Indian Journal of Agriculture and Allied Sciences
A Refereed Research Journal

ISSN 2395-1109
Volume: 1, No.: 4, Year: 2015

Received: 06.11.2015, Accepted: 16.12.2015

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH, YIELD AND NUTRIENTS AVAILABILITY OF RAJMASH IN ACID SOILS OF NAGALAND

T. Esther Longkumer* and P. K. Singh

Department of Agricultural Chemistry and Soil Science, SASRD, Nagaland University, Medziphema, Nagaland, 797106. India, Corresponding Author: T.Esther Longkumer

Abstract: *At the demonstration field of Krishi Vigyan Kendra (KVK) at Porba village, Phek District, Nagaland entitled "Effect of Integrated Nutrient management on soil properties, growth, and yield of Rajmash in acid soils of Nagaland". The field experiment was laid out in randomized block design (RBD) with three replications and 18 treatments. The integrated treatments involving both organic and inorganic fertilizer influenced favourably the fertility status of the soil as compared to the control. Available N (331.26 kg ha^{-1} and 324.11 kg ha^{-1}) and P (21.46 kg ha^{-1} and 21.33 kg ha^{-1}) content of the soil in both the experimental years was found to be highest in treatment T_{18} (5 ton FYM + Biofertilizer + Lime + 100% NPK). INM practices increased both growth and yield attributes. Organic source of fertilizer along with chemical fertilizer influenced the growth attributes of rajmash than those supplied through chemical fertilizers only, where, T_{17} (5 ton FYM + Biofertilizer + Lime + 50% NPK) recorded the highest total N, P and K uptake in both the years. In respect of grain and stover yield for both the years, the application of 5 ton FYM + Biofertilizer + Lime + 50% NPK gave the highest grain (9.65 q ha^{-1} and 9.58 q ha^{-1}) and stover (10.20 q ha^{-1} and 10.46 q ha^{-1}) yield respectively as compared to the other treatments.*

Keywords: *FYM, NPK, Lime, Nutrient availability, Growth, and Yield of Rajmash.*

Introduction: Among pulse crop, Rajmash is becoming popular with the farmers due to its high profit in comparison to other pulses and unlike other pulse crop; Rajmash is a stable cash crop free from insect pests and diseases. Rajmash (*Phaseolus vulgaris* L) belongs to the Leguminasae family and is also known as French bean, kidney bean, common bean.

In Nagaland, kholar bean is cultivated over an area of 14840 hectares with an annual production of 18590 MT [1].The soils of Nagaland having diversified topography and landscape are generally acidic in reaction and the major problems are shifting cultivation practices, acidity, low base status and landslides in hill slopes. Under the prevailing acidity, productivity of various crops is much low due to non-availability and toxicity of some nutrients. To combat this problem, the maintenance of soil fertility is to be relied upon regulation of natural soil processes and use of certain mineral additives besides addition of organic manures.

Hence, integration of chemical and organic sources and their management have shown promising results not only in sustaining the productivity but have also proved to be effective in maintaining soil health and enhancing nutrient use efficiency [2 & 3]. The present study was undertaken to study the effect of integrated nutrient management on growth, yield and nutrient availability of rajmash in acid soils of Nagaland.

Materials and Methods

The experiment was conducted during the *kharif* season of 2012 and 2013 at the demonstration farm of Krishi Vigyan Kendra at Porba Village, Phek District, Nagaland. The farm is located at latitude of 25°62'N and longitude of 95°33'E and at an elevation of 1842 m above the mean sea level. The experiment was laid out in randomized block design (RBD) with three replications. The treatments comprised of 18 treatments viz., T_1- Control, T_2- 50% NPK, T_3- 100% NPK, T_4- Biofertilizer, T_5 -Biofertilizer + 50% NPK, T_6- Biofertilizer + 100% NPK, T_7-

Biofertilizer + Lime, T_8-Biofertilizer + Lime + 50% NPK, T_9- Biofertilizer + Lime + 100% NPK, T_{10} – 5 ton FYM, T_{11} –5 ton FYM + 50% NPK, T_{12} –5 ton FYM + 100% NPK, T_{13}- 5 ton FYM + Biofertilizer, T_{14}- 5 ton FYM + Biofertilizer + 50% NPK, T_{15}-5 ton FYM + Biofertilizer + 100% NPK, T_{16}- 5 ton FYM + Biofertilizer + Lime, T_{17}- 5 ton FYM + Biofertilizer + Lime + 50% NPK and T_{18}- 5 ton FYM + Biofertilizer + Lime + 100% NPK. Different doses of nutrients were applied through different sources as per the need of the treatments. The recommended level (100%) of N (Urea), P (Single super phosphate) and K (Muriate of potash) are100, 40 and 20 kg ha^{-1} respectively. Initial values of soil as Available N-238.55 kg ha^{-1} (Alkaline Potassium Permanganate method) and Available P-8.20 kg ha^{-1} (Bray and Kurtz No. 1). The observation on various growth parameters were recorded at 30, 60 and 90 days after sowing. Yield attributes and yield were recorded at harvest. Grain and stover yield were expressed in terms of quintal per hectare.

Nutrient Status of the Soil: Results on status of available N, P and K of the soil at the end of the experimental period are presented in the Table 1. By and large, integrated treatments improved available nutrient status of soil of soil as against chemical treatments.

Table 1.: Effect of integrated nutrient management on available N and available P after the harvest of Rajmash.

	Available N (kg ha^{-1})			Available P (kg ha^{-1})		
Treatment	2012	2013	Pooled	2012	2013	Pooled
T_1- Control	240.56	228.53	234.55	10.90	9.48	10.19
T_2- 50% NPK	261.31	244.63	252.97	13.20	10.97	12.09
T_3- 100% NPK	271.77	262.42	267.10	14.78	11.50	13.14
T_4- Biofertilizer	276.96	269.40	273.18	12.92	10.82	11.87
T_5 -Biofertilizer + 50% NPK	278.17	275.32	276.75	13.87	12.05	12.96
T_6- Biofertilizer + 100% NPK	280.31	282.22	281.27	14.27	12.62	13.44
T_7- Biofertilizer + Lime	282.91	284.90	283.90	13.34	11.96	12.65
T_8-Biofertilizer + Lime + 50% NPK	287.40	287.68	287.55	14.00	12.84	13.42
T_9- Biofertilizer + Lime + 100% NPK	287.54	290.05	288.79	14.68	12.93	13.81
T_{10} – 5 ton FYM	288.71	292.83	290.77	13.92	12.02	12.97
T_{11} –5 ton FYM + 50% NPK	291.54	292.44	291.99	15.53	13.28	14.41
T_{12} –5 ton FYM + 100% NPK	299.04	301.97	300.51	16.23	13.86	15.04
T_{13}- 5 ton FYM + Biofertilizer	294.93	297.84	296.39	16.02	12.75	14.38
T_{14}- 5 ton FYM + Biofertilizer + 50% NPK	293.50	288.18	290.84	16.08	13.85	14.97
T_{15}- 5 ton FYM + Biofertilizer + 100% NPK	302.29	306.54	304.42	17.04	14.07	15.55
T_{16}- 5 ton FYM + Biofertilizer + Lime	300.81	301.94	301.38	16.04	13.11	14.58
T_{17}- 5 ton FYM + Biofertilizer + Lime+ 50% NPK	309.13	316.95	313.04	19.04	14.76	16.90
T_{18}- 5 ton FYM + Biofertilizer + Lime+ 100% NPK	331.26	324.11	327.69	21.46	21.33	21.39
Initial value	242.89	-	-	8.20	-	-
SEm±	3.80	3.18	2.99	0.68	0.30	0.35
CD (P=0.05)	10.91	9.18	8.59	1.97	0.86	1.00

Available N: In 2012, the available N content due to different treatments varied from 240.56 to 331.26 kg ha^{-1} after the harvest of the crop. The highest available nitrogen was observed in the treatment T_{18} (5 ton FYM + Biofertilizer + Lime + 100% NPK) giving a value of 331.26 kg ha^{-1} followed by T_{17} (5 ton FYM + Biofertilizer + Lime + 50% NPK) as 309.13 kg ha^{-1}, T_{15} (302.29 kg ha^{-1}), T_{16} (300.81 kg ha^{-1}) and T_{12} (299.04 kg ha^{-1}), and while the lowest under the control giving 240.56 kg ha^{-1}. Similarly, during the second year (2013), the highest available nitrogen was recorded in T_{18} (5 ton FYM + Biofertilizer + Lime + 100% NPK) as 324.11 kg ha^{-1} which was at par with the treatment T_{17} (316.95 kg ha^{-1}) and the lowest in T_1 (control) as 228.53 kg ha^{-1}.

Further analysis from the pooled data revealed that the maximum available N (327.69 kg ha^{-1}) was also obtained from 5 ton FYM + Biofertilizer + Lime + 100% NPK while control recorded the minimum available N (234.55 kg ha^{-1}).

In general, the available N was found to be higher in the integrated treatments vis-à-vis chemical treatments after the harvest of rajmash crop in both the experimental period. This might be due to increase in organic matter content of the soil which undergoes mineralization coupled with hydrolysis of urea creating a favourable condition for residual N balance in soil. Such an increase in available N was also observed [4 & 5]. Among the different integrated treatments, 5ton FYM+ biofertilizer + lime+ 100% NPK followed by 5ton FYM+ biofertilizer + lime+ 50% NPK showed the highest available nitrogen content in the soil. Though combination of FYM, lime, biofertilizer and inorganic fertilizer revealed better N availability, but this is true in all the INM treatments than that of chemical fertilizer alone. The increase in available N under INM treatments would also be due to the

multiplication of soil microbes leading to enhanced conversion of organically bound N into organic forms and rapid mineralization leading to higher available N [6]. It also observed that available N content in soil increased with the use of recommended dose of fertilizer in combination with manure [7].

Available P: Data on available P content of soil showed that different treatments significantly influenced the available P content of the soil. Initial available P content of the soil as recorded in 2012 was very low as (8.20 kg ha^{-1}). Available P content of the soil ranged from 10.90 to 21.46 kg ha^{-1}, with the highest value of 21.46 kg ha^{-1} recorded in the treatment T_{18} (5 ton FYM + Biofertilizer + Lime + 100% NPK) which was followed by T_{17} (5 ton FYM + Biofertilizer + Lime + 50% NPK) as 19.04 kg ha^{-1}.

Similarly, in 2013 the maximum (21.33 kg ha^{-1}) was recorded in T_{18} (5 ton FYM + Biofertilizer + Lime + 100% NPK) followed by T_{17} (5 ton FYM + Biofertilizer + Lime + 50% NPK) with a value of 14.76 kg ha^{-}1.The pooled data revealed that the maximum available P (21.39 kg ha^{-1}) was obtained from 5 ton FYM + Biofertilizer + Lime + 100% NPK while control recorded the minimum available P (10.19 kg ha^{-1}).

In the integrated treated plots available P content of soil was found to be increase over the initial value which might be due to additional P incorporation through organic sources which released P and thus increased its availability in soil. This result corroborates with the findings of [8 & 9]. During decomposition of organic manure, various organic acids will be produced which solubulize phosphatase and other phosphate bearing minerals and thereby lowers the phosphate fixation and increase its availability. Such an increase in available P was also observed by [10 & 11].

Moreover, the control plot having no fertilizer showed higher available P as compared to initial. This is attributed to the fact that the control plot received shoot biomass and considerable amount of root biomass of the crop. During the decomposition of the biomass by microorganisms, unavailable form of native P might have become available to plants. These results are in conformity with the findings [12 & 13].

Growth and Yield Parameters

Plant Height (cm): The observation on the height of rajmash as influenced by different treatment of INM were recorded at an interval of 30, 60 and 90 after sowing and presented in Table 2.a. At 30 DAS, it was apparent that the plant height increased at all stages of the growth with different treatments of INM. The maximum plant height was recorded from treatment T_{17} with 17.94cm (2012) followed by treatment T_{18} (17.23 cm) and the lowest being recorded under control as 9.69 cm. During the second year of experimentation, the highest plant height was found in the INM treated plot as 17.68 cm in T_{17} (5 ton FYM, Biofertilizer, Lime and 50% NPK) and the lowest being observed under control treatment as 9.68 cm.

Table.2.a: Effect of integrated nutrient management on the plant height (cm) of Rajmash.

	30 DAS			60 DAS			90 DAS		
Treatment	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
T_1- Control	9.69	9.68	9.69	19.59	16.93	18.26	25.33	24.24	24.78
T_2- 50% NPK	11.28	10.05	10.66	20.10	19.12	19.61	26.50	25.27	25.89
T_3- 100% NPK	11.52	10.57	11.04	20.84	20.11	20.48	27.93	27.62	27.78
T_4- Biofertilizer	11.51	11.18	11.35	21.52	20.80	21.16	28.65	28.54	28.60
T_5 -Biofertilizer + 50% NPK	12.29	11.67	11.98	22.62	21.60	22.11	29.02	29.06	29.04
T_6- Biofertilizer + 100% NPK	12.63	12.51	12.57	23.55	22.56	23.05	30.31	30.14	30.23
T_7- Biofertilizer + Lime	12.94	13.12	13.03	23.45	22.79	23.12	30.75	30.90	30.83
T_8-Biofertilizer + Lime + 50% NPK	13.41	13.98	13.70	24.11	23.52	23.82	32.63	32.20	32.42
T_9- Biofertilizer + Lime + 100% NPK	13.41	14.58	14.00	24.57	24.48	24.53	33.04	33.70	33.37
T_{10} - 5 ton FYM	14.59	14.74	14.66	25.10	25.42	25.26	33.87	34.13	34.00
T_{11} –5 ton FYM + 50% NPK	15.25	15.12	15.19	25.74	25.46	25.60	34.27	35.34	34.81
T_{12} –5 ton FYM + 100% NPK	15.83	15.61	15.72	26.41	26.37	26.39	34.73	35.68	35.21
T_{13}- 5 ton FYM + Biofertilizer	15.95	16.05	16.00	27.43	26.61	27.02	35.48	36.49	35.99
T_{14}- 5 ton FYM + Biofertilizer + 50% NPK	16.53	15.99	16.26	28.72	27.48	28.10	36.35	37.66	37.00
T_{15}- 5 ton FYM + Biofertilizer + 100% NPK	16.37	16.40	16.38	29.24	28.27	28.76	36.60	39.09	37.85
T_{16}- 5 ton FYM + Biofertilizer + Lime	16.57	17.21	16.89	29.71	28.75	29.23	36.96	39.66	38.31
T_{17}- 5 ton FYM + Biofertilizer + Lime+ 50% NPK	17.94	17.68	17.81	33.09	32.18	32.64	38.47	41.59	40.03
T_{18}- 5 ton FYM + Biofertilizer + Lime+ 100% NPK	17.23	17.40	17.31	32.27	30.07	31.17	37.43	40.08	38.76
SEm±	0.20	0.24	0.15	0.40	0.55	0.38	0.32	0.58	0.34
CD (P=0.05)	0.59	0.70	0.42	1.16	1.59	1.10	0.91	1.67	0.98

At 60 DAS, variations in plant height were observed to be significant with the control plot and the lowest plant height was recorded from control plot as 19.59cm (2012) and 16.93

cm (2013). It was found that the highest rate of increase in plant height in 2012 was recorded with the INM treated plot as 33.09 cm followed by treatment T_{18} (32.27 cm) and in 2013 as 32.18 cm under treatment T_{17} (5 ton FYM + Biofertilizer + Lime+ 50% NPK).

At 90 DAS, treatment T_{17} showed the highest plant height as 38.47cm in 2012 and 41.59 cm in 2013 while the control plot recorded the minimum i.e 25.33 cm (2012) and 24.24 cm (2013). From the pooled data (2012 and 2013), it was apparent that from T_{17} (5 ton FYM + Biofertilizer + Lime + 50% NPK) obtained the highest plant height (40.03 cm) in soil after harvest and the lowest as (24.78 cm) in the control plot. Results from the pooled data of 2012 and 2013, showed that highest plant height (17.81 cm) was recorded in T_{17} (5 ton FYM + Biofertilizer + Lime + 50% NPK). Minimum plant height (9.69 cm) was recorded from control.

The plant height was observed to be highest in the INM treated plot in both the experimental years as compared to control which might be due to the improvement in soil physical condition provided for plant growth and also due to increased availability of nutrients especially N, P_2O_5 and K_2O from the early stages of crop. Phosphorus fertilization improved the root system in French bean which in turn helped more assimilation of nutrients resulting in increased growth. These findings corroborates with the findings of [14 & 15].

Table.2.b: Effect of integrated nutrient management on the number of branches per plant of Rajmash.

	30 DAS			60 DAS			90 DAS		
Treatment	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
T_1- Control	3.00	2.73	2.87	3.27	3.17	3.22	3.31	3.17	3.24
T_2- 50% NPK	3.07	2.87	2.97	3.33	3.23	3.28	3.41	3.23	3.32
T_3- 100% NPK	2.80	2.97	2.88	3.27	3.37	3.32	3.26	3.57	3.41
T_4- Biofertilizer	3.27	3.33	3.30	3.33	3.47	3.40	3.17	3.43	3.30
T_5 -Biofertilizer + 50% NPK	3.40	3.47	3.43	3.67	3.90	3.78	3.64	3.60	3.62
T_6- Biofertilizer + 100% NPK	3.53	3.57	3.55	4.17	4.23	4.20	4.19	4.13	4.16
T_7- Biofertilizer + Lime	3.60	3.63	3.62	4.10	4.53	4.32	4.37	4.10	4.23
T_8-Biofertilizer + Lime + 50% NPK	3.73	3.73	3.73	4.40	4.37	4.38	4.37	4.40	4.38
T_9- Biofertilizer + Lime + 100% NPK	3.80	3.87	3.83	4.23	4.77	4.50	4.47	4.23	4.35
T_{10} - 5 ton FYM	3.87	3.93	3.90	4.13	4.50	4.32	4.56	4.50	4.53
T_{11} –5 ton FYM + 50% NPK	4.07	4.23	4.15	4.27	4.67	4.47	4.40	4.20	4.30
T_{12} –5 ton FYM + 100% NPK	4.20	4.50	4.35	4.30	5.03	4.67	4.37	5.00	4.68
T_{13}- 5 ton FYM + Biofertilizer	4.33	4.47	4.40	4.67	4.97	4.82	4.67	5.33	5.00
T_{14}- 5 ton FYM + Biofertilizer + 50% NPK	4.53	4.67	4.60	4.67	4.77	4.72	5.20	5.10	5.15
T_{15}- 5 ton FYM + Biofertilizer + 100% NPK	4.73	4.77	4.75	5.13	5.27	5.20	5.38	4.97	5.17
T_{16}- 5 ton FYM + Biofertilizer + Lime	4.77	4.87	4.82	4.93	5.27	5.10	5.10	5.20	5.15
T_{17}- 5 ton FYM + Biofertilizer + Lime+ 50% NPK	5.17	5.30	5.23	5.53	5.47	5.50	5.10	5.17	5.13
T_{18}- 5 ton FYM + Biofertilizer + Lme+ 100% NPK	4.93	5.77	5.35	5.20	4.87	5.03	4.57	4.63	4.60
SEm±	0.11	0.24	0.10	0.15	0.08	0.07	0.13	0.12	0.09
CD (P=0.05)	0.32	0.68	0.30	0.43	0.24	0.21	0.39	0.34	0.26

Number of Branches per Plant: Results of the influence of INM on number of branches per plant at 30, 60 and 90 DAS are presented in Table 2 (b).

At 30 DAS, highest number of branches per plant was recorded from treatment T_{17} (5 ton FYM + Biofertilizer + Lime + 50% NPK) with 5.17 which was at par with the treatment T_{18} as 4.93 and the lowest being recorded under control treatment as 3.00 in the first year of experimentation. In 2013, the highest number of branches per plant was recorded from treatment T_{18} with 5.77 which was at par with the treatment T_{17} as 5.30, while the lowest was recorded under control treatment as 2.73.

At 60 DAS, numbers of branches per plant were observed to be significant and the minimum number of branches per plant was recorded from control plot and T_3 as 3.27 in 2012 and in 2013 under control as 3.17. The maximum number of branches per plant was recorded in 2012 as 5.53 and in 2013 as 5.47 in T_{17}.

At 90 DAS, the maximum number of branches per plant was observed as 5.38 under the treatment T_{15} (5 ton FYM + Biofertilizer + 100% NPK) and was found to be statistically at par with the treatments $T_{14,}$ T_{16} and T_{17} (5.20, 5.10 and 5.10) in 2012 and in 2013 maximum number of branches per plant recorded as 5.33 under treatment T_{13} followed by T_{16}. The lowest number of branches per plant was recorded as 3.17 in both the years of experimentation. Results from the pooled data, showed that highest number of branches per plant (5.17) was recorded in T_{15} (5 ton FYM + Biofertilizer + Lime). Minimum number of branches per plant (3.24) was recorded from control plot.

Table 3: Effect of integrated nutrient management on the grain and stover yield of Rajmash.

	Grain yield (q ha^{-1})			Stover yield (q ha^{-1})		
Treatment	2012	2013	Pooled	2012	2013	Pooled
T_1- Control	5.15	5.22	5.19	8.16	8.22	8.19
T_2- 50% NPK	6.64	6.97	6.81	8.19	8.28	8.24
T_3- 100% NPK	7.23	7.25	7.24	8.23	8.32	8.27
T_4- Biofertilizer	6.54	6.54	6.54	8.28	8.34	8.31
T_5 -Biofertilizer + 50% NPK	7.29	7.31	7.30	8.41	8.44	8.42
T_6- Biofertilizer + 100% NPK	7.26	7.61	7.44	8.50	8.55	8.53
T_7- Biofertilizer + Lime	7.09	7.17	7.13	8.63	8.62	8.63
T_8-Biofertilizer + Lime + 50% NPK	8.43	8.38	8.41	8.72	8.76	8.74
T_9- Biofertilizer + Lime + 100% NPK	7.98	7.96	7.97	8.78	8.82	8.80
T_{10} – 5 ton FYM	7.34	7.26	7.30	8.90	8.90	8.90
T_{11} –5 ton FYM + 50% NPK	7.82	7.96	7.89	9.18	9.04	9.11
T_{12} –5 ton FYM + 100% NPK	8.21	8.19	8.20	9.37	9.18	9.28
T_{13}- 5 ton FYM + Biofertilizer	7.34	7.44	7.39	9.61	9.47	9.54
T_{14}- 5 ton FYM + Biofertilizer + 50% NPK	8.83	8.68	8.76	9.61	9.71	9.66
T_{15}- 5 ton FYM + Biofertilizer + 100% NPK	8.47	8.43	8.45	9.82	9.90	9.86
T_{16}- 5 ton FYM + Biofertilizer + Lime	8.13	8.02	8.08	9.99	10.09	10.04
T_{17}- 5 ton FYM + Biofertilizer + Lime+ 50% NPK	9.65	9.58	9.62	10.20	10.46	10.33
T_{18}- 5 ton FYM + Biofertilizer + Lime+ 100% NPK	8.45	8.76	8.61	10.10	10.25	10.18
SEm±	0.20	0.20	0.09	0.09	0.05	0.05
CD (P=0.05)	0.58	0.56	0.27	0.26	0.16	0.14

Grain Yield: It is evident from the data presented in Table 3, that the grain yield of rajmash was found to be higher in 1st year as compared to 2nd year and affected significantly due to effect of different treatments of INM. In 2012, the grain yield of the system as a whole ranged from 5.15 to 9.65 q ha^{-1}. The highest grain yield (9.65 q ha^{-1}) was recorded in the treatment T_{17} followed by T_{14} (8.83 q ha$^{-1)}$ and T_{18} (8.45 q ha^{-1}) and the lowest (5.15 q ha^{-1}) under the control. Whereas in the second year of experimentation (2013), it showed the highest grain yield with 9.58 q ha^{-1} (T_{17}) followed by T_{18} (8.76 q ha^{-1}) and T_{14} (8.68 q ha^{-1}). The lowest grain yield being found under control as 5.22 q ha^{-1}.

Further analysis of the mean pool data of 2012 and 2013 revealed that the maximum grain yield was recorded from T_{17} (5 ton FYM + Biofertilizer + Lime + 50% NPK) (9.62 q ha^{-1}) which was significantly superior over the rest of the treatments.

The higher yield under integrated use of organics with NPK fertilizers as compared to the chemical fertilizers alone may be ascribed to balanced use of essential nutrients besides improvement in soil health coupled with higher assimilation of nutrients. This result is in conformity with the findings of [16 & 17].

Stover Yield: Results of the influence of INM on the stover yield are depicted in Table 3. Data of both the years of experimentation showed significant influence of the different treatments on the stover yield.

In the first year (2012), 5 ton FYM + Biofertilizer + Lime + 50% NPK increased the stover yield with a maximum of 10.20 q ha^{-1} and was found to be statistically at par with the treatments T_{16} (9.99) and T_{18} (10.10) and the control plot recorded the lowest stover yield with 8.16 q ha^{-1}. A similar trend was recorded for the second year (2013) giving the stover yield as 10.46 q ha^{-1}, while the lowest (8.22 q ha^{-1}) was recorded under the control which was found to be at par with the treatments T_2 (8.28), T_3 (8.32) and T_4 (8.34).

Data from pooled analysis (2012 and 2013) of stover yield of rajmash recorded that the maximum stover yield was recorded from T_{17} (5 ton FYM + Biofertilizer + Lime + 50% NPK) as 10.33 q ha^{-1}) and the lowest was recorded under control (8.19 q ha^{-1}).

Results on the stover yield indicated that there was slight increase in the integrated treated plots. This might be ascribed due to better utilization of nutrients from the soil that resulted proper vegetative growth and increased stover yield. The plot receiving 100% NPK applied through inorganic sources of fertilizers also showed a high straw yield which might be due to more vegetative growth resulting from higher dose of applied nitrogenous fertilizers. This corroborates the findings of [18].

Summary and Conclusion

1. Maximum increase in available N in soil (331.26 kg ha^{-1} in 2012 and 324.11 kg ha^{-1} in 2013) was found with T_{18} (5 ton FYM + Biofertilizer + Lime+ 100% NPK). Available P content of the soil showed significantly higher value in all treatments over the initial value. Among the treatments, the treatment receiving 5 ton FYM + Biofertilizer + Lime + 100% NPK in both the experimental year showed the highest P

content of the soil (10.90 to 21.46 kg ha^{-1} in 2012 and 9.48-21.33 kg ha^{-1} in 2013).

2. In respect of grain and stover yield for the year of experimentation (2012 and 2013), the application of 5 ton FYM + Biofertilizer + Lime + 50% NPK (T_{17}) gave the highest grain (9.65q ha^{-1}in 2012 and 9.58 q ha^{-1} in 2013) and stover yield (10.20 q ha^{-1} in 2012 and 10.46 q ha^{-1} in 2013) as compared to the other treatments.

Considering sustainability of soil health, crop yield, treatments involving use of 5 ton FYM + Biofertilizer + Lime + 50% NPK (T_{17}) may be recommended for growing rajmash in the acid soil of Nagaland under Sub Alpine Temperate agro-climatic condition.

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