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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(12): 1260-1268

www.thepharmajournal.com
Received: 07-09-2023
Accepted: 18-10-2023

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Effect of straight and mixed fertilizers on periodic nutrient availability in lateritic soils of Konkan

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Abstract
An incubation study was carried out in the Department of Soil Science and Agricultural Chemistry, College of Agriculture Dapoli, during the years 2021-22 and 2022-23 to evaluate the impact of straight and mixed fertilizers on periodic nutrient availability in lateritic soils of Konkan. There were three levels of recommended dose of nitrogen *viz.* 100, 80 and 60 percent through Konkan Annapurna Briquettes (KAB) with and without fertilization of zinc and boron. The recommended dose of straight fertilizers with and without zinc and boron was also included in the experiment. The result revealed that, the treatment effect on soil reaction, electrical conductivity and organic carbon were not affected significantly in most of the samplings (30, 60, 90 and 120 DAI) during both the years of investigation. The available nitrogen content in soil was found to be increased up to 90 DAI and then slightly decreased at 120 DAI. Available phosphorus and potassium content in soil was found to be increased periodically from 30 DAI to 120 DAI. The highest content of available Zn and B at 30, 60, 90 and 120 DAI was observed in the treatment comprised of 100 percent N through Konkan Annapurna Briquettes (KAB) fortified with 2 kg boron and 3 kg zinc ha^{-1}.

Keywords: RDF, konkan Annapurna briquettes, fortified, zinc and boron

Introduction
The improved understanding of N mineralization and N immobilization, along with their continuous changing dynamics may improve our ability to manage N cycling and increase nitrogen use efficiency (NUE) by minimizing N losses whatever the form (Cabrera *et al.*, 2005) [3]. The use of slow N releasing fertilizers having higher nitrogen release potential is new development in this direction of improving NUE of fertilizers. To minimize nutrient losses and increase the use efficiency of N fertilizer, the placement of fertilizer or spot application of fertilizer, use of slow-release fertilizer are recommended. However, the information regarding a comparative performance of neem coated urea, SSP, MOP, Konkan Annapurna Briquette and KAB fortified with zinc and boron with respect to nitrogen release pattern from these sources is limited. Therefore, the present study was undertaken to study the effect of the various fertilizers on periodic nutrient availability in lateritic soils of Konkan

Materials and Methods
During the November to April of the years 2021-22 and 2022-23, the incubation study was carried out in the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri. For this the bulk soil sample from 0-15 cm depth was collected from field experimental site, Agronomy Farm, College of Agriculture, Dapoli. The soil was processed using wooden mortar and pestle and passes through 2 mm sieve. The processed soil used for the incubation study.

The experiment was conducted in completely randomized design (CRD) with nine treatments and four replications. The methodology adopted for sampling was destructive i.e., at each sampling replication was withdrawn for analysis. Thus, there were 108 pots under incubation study. The experiment comprises of nine treatments *viz.*, Absolute control, RDF (150:50:50 N: P_2O_5: K_2O kg ha^{-1}) through straight fertilizers, 100% N through Konkan Annapurna Briquettes (KAB), 80% N through Konkan Annapurna Briquettes (KAB), 60% N through Konkan Annapurna Briquettes (KAB), RDF + 2 kg Boron + 3 kg Zinc ha^{-1}, 100% N through KAB fortified with 2 kg boron + 3 kg zinc ha^{-1}, 80% N through KAB fortified with 2 kg boron + 3 kg zinc ha^{-1} and 60% N through KAB fortified with 2 kg boron + 3 kg zinc ha^{-1}. The boron and zinc were given through borax and zinc sulphate, respectively in T_6 and in T_7, T_8 and T_9 it was fortified with Konkan Annapurna Briquette. The FYM @ 20 t ha^{-1} was given to all the treatments except T_1 (Absolute control) treatment.

Incubation technique

For this 2 kg processed soil sample was placed in plastic pots (dimension: - 16.5 cm height × 18 cm width) and treatment wise FYM and inorganic fertilizers were added as per the treatments in four replications without crop and mixed thoroughly. Subsequently, soils in the pots were brought to field capacity by adding water. All the pots were incubated under ambient conditions. The moisture losses measured gravimetrically and compensated by adding the measured quantity of water periodically throughout incubation period. At each sampling *i.e*., 30, 60, 90 and 120 days after incubation treatment wise soil samples were obtained and analysed for pH, electrical conductivity, organic carbon, available N, P_2O_5, K_2O and micronutrients by using standard methods.

Results and discussion

Soil reaction (pH): The result pertaining to the periodical changes in soil reaction due to various treatments at different period of incubation are reported in Table 1. It is evident that soil pH values at all periods of incubation did not influence significantly due to various treatments. In general soil pH was found to be varied from 5.64 to 6.26 during the year 2021-22. Similarly, it showed variation from 5.97 to 6.18 during the year 2022-23.

The general soil pH was found to be reduced as incubation days increased from 30 to 120 DAI. It may be due to conversion of ammonium (NH_4^+) to nitrate (NO_3^-), which contributes to soil acidification or organic matter in the soil releases organic acids as it decomposes which also contributed to soil acidification or in the absence of plant, respiration of microbes produces carbon dioxide (CO_2) as a result of their metabolic processes and when CO_2 dissolves in water, it forms carbonic acid, which can lower the pH. These finding are in agreement with the findings reported by Bolan *et al*. (1991) [2].

Table 1: Effect of various fertilizers on soil reaction (pH)

Treatment	2021-22				2022-23			
	Period of incubation (days)				Period of incubation (days)			
	30	60	90	120	30	60	90	120
T_1	6.26	6.25	6.03	5.89	6.11	6.12	6.10	6.07
T_2	6.23	6.02	5.84	5.91	6.15	6.11	6.08	6.02
T_3	6.04	6.12	5.89	5.71	6.16	6.10	6.10	6.05
T_4	6.14	6.04	5.91	5.69	6.15	6.09	6.08	6.04
T_5	6.12	6.04	5.98	5.68	6.14	6.05	6.04	5.97
T_6	6.13	6.01	5.95	5.67	6.15	6.11	6.06	6.01
T_7	6.03	6.02	5.74	5.68	6.18	6.12	6.09	6.06
T_8	6.19	6.03	5.73	5.66	6.17	6.11	6.07	6.01
T_9	6.07	6.04	5.85	5.64	6.13	6.10	6.08	6.03
SE(m) ±	0.10	0.08	0.07	0.06	0.02	0.02	0.02	0.03
C. D. @ 1%	NS	NS	NS	NS	NS	NS	NS	NS

Electrical conductivity (dS m^{-1})

The data on periodic observation on electrical conductivity was presented in Table 2. In general, electrical conductivity found to be varied from 0.18 to 0.55 dS m^{-1} during the year 2021-22. Similarly, it showed variation from 0.22 to 0.42 dS m^{-1} during the year 2022-23. All the treatments failed to produced statistically significant effect on electrical conductivity of soil during both the years of investigation.

The general trend of electrical conductivity during incubation period is declining it may be due to the fact that when pots initially filled with a substrate that contained soluble salts, the dissolution of this salts could have contributed to initial increase in electrical conductivity. As time passed, these salts might have been gradually broken down by microbial activity, leading to decrease in EC or if pH increased initially due to factors like microbial activity, this might have influenced the solubility of certain salts, leading to declined pattern in electrical conductivity. These findings are in agreement with the findings of Surin *et al.* (2019) [9].

Table 2: Effect of various fertilizers on electrical conductivity

Treatment	2021-22				2022-23			
	Period of incubation (days)				Period of incubation (days)			
	30	60	90	120	30	60	90	120
T_1	0.27	0.25	0.23	0.18	0.28	0.25	0.26	0.21
T_2	0.42	0.34	0.30	0.25	0.37	0.31	0.28	0.24
T_3	0.52	0.42	0.38	0.31	0.38	0.33	0.30	0.25
T_4	0.53	0.44	0.39	0.30	0.35	0.31	0.29	0.26
T_5	0.51	0.43	0.40	0.35	0.32	0.30	0.29	0.23
T_6	0.45	0.40	0.33	0.29	0.36	0.34	0.32	0.26
T_7	0.55	0.48	0.41	0.34	0.42	0.39	0.34	0.30
T_8	0.53	0.42	0.38	0.34	0.35	0.33	0.32	0.26
T_9	0.48	0.39	0.34	0.30	0.31	0.27	0.26	0.22
SE(m) ±	0.05	0.04	0.04	0.03	0.06	0.04	0.03	0.02
C. D. @ 1%	NS	NS	NS	NS	NS	NS	NS	NS

Organic carbon (g kg^{-1})

The data on periodic observation on organic carbon (g kg^{-1}) was presented in Table 3. Organic carbon found to be varied from 17.09 to 19.50 g kg^{-1} during the year 2021-22. Similarly, it showed variation from 14.55 to 16.90 g kg^{-1} during the year 2022-23. All the treatments failed to Produced statistically significant effect on organic carbon of soil during both the years of investigation.

Table 3: Effect of various fertilizers on organic carbon (g kg^{-1})

Treatment	2021-22				2022-23			
	Period of incubation (days)				Period of incubation (days)			
	30	60	90	120	30	60	90	120
T_1	18.85	18.20	18.02	17.80	16.51	16.20	15.65	14.95
T_2	19.50	18.98	18.35	17.98	16.32	15.99	15.35	15.21
T_3	19.11	18.12	18.15	18.02	16.77	15.69	15.20	14.89
T_4	19.24	18.23	18.20	18.00	16.51	16.10	15.90	15.02
T_5	18.59	18.15	18.10	17.09	16.90	15.90	15.50	14.65
T_6	18.20	18.00	17.90	17.90	16.12	15.90	15.92	14.55
T_7	18.59	18.32	18.20	17.90	16.32	16.02	15.80	14.65
T_8	17.94	18.10	17.98	17.80	16.20	15.90	15.30	14.60
T_9	18.98	18.68	18.00	17.80	16.89	15.56	15.25	14.58
SE(m) ±	0.38	0.49	0.48	0.47	0.44	0.42	0.41	0.40
C. D. @ 1%	NS	NS	NS	NS	NS	NS	NS	NS

Over extended period of time, the absence of organic input can lead to gradual decrease in organic carbon content or in pots without crop, microorganisms present in the soil continue to feed on organic matter, breaking it down and releasing carbon dioxide as a by product. This microbial decomposition can lead to decrease organic carbon over time. The highest amount of soil organic carbon at the beginning of the incubation was indicative of a larger pool of the less resistant fractions that were available to be broken down and recycled, thus resulting in lower contents remaining at the end incubation (Roy and Kashem, 2014) [8].

Available nitrogen (kg ha^{-1})

The values of available nitrogen (kg ha^{-1}) as determined at 30, 60, 90 and 120 DAI are presented in Table 4.

At 30 Days after Incubation (DAI)

The data indicated that treatment receiving application of 100 percent N through Konkan Annapurna Briquettes (KAB) fortified with 2 kg boron and 3 kg zinc ha^{-1} (T_7) registered maximum value 221.61 during 2021-22 and 100 percent RDF through straight fertilizer registered maximum value 249.84 kg ha^{-1} during 2022-23 of available nitrogen content of soil. However, minimum (175.62 and 185.02 kg ha^{-1}) available N content was seen in the treatment absolute control (T_1) during the years 2021-22 and 2022-23, respectively.

At 60 Days after Incubation (DAI)

The data indicated that treatment receiving (T_3) 100 percent N through Konkan Annapurna Briquettes (KAB) registered maximum value 266.57 and 235.55 kg ha^{-1} during 2021-22 and 2022-23, respectively. However, minimum (194.41 and 176.66 kg ha^{-1}) available N content was seen in the treatment absolute control (T_1) treatment during the years 2021-22 and 2022-23, respectively. A critical examination of data further indicated that treatment T_3 produced statistically at par results with T_2, T_6 and T_7 treatment during 2021-22 and 2022-23, respectively.

Table 4: Effect of various fertilizers on available nitrogen (kg ha^{-1})

Treatment	2021-22				2022-23			
	Period of incubation (days)				Period of incubation (days)			
	30	60	90	120	30	60	90	120
T_1	175.62	194.41	191.05	188.38	185.02	176.66	194.43	175.21
T_2	213.25	260.97	264.47	260.26	213.25	226.58	221.61	220.32
T_3	211.16	266.57	270.56	268.32	210.11	235.55	232.06	226.32
T_4	209.07	251.93	257.15	245.32	204.89	215.67	227.88	208.83
T_5	194.43	243.56	247.74	239.21	187.11	194.03	205.93	189.32
T_6	210.85	259.24	265.51	260.23	212.20	228.34	226.84	220.35
T_7	221.61	264.95	277.01	269.25	210.11	234.67	229.97	224.26
T_8	206.97	250.88	258.73	248.65	206.98	215.40	217.43	208.29
T_9	188.16	244.61	241.47	236.58	198.61	191.65	200.70	186.58
Mean	203.46	248.57	252.63	246.24	203.14	213.17	217.43	206.61
SE(m) ±	4.10	3.52	4.57	6.36	4.72	5.16	5.53	5.21
C. D. @ 1%	12.28	10.53	13.38	19.08	14.15	15.48	16.56	15.63

At 90 Days after Incubation (DAI)

The highest values 350.15 and 255.36 kg ha^{-1} of available nitrogen content were found in the treatment receiving application of 100 percent N through Konkan Annapurna Briquettes (KAB) fortified with 2 kg boron and 3 kg zinc ha^{-1} (T_7) and (T_3) receiving application of 100 percent N through Konkan Annapurna Briquettes (KAB) during the years 2021-22 and 2022-23, respectively and produced statistically significant effect on available nitrogen content of soil over almost all treatments with exception of treatments T_2, T_3, T_6, and T_2, T_4, T_6, T_7, T_8 during the years 2021-22 and 2022-23, respectively.

At 120 Days after Incubation (DAI)

The treatment 100 percent RDF through Konkan Annapurna Briquettes fortified with 2 kg boron and 3 kg zinc ha^{-1} (T_7) and (T_3) 100 percent N through Konkan Annapurna Briquettes (KAB) recorded the highest values 269.70 and 213.25 kg ha^{-1} of available nitrogen content in the soil during 2021-22 and 2022-23, respectively and produced statistically significant effect on available nitrogen content of soil over almost all treatments with exception of treatments T_2, T_3, T_6 and T_2, T_6, T_7 during the years 2021-22 and 2022-23, respectively.

Generally, available nitrogen content in soil is found to be increased up to 90 DAI and then slightly decreased at 120 DAI. It may be due to as the experiment progressed and microbial decomposition continued, the available nitrogen from the initial sources might have been exhausted, leading to decrease in nitrogen levels. one more probability of decrease in available N at 120 DAI was as microbial population grew, immobilization could have been more significant, causing decrease in available nitrogen. N release depends on soil type, soil moisture, and the type of organic amendment used. (Uddin *et al*., 2021) [10]. The release of nitrogen from fertilizer application is a complex process that is influenced by a number of factors. It is important to understand these factors in order to optimize nitrogen use efficiency and reduce environmental losses.

Available phosphorous (kg ha^{-1})

The periodic availability of P_2O_5 determined at different period of incubation are given in Table 5.

At 30 Days after Incubation (DAI)

It is evident from the data that the treatment receiving application of 100 percent N through KAB fortified with 2 kg boron and 3 kg zinc ha^{-1} (T_7) recorded the highest values 22.09 and 18.57 kg ha^{-1} of available phosphorus content of soil at 30 DAI during the years 2021-22 and 2022-23, respectively and found to be statistically at par results with T_2, T_3, T_6 and T_8 during the year 2021-22 and during the year T_2, T_3, T_4, T_6 and T_8 2022-23. The lowest values (14.46 and 11.20 kg ha^{-1}) of available phosphorus content of soil at 30 DAI were observed in the treatment absolute control (T_1) during the years 2021-22 and 2022-23, respectively.

At 60 Days after Incubation (DAI)

In the treatment receiving application of 100 percent N through KAB fortified with 2 kg boron and 3 kg zinc ha^{-1} (T_7) produced statistically at par results with treatments T_2, T_3 and T_6 during 2021-22 and T_3 during 2022-23.

At 90 Days after Incubation (DAI)

Further, the application of 100 percent N through KAB fortified with 2 kg boron kg ha^{-1} (T_7) registered the highest values 23.87 and 25.19 kg ha^{-1} of available phosphorus content in soil and found statistically significant over almost all other treatments with exception of treatment T_3 during the years 2021-22 and 2022-23, respectively. The treatment absolute control (T_1) recorded the lowest available phosphorus content (15.08 and 13.79 kg ha^{-1}) during the years 2021-22 and 2022-23, respectively.

At 120 Days after Incubation (DAI)

The data revealed that the highest values 23.05 and 27.20 kg ha^{-1} of available phosphorus content of soil were observed in the treatment receiving application of 100 percent N through Konkan Annapurna Briquette (T_3) during the year 2021-22 and 100 percent N through KAB fortified with 2 kg boron and 3 kg zinc ha^{-1} (T_7) during 2022-23, respectively and T_3 and T_7 remained at par with each other during the years 2021-22 and 2022-23.

Table 5: Effect of various fertilizers on available phosphorus (kg ha^{-1})

Treatment	2021-22				2022-23			
	Period of incubation (days)				Period of incubation (days)			
	30	60	90	120	30	60	90	120
T_1	14.46	15.20	15.08	14.99	11.20	11.57	13.79	14.39
T_2	21.80	22.38	21.84	19.67	16.53	19.04	19.49	18.74
T_3	22.05	23.16	23.45	23.05	18.54	22.58	24.92	24.47
T_4	19.52	20.33	20.87	20.48	15.86	18.90	20.08	21.27
T_5	17.46	19.50	19.98	19.06	14.98	15.70	14.88	14.61
T_6	21.84	22.35	21.82	20.83	16.93	19.21	19.04	18.19
T_7	22.09	23.64	23.87	22.86	18.57	23.38	25.19	27.20
T_8	20.03	20.66	21.70	21.27	17.36	19.76	21.64	22.25
T_9	17.30	18.46	19.46	19.27	15.13	15.61	19.78	20.28
SE(m) ±	0.80	0.58	0.54	0.52	1.05	0.69	0.94	1.50
C. D. @ 1%	2.39	1.76	1.63	1.57	3.16	2.05	2.81	4.49

Generally, available phosphorus content in pot soil is found to be increased up to 90 DAI and then slightly decreased at 120 DAI in first year. It may be due to as the experiment progressed and microbial population established and grew, they might have taken up phosphorous for their growth and metabolism, leading to decrease in its availability in the soil. one more possibility of decrease in available phosphorus at 120 DAI was microbes can immobilize phosphorous by incorporating it into their biomass; this process can reduce the immediate availability. In second year, phosphorus content in pot soil is found to be increased periodically from 30 DAI to 120 DAI.

At a high concentration of phosphorus, the availability of phosphorus in the labile pool was also high for eight weeks and later declines. Since the phosphate anion and sesquioxides have greater bonding strength, they would have snugly fit into the colloidal complexes. Therefore, the conjoint application of Phosphorus and FYM with bio inoculants (Phosphorus solubilizing bacteria) have increased the concentration of P in the labile pool throughout incubation (Vanitha *et al*., 2020) [11].

Available potassium (kg ha^{-1}): The data on periodic observation on available potassium (kg ha^{-1}) was presented in Table 6.

At 30 Days after Incubation (DAI)

Data on available K_2O at 30 DAI showed variation in its status from 179.20 to 250.88 kg ha^{-1} and 199.36 to 232.88 kg ha^{-1} during the years 2021-22 and 2022-23, respectively. The highest available potassium found in the (250.88 and 232.88 kg ha^{-1}) treatment (T_2) receiving application RDF through straight fertilizers during the years 2021-22 and 2022-23, respectively. The treatment receiving application of RDF (150:50:50 N: P_2O_5: K_2O kg ha^{-1}) through straight fertilizers (T_2) showed statistically significant effect over all remaining treatments except T_6 (RDF + 2 kg B and 3 kg Zn ha^{-1}) during both the years of investigation.

At 60 Days after Incubation (DAI)

Maximum values (246.43 and 247.88 kg ha^{-1}) of available potassium content in soil were seen in the treatment (T_6) receiving application of RDF + 2 kg boron + 3 kg zinc ha^{-1} at 60 DAI during 2021-22 and during 2022-23 available potassium content in soil were seen in the treatment (T_2) receiving application of recommended dose of fertilizer through straight fertilizers. 219.72 and 213.88 kg ha^{-1} was an average available potassium content during the years 2021-22 and 2022-23, respectively. T_2 and T_6 remained at par with each other during the years 2021-22 and 2022-23.

At 90 Days after Incubation (DAI)

The highest values (263.70 and 261.21 kg ha^{-1}) of available K_2O content were seen in the treatment (T_2) where RDF (150:50:50 N: P_2O_5: K_2O kg ha^{-1}) through straight fertilizers was applied during both the years of investigation. Data on available K_2O content when critically examined revealed that treatment (T_2) showed statistically significant effect over all remaining treatments except T_6 (RDF + 2 kg boron + 3 kg zinc ha^{-1}) during both the years of investigation.

At 120 Days after Incubation (DAI)

The highest values (267.34 and 265.21 kg ha^{-1}) of available K_2O content were seen in the treatment (T_2) where RDF (150:50:50 N: P_2O_5: K_2O kg ha^{-1}) through straight fertilizers was applied during both the years of investigation. Data on available K_2O content when critically examined revealed that treatment (T_2) showed significant effect over all treatments except T_6 (RDF + 2 kg boron + 3 kg zinc ha^{-1}) during both the years of investigation.

Table 6: Effect of various fertilizers on available potassium (kg ha^{-1})

Treatment	2021-22				2022-23			
	Period of incubation (days)				Period of incubation (days)			
	30	60	90	120	30	60	90	120
T_1	179.20	204.74	225.40	224.32	199.36	201.00	208.53	206.84
T_2	250.88	244.80	263.70	267.34	232.88	247.88	261.21	265.21
T_3	210.56	220.71	238.33	246.98	214.86	221.53	227.92	229.65
T_4	215.04	219.73	225.02	235.32	193.94	196.04	201.39	205.33
T_5	192.64	210.36	227.28	230.56	191.92	193.64	198.33	200.20
T_6	228.48	246.43	261.82	262.03	228.49	241.82	255.92	261.28
T_7	215.04	217.86	235.61	245.21	208.20	217.53	222.86	225.65
T_8	192.64	212.43	221.31	228.21	204.33	206.67	214.78	216.32
T_9	183.68	200.40	218.39	220.85	195.19	198.86	200.94	203.65
SE(m) ±	11.27	7.97	8.19	6.04	4.18	5.55	2.14	5.93
C. D. @ 1%	33.76	23.86	24.53	18.12	12.51	16.62	6.39	17.79

The availability of K_2O increased with advancement of incubation period irrespective of all treatments. It may be due to over time, minerals in the soil containing potassium undergo weathering processes, releasing potassium into soil and increasing available K_2O levels. Another reason of increasing avail. K_2O in incubation study was might be the breakdown of organic matter over time can release potassium into the soil solution.

Lal *et al*. (2000) [6] reported that with the increase in incubation time the K mineralized increased significantly and raised the available K pool in soil due to release of more organically bound potassium in course of decomposition of organic waste. Dhanorkar *et al*., (1994) [4] observed that increase in available K was not only due to enrichment of K by organic material application. Besides this, native K also become more available due to action of organic acids liberated during decomposition of organic matter.

DTPA extractable iron (mg kg^{-1})

The data on periodic observation on DTPA extractable iron (mg kg^{-1}) was presented in Table 7. DTPA extractable iron found to be varied from 31.64 to 36.85 mg kg^{-1} during the year 2021-22. Similarly, it showed variation from 31.58 to 35.87 mg kg^{-1} during the year 2022-23. The effect of different treatments on available Fe at all period of incubation was found to be non-significant.

Over extended period of time, gradual increase in DTPA extractable iron content in pots without crop was recorded from 30 DAI to 120 DAI. Alteration in pH can made impact on solubility of iron compounds, if pH shifted to conditions favouring iron solubility, this could result in an increase in DTPA extractable iron. Similar findings were reported by Modaihsh *et al*. (1989) [7].

Table 7: Effect of various fertilizers on DTPA extractable iron (mg kg^{-1})

Treatment	2021-22				2022-23			
	Period of incubation (days)				Period of incubation (days)			
	30	60	90	120	30	60	90	120
T_1	34.68	35.56	35.88	36.20	32.25	33.10	34.23	34.89
T_2	33.63	33.78	34.33	35.87	33.23	33.56	35.21	35.88
T_3	34.06	34.21	35.20	36.21	33.02	33.44	35.26	35.68
T_4	33.30	34.10	35.62	36.85	33.12	33.50	35.45	35.79
T_5	33.42	33.98	34.87	35.89	32.67	33.21	34.36	35.20
T_6	31.64	32.52	34.25	35.77	31.58	34.21	35.20	35.87
T_7	33.34	33.52	34.33	36.23	32.15	33.29	34.68	35.26
T_8	34.09	34.25	34.98	35.99	32.58	33.42	34.89	35.12
T_9	33.39	34.68	35.02	35.25	32.47	33.25	34.02	34.72
SE(m) ±	1.29	0.91	1.07	0.96	0.87	0.89	1.04	0.94
C. D. @ 1%	NS	NS	NS	NS	NS	NS	NS	NS

DTPA extractable manganese (mg kg^{-1})

The data on periodic observation on DTPA extractable manganese (mg kg^{-1}) was presented in Table 8. DTPA extractable manganese found to be varied from 71.05 to 102.79 mg kg^{-1} during the year 2021-22. Similarly, it showed variation from 72.33 to 99.97 mg kg^{-1} during the year 2022-23. All the treatments failed to produced statistically significant effect on DTPA extractable manganese in soil during both the years of investigation.

Table 8: Effect of various fertilizers on DTPA extractable manganese (mg kg^{-1})

Treatment	2021-22				2022-23			
	Period of incubation (days)				Period of incubation (days)			
	30	60	90	120	30	60	90	120
T_1	75.47	79.28	83.78	98.74	80.40	78.96	77.57	94.25
T_2	71.08	78.55	76.81	95.69	75.47	73.93	76.30	92.37
T_3	73.35	79.58	77.21	96.12	72.33	77.19	76.74	93.22
T_4	71.05	74.65	85.89	99.09	79.33	74.73	70.98	94.98
T_5	78.79	78.94	86.56	98.80	81.51	82.62	79.83	95.11
T_6	76.01	83.10	81.07	100.74	75.66	79.06	81.39	99.97
T_7	75.25	88.07	82.10	99.25	78.22	79.39	86.15	95.68
T_8	80.38	83.52	79.54	97.24	78.09	80.59	82.11	94.54
T_9	77.98	86.59	81.54	102.49	78.77	80.63	85.50	99.12
SE(m) ±	3.70	2.92	4.69	1.19	6.23	3.43	3.75	1.49
C. D. @ 1%	NS	NS	NS	NS	NS	NS	NS	NS

Over extended period of time, gradual increase in DTPA extractable manganese content in pots without crop was recorded from 30 DAI to 120 DAI. Alteration in pH can made impact on solubility of manganese compounds, if pH shifted to conditions favouring manganese solubility, this could result in an increase in DTPA extractable manganese. Another reason of increasing DTPA extractable manganese content is might be due to changes in redox conditions of soil can influence the solubility and availability of manganese. Similar findings were reported by Modaihsh *et al*. (1989) [7].

DTPA extractable zinc (mg kg^{-1})

The values of available Zn content in soil at different period of incubation as influenced by various treatments are given in Table 9.

At 30 Days after Incubation (DAI)

The treatment receiving application of 100 percent N through KAB fortified with 2 kg boron and 3 kg zinc ha^{-1} (T_7) recorded the significantly highest values 1.18 mg kg^{-1} of available Zn content of soil during the years 2021-22 and 2022-23, respectively and treatment (T_7) produced statistically significant effect over almost all the treatment combinations. However, it remained statistically at par with the treatments T_6 and T_8 during both the year.

Table 9: Effect of various fertilizers on DTPA extractable zinc (mg kg^{-1})

Treatment	2021-22				2022-23			
	Period of incubation (days)				Period of incubation (days)			
	30	60	90	120	30	60	90	120
T_1	0.86	1.17	1.01	0.84	0.81	1.12	1.01	0.81
T_2	0.87	1.19	0.96	0.88	0.84	1.18	0.87	0.82
T_3	0.81	1.18	0.91	0.83	0.77	1.15	0.87	0.87
T_4	0.75	1.17	0.96	0.85	0.70	1.13	0.81	0.83
T_5	0.68	1.14	0.94	0.87	0.66	1.09	0.87	0.83
T_6	1.06	1.31	1.03	0.89	1.11	1.29	0.98	0.93
T_7	1.18	1.37	1.39	1.07	1.18	1.33	1.35	1.10
T_8	1.08	1.31	1.33	0.99	1.10	1.27	1.28	1.00
T_9	0.93	1.18	1.09	0.90	0.90	1.15	1.04	0.90
SE(m) ±	0.05	0.05	0.08	0.03	0.06	0.04	0.09	0.04
C. D. @ 1%	0.14	0.14	0.23	0.09	0.17	0.13	0.28	0.12

At 60 Days after Incubation (DAI)

The available Zn status was found to be maximum (1.37 and 1.33 mg kg^{-1}) at 60 DAI in the treatment (T_7) receiving application of 100 percent N through KAB fortified with 2 kg boron and 3 kg zinc ha^{-1}. Application of 100 percent N through KAB fortified with 2 kg boron and 3 kg zinc ha^{-1} (T_7) showed statistically significant effect on Zn content over all the treatments during both the years of investigation except treatment T_6 and T_8. A critical examination of data further indicated that average available Zn content was higher at 60 DAI as compared to available Zn at 30 DAI during the 2021-22 and 2022-23 where zinc was applied.

At 90 Days after Incubation (DAI)

The highest available Zn found in the treatment of 100 percent N through KAB fortified with 2 kg boron and 3 kg zinc ha^{-1} treatment (T_7) and it showed statistically significant effect on available Zn status over all the treatments with exception of T_8 only during the 2021-22 and 2022-23.

At 120 Days after Incubation (DAI)

The maximum values 1.07 and 1.10 mg kg^{-1} of Zn content were observed in the treatment (T_7). The statistically analyzed data revealed that the zinc availability was varied at 120 DAI and T_7 showed at par results with T_8 treatment only during both the year.

It is clear from results that the zinc availability increased at 90 DAI as compared to 60 DAI and further tended to decrease with advancement of period of incubation in all treatments, it may be due to microbes might have taken up zinc for their growth and metabolic processes, leading to decrease in its availability in the soil. Another possible reason was microbes can immobilize zinc by incorporating it into their biomass, this may reduce the immediate availability of zinc to soil or initial source of zinc might have been depleted over time, leading to decrease in its availability. Decrease in DTPA extractable Zn in soil on flooded moisture condition may be due to their precipitation as hydroxides, hydroxy carbonates, sulphides and franklinite type of compounds in presence of excess amount of soluble Fe and Mn (Dutta *et al*., 1989) [5]. These findings are in agreement with the findings of Wijebandara *et al*. (2014) [12].

DTPA extractable copper (mg kg^{-1})

The data regarding periodic observation on DTPA extractable copper (mg kg^{-1}) was presented in Table 10. The DTPA extractable copper found to be varied from 10.35 to 11.91 mg kg^{-1} during the year 2021-22.

Table 10: Effect of various fertilizers on DTPA extractable copper (mg kg^{-1})

Treatment	2021-22				2022-23			
	Period of incubation (days)				Period of incubation (days)			
	30	60	90	120	30	60	90	120
T_1	11.21	11.73	11.23	10.89	9.23	9.02	8.76	8.21
T_2	11.91	11.78	11.10	10.68	9.20	8.98	8.69	8.32
T_3	11.55	11.33	10.98	10.65	9.50	9.16	8.69	8.34
T_4	11.77	11.78	11.20	10.55	8.74	8.36	8.30	7.90
T_5	11.53	11.41	11.02	10.75	8.77	8.35	8.15	7.87
T_6	11.36	11.04	10.75	10.39	8.67	8.26	8.20	7.70
T_7	11.22	11.01	10.88	10.55	8.48	8.36	8.15	7.56
T_8	11.21	11.46	11.09	10.56	7.88	8.02	7.96	7.45
T_9	11.28	11.30	10.60	10.35	8.41	8.22	8.06	7.59
SE(m) ±	0.17	0.18	0.29	0.28	0.24	0.23	0.21	0.21
C. D. @ 1%	NS	NS	NS	NS	NS	NS	NS	NS

The available Cu content in soil at 30, 60, 90 and 120 DAI was found to be non-significant. Over extended period of time, gradual decrease in DTPA extractable copper content in pots without crop was recorded from 30 DAI to 120 DAI. This might be due to over period of time, copper may undergo chemical reactions in the soil and forming complexes or precipitating with other compounds or it may be due to, immobilization of copper by microbes causing decline in DTPA extractable copper content in the soil. Similar decreasing trend were reported by Yang *et al*. (2002) [13].

Hot water extractable boron (mg kg^{-1}): The periodic availability of B as influenced by various treatments are given in Table 11.

At 30 Days after Incubation (DAI)

The available boron was found maximum in the treatment T_7 and minimum in T_1 and T_4, during both the year of investigation, respectively. Application of 100 percent N through KAB fortified with 2 kg boron and 3 kg zinc ha^{-1} treatment (T_7), showed significantly higher hot water extractable boron status over all the treatments with exception of T_6 during 2021-22 and T_6 and T_8 during 2022-23, respectively.

Table 11: Effect of various fertilizers on hot water extractable boron (mg kg^{-1})

Treatment	2021-22				2022-23			
	Period of incubation (days)				Period of incubation (days)			
	30	60	90	120	30	60	90	120
T_1	0.80	0.81	0.83	0.96	0.44	0.44	0.50	0.51
T_2	1.01	1.25	1.28	1.26	0.49	0.54	0.67	0.68
T_3	1.11	1.22	1.27	1.28	0.45	0.48	0.64	0.66
T_4	1.05	1.23	1.29	1.25	0.41	0.46	0.65	0.66
T_5	0.87	0.99	1.15	1.10	0.46	0.37	0.51	0.60
T_6	1.37	1.46	1.53	1.55	0.67	0.69	0.77	0.86
T_7	1.51	1.63	1.69	1.72	0.72	0.74	0.84	1.08
T_8	1.25	1.33	1.41	1.43	0.60	0.64	0.78	1.00
T_9	1.15	1.21	1.28	1.27	0.52	0.57	0.66	0.84
SE(m) ±	0.07	0.10	0.11	0.10	0.05	0.04	0.03	0.03
C. D. @ 1%	0.21	0.30	0.34	0.30	0.14	0.11	0.08	0.09

At 60 Days after Incubation (DAI)

At 60 DAI, the treatment receiving application of 100 percent N through KAB fortified with 2 kg boron and 3 kg zinc ha^{-1} (T_7) recorded the significantly highest values 1.63 and 0.74 mg kg^{-1} of hot water extractable boron content of soil during the years 2021-22 and 2022-23, respectively and treatment (T_7) produced statistically significant effect over almost all the treatment combinations. However, it remained statistically at par with the treatments T_6 and T_8 during both the year.

At 90 Days after Incubation (DAI)

The highest values 1.69 and 0.84 mg kg^{-1} of hot water extractable boron content of soil were observed in the treatment receiving application of 100 percent N through KAB fortified with 2 kg boron and 3 kg zinc ha^{-1} (T_7) during the years 2021-22 and 2022-23, respectively and found to be statistically significant over all the treatments with exception of T_6 and T_8 during the both year.

At 120 Days after Incubation (DAI)

The hot water extractable boron status was found to be maximum (1.72 and 1.08 mg kg^{-1}) at 120 DAI in the treatment (T_7) receiving application of 100 percent N through KAB fortified with 2 kg boron and 3 kg zinc ha^{-1}, while the lowest values (0.96 and 0.51 mg kg^{-1}) of hot water extractable boron content were seen in the treatment absolute control (T_1). Application of 100 percent N through KAB fortified with 2 kg boron and 3 kg zinc ha^{-1} (T_7) showed statistically significant effect on hot water extractable boron content over all the treatments during 2021-22 except T_6 and T_8 treatment and during 2022-23 T_8 remained at par with T_7 treatment.

A critical examination of data further indicated that average hot water extractable boron content was higher at 120 DAI as compared to hot water extractable boron at 30, 60 and 90 DAI during both years. It may be due to, over time, certain soil minerals may slowly release boron into the soil solution. This could contribute to an increase in boron content in the absence of crop uptake or boron-containing fertilizers were applied at the beginning of the experiment, they may continue to release boron into the soil throughout the study, leading to an increase in boron content over time. The availability of B in the soil was mainly influenced by the dynamics of B fractions in the soil. Addition of organic amendments enhanced the readily available and specifically adsorbed B fractions in the soil and thereby increased B availability (Ajayan and Thampatti, 2021) [1].

Conclusion

In conclusion, the highest content of available N, P_2O_5, Zn and B at 30, 60, 90 and 120 DAI was observed in the treatment comprised of 100 percent N through Konkan Annapurna Briquettes (KAB) fortified with 2 kg boron and 3 kg zinc ha^{-1} and highest Avail. K_2O was observed in the treatment comprised of Recommended dose of fertilizer + 2 kg boron and 3 kg zinc ha^{-1}.

References

1. Ajayan AS, Thampatti MKC. Boron dynamics in red loam soil amended with different organic fertilizers. International Collegiate Journal of Science. 2021;9(1):1071-1076.
2. Bolan NS, Hedley MJ, White RE. Processes of soil acidification during nitrogen cycling with emphasis on legume-based pastures. Plant and Soil. 1991;134(1):53-63.
3. Cabrera ML, Kissel DE, Vigil MF. Nitrogen mineralization from organic residues. Journal of Environmental Quality. 2005;34:75-79.
4. Dhanorkar BA, Borkar DK, Puranik RB, Joshi RP. Forms of soil potassium as influenced by long-term application of FYM and NPK in Vertisol. Journal of Potassium Research. 1994;10:42-48.
5. Dutta D, Mandal B, Mandal LN. Decrease in availability of zinc and copper in acidic to near neutral soils on submergence. Soil Science. 1989;147:187-195.
6. Lal JK, Mishra B, Sarkar AK. Effect of Plant Residues incorporation on specific microbial groups and availability of some plant nutrients in soil. Journal of the Indian Society of Soil Science. 2000;48:67-71.
7. Modaihsh AS, Al-Mustafa WA, Metwally AI. Effect of elemental sulphur on chemical changes and nutrient availability in calcareous soils. Plant and Soil. 1989;116:95-101.
8. Roy S, Kashem M. Effects of organic manures in changes of some soil properties at different incubation periods. Open Journal of Soil Science. 2014;4:81-86.
9. Surin P, Supsuan P, Yampracha S. Release of various elements from organic fertilizers incubated in organic and non-organic paddy soils at various time periods. Current Applied Science and Technology. 2019;19:276-288.
10. Uddin S, Islam MR, Jahangir MMR, Rahman MM, Hassan S, Hassan MM, *et al.* Nitrogen release in soils amended with different organic and inorganic fertilizers

under contrasting moisture regimes: A laboratory incubation study. Agronomy. 2021;11(11):2163.
11. Vanitha P, Indirani R, Saravana PP, Rajamanickam C. An incubation study on the releasing pattern of phosphorus in conjoint with organic manures and bio inoculants in red soil (Typic Rhodustalfs). Journal of Pharmacognosy and Phytochemistry. 2020;9(6):188-190.
12. Wijebandara DMDI, Dasog GS, Patil PL. Transformation of applied Zn in a flooded soil in a rainfed ecosystem. Journal of The Soil Science Society of Sri Lanka. 2014;24:1-8.
13. Yang XE, Long XX, Ni WZ, Ye ZQ, He ZL, Stoffella PJ, *et al*. Assessing copper thresholds for phytotoxicity and potential dietary toxicity in selected vegetable crops. Journal of Environmental Science and Health. 2002;37(6):625-35.