exchanged between soil and plants. A major characteristic of mung bean crops is their ability to form symbiotic relationships with specific bacteria, supplying them with nitrogen through a process called biological nitrogen fixation (Mandal *et al.*, 2009) [14].

In addition to organic fertilizers, farming systems can also benefit from compost and farmyard manure, and can improve soil health by recycling crop and organic residues. Organic fertilizers are scarce and high transportation costs impose major constraints. Therefore, legumes should be incorporated into current cropping systems based on this scenario. The symbiosis between legumes and the bacteria Rhizobium aids in the biological fixation of atmospheric nitrogen (N). A rotation of field crops can partially reduce the need for nitrogen fertilizer. Consequently, it turns into a moderate supply of nitrogen for farmers who lack access to resources (McDonagh *et al.*, 1995) [15]. Legumes, together with grain, are crucial for boosting agricultural yield, sustaining crop output, enhancing human nutrition, and preserving the health of the soil (Norman *et al.*, 1984: Patel *et al.*, 2020) [20, 23]. There has been documented competitiveness and yield reduction resulting from weeds in greengram (Parkash *et al*., 1988) [21], as well as up to 96.5% yield reduction resulting from crop weed competition (Verma *et al*., 2015) [9]. Hand weeding is a good method for reducing weeds in the greengram, but it is not practical because of the expense, labour shortage, and constant rain during the rainy season. Because of this, chemical weed control is a great alternative and can keep an area free of weeds for up to 30-35 days after sowing (Dungarwal *et al.*, 2003). The goal of the current investigation was to determine the lasting effects of organic materials and bio-fertilizers used on the rice that came before the mung bean in an organic cropping system.

Methods and Materials

The field experiment was carried out in the zaid and kharif seasons in both 2020 and 2021 at the research farm of the Tirhut College of Agriculture, Dholi, (Muzaffarpur) of R.P.C.A.U., Pusa, Bihar, India. It has a location on the southern bank of the river Burhi Gandak in the Samastipur district at 25.590 North latitude and 85.750 East longitude, and is 52.92 m above mean sea level (Arabian Sea) for two years (2020 to 2021 and 2021 to 2022). The soil had a pH of 8.50, a low amount of available nitrogen (175.66 kg ha-1), a medium amount of available phosphorus (16.12 kg ha-1), and a low amount of available potassium (111.67 kg ha-1). Available organic C in the soil was.35 percent. Its availability was also low. With three replications, the experiment was set up using a factorial randomised block design. Treatments comprise three factors: seed inoculation, weed management, and foliar nutrition: Seed inoculation [(Rhizobium + PSB (Local) and LSMR 1 (*Stenotrophomonas maltophilia*) + RB 3 (Microbial consortia)], weed management (weedy check, two-hand weeding at 20 and 40 DAS, Propaquizafop 2.50% + imazethapyr 3.75% ME @ 125g/ha at 15-20 DAS and Fomesafen @ 220 g/ha + Fluzifop-p-butyl @ 220 g/ha at 15-20 DAS), and foliar nutrition [(Water spray (Flower initiation + Pod initiation), Urea spray 2% (Flower initiation + Pod initiation) and 19:19:19 NPK at 2% (Flower initiation + Pod initiation)] and all treatment compressions were done with absolute control.

Analytical technique

Macro Wiley Mill (Paul N. Gardner Company, Inc., FL, USA) was used to grind mung bean grain and stover samples into 40-mesh sieves after drying at 60 ^{0}C for six hours. We determined nitrogen, phosphorus, and potassium using a 0.5-g sample of grain and straw. A modified Kjeldahl method (Jackson 1973) [5] was used to measure nitrogen in grain and straw samples. Total phosphorus levels were measured using a Vanadomolybdo phosphoric acid yellow color method and flame photometry, as described by Prasad *et al*. (2006) [27]. In percentages, NPK concentrations were calculated in grain and straw. Using their percent concentrations in grain or straw and their yields, N, P, and K uptake was calculated. In grain and straw, N, P, and K were added together to obtain the total uptake. This was expressed in kilograms per hectare.

Nutrient uptake by weeds

Uptake of N, P, and K by weeds was estimated using the following formula:

$$\text{Nutrient uptake by weed kg ha}^{-1} = \frac{\text{Nutrient content in weed \% x weed dry matter kg ha}-1}{100}$$

Statistical analysis

Using a factorial randomized block design, Cochran and Cox (1957) applied the 'analysis of variance' method to analyze the data pertaining to each character. In order to compare the mean differences presented in the summary table at a 5% level of significance, a critical difference of 5% was calculated.

Results and Discussion

Nitrogen, phosphorus and potassium uptake of Mungbean

The study of different factors *viz*., seeds inoculations, weed management, and foliar application treatments significantly influenced by the Nitrogen, phosphorus and potassium uptake in green gram crops. Data showed in Table 1 response of seed inoculation with LSMR 1 (*Stenotrophomonas maltophilia*) + RB 3 (Microbial consortia) significantly higher Nitrogen, phosphorus and potassium uptake was recorded (103.13, 101.15), (12.15, 11.16) and (172.93, 170.95) kg/ha than the Rhizobium + PSB (Local) (99.10, 96.96), (10.43, 9.45) and (166.08, 164.11) kg/ha in both years (2020 and 2021) respectively similar results recorded by Kumawat *et al*. (2021) [12].

Under weed management, two hands weeding at 20 and 40 DAS obtained significantly higher Nitrogen, phosphorus and potassium uptake (105.56,103.37), (13.67, 12.66) and (177.90, 175.88) kg kg/ha than Propaquizafop 2.50% + imazethapyr 3.75% ME @ 125g/ha at 15-20 DAS (101.99, 99.81), (12.68, 11.67) and (172.20, 170.18) kg/ha and Fomesafen @ 220 g/ha + Fluzifop-p-butyl @ 220 g/ha at 15-20 DAS (99.93, 97.97), (11.67, 10. 69) and (167.02, 165.06) kg ha^{-1} weedy check (96.97, 95.05), (7.13, 6.17) and (160.92, 159.0) kg ha^{-1} however Propaquizafop 2.50% + imazethapyr 3.75% ME @ 125g/ha at 15-20 DAS shown at par response with two hands weeding at 20 and 40 DAS in each year (2020 and 2021) data respectively similar result are observed Kaur *et al*., (2010) [8], Komal *et al*. (2015) [9]., Jagadesh, M., & Raju, M. (2021) [6].

In the case of foliar nutrition on 19:19:19 NPK at 2% (Flower initiation + Pod initiation) (102.87, 100.63), (12.44, 11.44) and (172.22, 170.23) was recorded maximum Nitrogen, phosphorus and potassium uptake than water spray (Flower initiation + Pod initiation) (99.29, 97.32), (10.16, 9.18) and (166.57, 164.61) kg/ha and Urea spray 2% (Flower initiation + Pod initiation) (101.18, 99.20), (11.27, 10.28) and (169.72, 167.75) kg/ha however Urea spray 2% (Flower initiation + Pod initiation) are found at par response with 19:19:19 NPK at 2% (Flower initiation + Pod initiation) in both years(2020 and 2021) respectively similar result are found Kumar *et al*. (2018), Mondal *et al*. (2011) [16]. Whereas all treatments are obtained maximum Nitrogen, phosphorus and potassium uptake (101.11, 99.05), (11.29, 10.30) and (169.51, 167.53) kg/ha than absolute control (87.23, 85.47), (5.27, 4.39) and (154.20, 152.44) kg/ha in both years (2020 and 2021) respectively.

Nutrient uptake of rice

Residual impact of previous mungbean and their application of different treatments of nitrogen uptake on rice crop presented in Table 2

In seed inoculation are shown LSMR 1 (*Stenotrophomonas maltophilia*) + RB 3 (Microbial consortia) significantly higher Nitrogen, phosphorus and potassium uptake (89.60, 91.60), (16.94, 17.95) and (109.60, 110.59) kg/ha than (Rhizobium + PSB (Local) (80.92, 82.83), (15.90, 16.88) and (100.74, 101.66) kg/ha in both years (2020 and 2021) respectively similar result is found Saxena and Yadav (1998) [30].

Under weed management, two hands weeding at 20 and 40 DAS obtained significantly higher Nitrogen, phosphorus and potassium uptake (92.32, 94.31), (17.76, 18.76) and (112.34, 113.31) kg/ha compared to all other treatments Propaquizafop 2.50% + imazethapyr 3.75% ME @ 125g/ha at 15-20 DAS (88.98, 91.02), (17.08, 18.08) and (108.81, 109.66) kg/ha and Fomesafen @ 220 g/ha + Fluzifop-p-butyl @ 220 g/ha at 15-20 DAS (85.20, 87.19), (16.41, 17.36) and (105.20, 196.20) kg/ha and lowest Nitrogen, phosphorus and potassium uptake are observed weedy check (74.33, 76.34), (14.42, 15.46) and (102.68, 103.61) kg/ha however Propaquizafop 2.50% + imazethapyr 3.75% ME @ 125g/ha at 15-20 DAS are shown at par response with two hands weeding at 20 and 40 DAS in both years (2020 and 2021) respectively similar result are obtained Pooniya and Shivay (2012) [24]. Previous foliar nutrition application on mungbean and their residual impact on rice crop are found non-significant difference among factors in both year (2020 and 2021) respectively because foliar nutrition has no have any residual effect on rice crop. However, all treatments have been obtained maximum Nitrogen, phosphorus and potassium uptake (85.21, 87.22), (16.42, 17.42) and (105.17, 106.12) kg/ha than absolute control (60.74, 62.70), (13.47, 14.35) and (80.74, 81.82) kg/ha in both year (2020 and 2021) respectively similar result are found Kumar *et al.* (2018) [10], Mondal *et al.* (2011) [16].

Nutrient uptake of weed

The Nitrogen, phosphorus and potassium uptake by weed was significantly influenced by different factors *viz* seed inoculation, weed management, and foliar application and data are presented in Table 3

In seed inoculation with the combination of (Rhizobium + PSB (Local) observed higher Nitrogen, phosphorus and potassium uptake (7.60, 6.59), (2.76, 2.21) and (9.60, 8.60) kg/ha than LSMR 1 (*Stenotrophomonas maltophilia*) + RB 3 (Microbial consortia) (7.14, 6.14), (2.39, 1.83) and (9.14,8.17) kg/ha in each year (2020 and 2021) similar result are found by Kumawat *et al.* (2021) [12].

Under weed management two hand weeding at 20 and 40 DAS are exhibited significantly lowest Nitrogen, phosphorus and potassium uptake (4.33, 3.34), (1.23, 0.69) and (5.33, 4.35) kg/ha than Propaquizafop 2.50% + imazethapyr 3.75% ME @ 125g/ha at 15-20 DAS (5.40, 4.39), (2.29, 1.74) and (6.40, 5.43) kg/ha and Fomesafen @ 220 g/ha + Fluzifop-p-butyl @ 220 g/ha at 15-20 DAS (6.35, 5.35), (2.76, 2.20) and (7.35, 6.35) kg/ha, and maximum Nitrogen, phosphorus and potassium uptake are observed weedy check (13.41, 12.39), (4.01, 3.45) and (18.41, 17.44) kg/ha however Propaquizafop 2.50% + imazethapyr 3.75% ME @ 125g/ha at 15-20 DAS shown at par with two hands weeding at 20 and 40 DAS in both years (2020 and 2021) respectively similar result are found Harisha *et al*. (2021) [4], Jagadesh, M., & Raju, M. (2021) [6].

In the case of foliar nutrition on water spray (Flower initiation + Pod initiation) observed that significantly higher Nitrogen, phosphorus and potassium uptake (7.96, 6.94), (2.96, 2.42) and (9.96, 8.94) kg/ha of weed than 19:19:19 2% NPK spray (Flower initiation + Pod initiation) (6.89, 5.90), (2.22, 1.65) and (8.89) kg/ha and urea 2% spray (Flower initiation + Pod initiation) (7.28, 6.26), (2.53, 1.99) and (9.96, 8.94) kg/ha in both years (2020 and 2021) respectively However all treatments are found lowest Nitrogen, phosphorus and potassium uptake (7.37, 6.37), (2.57, 2.02) and (9.37, 8.39) kg/ha than absolute control (15.38, 14.44), (6.23, 5.64) and (20.13, 19.14) kg/ha in both years (2020 and 2021) respectively similar result are found Kumar *et al.* (2018) [10], Mondal *et al.* (2011) [16].

Table 1: Total NPK uptake in Mungbean

	Total nitrogen kg/ha		Total phosphorus kg/ha		Total potassium kg/ha	
Treatment	2020	2021	2020	2021	2020	2021
Seed Inoculation						
S_1	99.10	96.96	10.43	9.45	166.08	164.11
S_2	103.13	101.15	12.15	11.16	172.93	170.95
S.Em±	1.34	1.33	0.13	0.13	2.25	2.24
CD ($p\leq 0.05$)	3.81	3.78	0.38	0.38	6.38	6.37
Weed management						
W_1	96.97	95.05	7.13	6.17	160.92	159.00
W_2	105.56	103.37	13.67	12.66	177.90	175.88
W_3	101.99	99.81	12.68	11.67	172.20	170.18
W_4	99.93	97.97	11.67	10.69	167.02	165.06
S.Em±	1.90	1.88	0.19	0.19	3.18	3.17
CD ($p\leq 0.05$)	5.39	5.34	0.54	0.54	9.03	9.01
Foliar Nutrition						
F_1	99.29	97.32	10.16	9.18	166.57	164.61
F_2	101.18	99.20	11.27	10.28	169.73	167.75
F_3	102.87	100.63	12.44	11.44	172.22	170.23
S.Em±	1.64	1.63	0.16	0.16	2.75	2.74

CD ($p \leq 0.05$)	4.67	4.63	0.46	0.47	7.82	7.80
Tr	101.11	99.05	11.29	10.30	169.51	167.53
Absolute control	87.23	85.47	5.27	4.39	154.20	152.44
S.Em±	1.34	1.33	0.13	0.13	2.25	2.24
CD (p≤0.05)	3.81	3.78	0.38	0.38	6.38	6.37

Table 2: Total NPK uptake in rice

	Total nitrogen kg/ha		**Total phosphorus kg/ha**		**Total potassium kg/ha**	
Treatment	2020	2021	2020	2021	2020	2021
Seed Inoculation						
S_1	80.82	82.83	15.90	16.88	100.74	101.66
S_2	89.60	91.60	16.94	17.95	109.60	110.59
S.Em±	1.19	1.35	0.23	0.27	1.48	1.64
CD ($p \leq 0.05$)	3.39	3.84	0.66	0.77	4.21	4.68
Weed management						
W_1	74.33	76.34	14.42	15.46	94.33	95.32
W_2	92.34	94.31	17.76	18.76	112.34	113.31
W_3	88.98	91.02	17.08	18.08	108.81	109.66
W_4	85.20	87.19	16.41	17.36	105.20	106.20
S.Em±	1.69	1.91	0.33	0.38	2.09	2.33
CD ($p \leq 0.05$)	4.80	5.42	0.94	1.08	5.96	6.61
Foliar Nutrition						
F_1	82.80	84.81	15.96	16.97	102.68	103.61
F_2	85.46	87.46	16.45	17.44	105.46	106.44
F_3	87.37	89.38	16.84	17.83	107.37	108.32
S.Em±	1.46	1.65	0.29	0.33	1.81	2.01
CD ($p \leq 0.05$)	4.16	4.70	0.81	0.94	5.16	5.73
Tr	85.21	87.22	16.42	17.42	105.17	106.12
Absolute control	60.74	62.70	13.47	14.35	80.74	81.82
S.Em±	1.19	1.35	0.23	0.27	1.48	1.64
CD ($p \leq 0.05$)	3.39	3.84	0.66	0.77	4.21	4.68

Table 3: NPK uptake in weed

	Total nitrogen kg/ha		**Total phosphorus kg/ha**		**Total potassium kg/ha**	
Treatment	2020	2021	2020	2021	2020	2021
Seed Inoculation						
S_1	7.60	6.59	2.76	2.21	9.60	8.60
S_2	7.14	6.14	2.39	1.83	9.14	8.17
S.Em±	0.15	0.10	0.05	0.03	0.20	0.14
CD ($p \leq 0.05$)	0.41	0.30	0.14	0.09	0.56	0.41
Weed management						
W_1	13.41	12.39	4.01	3.45	18.41	17.44
W_2	4.33	3.34	1.23	0.69	5.33	4.33
W_3	5.40	4.39	2.29	1.74	6.40	5.43
W_4	6.35	5.35	2.76	2.20	7.35	6.35
S.Em±	0.21	0.15	0.07	0.05	0.28	0.20
CD ($p \leq 0.05$)	0.59	0.42	0.19	0.13	0.79	0.57
Foliar Nutrition						
F_1	7.96	6.94	2.96	2.42	9.96	8.94
F_2	7.28	6.26	2.53	1.99	9.28	8.33
F_3	6.89	5.90	2.22	1.65	8.89	7.89
S.Em±	0.18	0.13	0.06	0.04	0.24	0.17
CD ($p \leq 0.05$)	0.51	0.37	0.17	0.11	0.68	0.50
Tr	7.37	6.37	2.57	2.02	9.37	8.39
Absolute control	15.38	14.44	6.23	5.64	20.13	19.14
S.Em±	0.15	0.10	0.05	0.03	0.20	0.14
CD ($p \leq 0.05$)	0.41	0.30	0.14	0.09	0.56	0.41

Conclusion

The present study maximum NPK uptake in mungbean recorded under seed inoculation and foliar nutrition while in rice non-significant difference were observed in both factors. Maximum NPK uptake was estimated in mungbean and rice under two hand weeding at 20 and 40 DAS. However, Propaquizafop 2.50% + imazethapyr 3.75% ME @ 125g/ha at 15-20 DAS have shown at par response of two hand weeding at 20 and 40 DAS in each year as well as based on pooled data.

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