J. Sylhet Agril. Univ. 4(2):191-198, 2017 **ISSN: 2308-1597**

GROWTH AND YIELD OF COWPEA UNDER INTEGRATED NUTRIENT MANAGEMENT PRACTICES

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(Available online at: www.jsau.com.bd)

Abstract

A field experiment was carried out on Chandragonj soil group of AEZ-17 at Gabua, Noakhali to conserve soil fertility through integrated nutrient management practices during November 2012 to April 2013 under integrated nutrient management practices. Cowpea cv. Bari Fallon-1 was cultivated under six fertilizer management practices viz. soil test based chemical fertilizer dose (T1), chemical fertilizer along with cow dung @ 5 t ha^{-1} (T2), chemical fertilizer along with dhaincha @ 0.6 t ha^{-1} (T3), chemical fertilizer along with bio-fertilizer inoculums @ 1.6 t ha^{-1} (T4), farmer's practice (T5), and control (T6). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Results was revealed that plant height increased up to 120 days after sowing (DAS) and the highest plant height was found in T4, T2 and T1 practices, followed by T3. The highest branches $plant^{-1}$ was found in T2, T1, and T3 followed by T4. The highest effective plants $plot^{-1}$ were found in T3 followed T2 and T6. The nodule numbers $plant^{-1}$ increased from 45 DAS to 75 DAS and then declined up to 105 DAS where nodule numbers of the T2, T3 and T4 were similar. The highest total fresh weight was found in T4 and T2 practices, whereas the highest total dry matter (TDM) was in T2, followed by T3 and T4 approaches. T5 practice allocated the maximum dry matter into leaves and roots, T2 and T3 allocated into stem, whereas T1, T2 and T4 allocated statistically similar amount of dry matter into pod. The longest pod was in T1 and T4 practices followed by T3 and T2 practices. The highest number of pods $plant^{-1}$ was in T4 practice followed by T3; while the highest number of seeds pod^{-1} were in T3, followed by T4 practice. The maximum seed weight $plant^{-1}$ was in T4, followed by T1, T2, T3 and T6. The highest thousand seed weight was in T1 practice. The highest seed-pod ratio percentage was in T4 and the lowest ratio was in T5. The maximum seed dry weight as well as shoot dry weight $plot^{-1}$ was in T2, followed by T3. The highest seed-shoot ratio was achieved in T1, followed by T4 and the lowest seed-shoot ratio was found in T5. The highest seed yield was obtained from T3 followed by T2 and T4. Prior to the experiment, total N and available P was below to the critical limit, whereas after conduction of the experiment all of nutrient elements studied was found in increased amount. Results revealed that chemical fertilizer along with dhaincha (*Sesbania esculenta*) @ 0.6 t ha^{-1} showed the best seed yield (2.445 t ha^{-1}). Soil test based chemical fertilizer dose and IPNS practices improved the fertility of the soils than farmer's practice and control. Chemical fertilizer along with cowdung @ 5 t ha^{-1} practice improved the Zn status of the soil than other practices.

Keywords: Biological nitrogen fixation, fallon, integrated nutrient management system, biofertilizer inoculums, soil fertility conservation.

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp] commonly known as 'Fallon', is a minor vegetable crop in Bangladesh, while it is a major staple food crop in dry Savanna regions of West Africa. The seeds are a major source of proteins and vitamins for resource-poor rural and urban people, feed for animals, and also a source of income. The young leaves and immature pods are eaten as vegetables. The haulm (dried stalk) of cowpea is a valuable byproduct, which is used as an animal feed. It contains low anti-nutritional factors (*Rangel et al.*, 2003). Cowpea is a quick growing as well as short day flowering plant, able to fix atmospheric nitrogen to soil, grows well in poor soil, shade tolerant and cover crop, which allows it to fit in multiple cropping systems, compatible to intercrop and helpful to reduce salinity level (Poehlman, 1978). In the last five years (2009-2010 to 2013-2014), average production of cowpea was 45,000 tons under 42,000 ha of land with a yield of 1.07 ton ha^{-1} (BBS, 2014). Out of 1,689,831 ha of cultivable land in coastal and off-shore area of Bangladesh 1,056,260 ha of lands are affected by varying degrees of soil salinity. Around 42.9% of this salinity affected areas are potentially vulnerable to produce most crops (SRDI, 2010). Bangladesh soil is poor in nitrogen and carbon content, and therefore, by including this crop in the cropping system, the fertility of the soils can be enriched to a large extent.

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Due to shrinkage of land and overcrowded populations, cropping intensity in Bangladesh needs to be increased. Use of chemical fertilizer increases day by day with increasing cropping intensity. Intensive cropping with high yielding varieties and large scale use of chemical fertilizers have resulted depletion of soil fertility (Jahiruddin *et al.*, 1994). Manure or chemical fertilizer alone can not sustain soil fertility and crop yield over time, their combinations is essential for sustenance (FRG, 2012). Judicious use of chemical fertilizer along with organic fertilizer is essential to maintain soil fertility. In modern agriculture, the approach of integrated nutrient management (INM) has been proposed for soil fertility conservation and improvement (Khan *et al.*, 2008). It improves all aspects of nutrient cycling. However, irrational or excessive use of chemical fertilizer causes depletion of soil nutrients and brings environment vulnerable. Therefore, it is needed to find out the suitable practice of fertilizer management which will lead to reduce production cost as well as save environment with conserving soil fertility.

To increase the yield productivity of cowpea, various agronomic techniques have been tried by many workers (Biswas *et al.*, 1996). However, its productivity needs to be increased further to make it profitable. Information on fertilizer management in cowpea is scanty. It is common phenomena in the southern region that needy farmers sale the top soil of the land. It is leading the deterioration of soil fertility, topographic changes and depletion of plant materials. IPNS practice may be an appropriate tool for sustainable use of land where organic fertilizer/bio-fertilizer is used with chemical fertilizer. Soil test based fertilizer dose might be a great tool for balanced fertilization. Considering all these factors the present investigation was undertaken to evaluate the growth and yield performance of cowpea as well as soil fertility conservation under integrated nutrient management practices.

Materials and Methods

The experiment was conducted at the research farm of Regional Laboratory of Soil Resource Development Institute (SRDI), Gabua, Noakhali in the southern part of Bangladesh. It lies between latitudes $22^0 53' 49.1''$ and $22^0 53' 49.9''$ North and longitudes $91^0 6' 14.5''$ and $91^0 6' 14.9''$ East with an elevation of less than 2 m from sea level, during November 2012 to April 2013. The experimental field was man-made high land belonging to Chandragonj soil group of Non-calcareous Gray Floodplain Soil type under agro-ecological zone of Lower Meghna River Flood plain (AEZ-17). Soils of the experiment site was silty clay loam in the upper 15 cm. Seeds of BARI Fallon-1 were collected from On-farm Research Division (OFRD), Bangladesh Agricultural Research Institute (BARI), Noakhali. Inoculums of biofertilizer were collected from Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh.

Six nutrient management practices were used as treatments. First treatment was only chemical fertilizer dose approach, where nutrients requirement was assessed on soil test value basis. Second treatment was combined dose of chemical fertilizer and organic manure (cow dung). Rate of cow dung was adjusted to 5 t ha^{-1}. At first the amount of nutrients supplied from cow dung was calculated and then it was deducted from the total requirements of nutrients. The rest amount of nutrients was supplied through chemical fertilizers. Third treatment was combined dose of chemical fertilizer and green manure crop (dhaincha). For this purpose dhaincha (*Sesbania esculent* L.) was grown in three experiment plots and when their height became 12 cm, whole bodies were incorporated into soil. Biomass was yielded to 0.60 t ha^{-1}. It was calculated according to Meelu *et al.* (1994) where they stated that dhaincha (*Sesbania* sp.) can yield 3 to 5 t ha^{-1} dry biomass in 50 - 60 days at height of 90 to 110 cm. According to FRG (2005), 1.0 t dhaincha materials supply 2.5 kg N, 0.3 kg P and 2.0 kg K. Thus, 0.6 ton materials was supposed to supply 1.5 kg N, 0.18 kg P and 1.2 kg K ha^{-1}, respectively. The amount of nutrients was deducted from the total requirements. The rest amounts of nutrients were supplied through chemical fertilizers. Fourth treatment was combined dose of chemical fertilizer and bio-fertilizer. Seeds and inoculums were treated with molasses and then sowed in the field. Fifth treatment was farmer's practice. Three experimental plots were given to a farmer, where he applied only urea @ 0.21 t ha^{-1}. Sixth treatment was control, where no chemical fertilizer or manure was applied. Before ploughing composite soil samples were collected from the field and analyzed at Regional Laboratory of Soil Resource Development Institute (SRDI), Noakhali. Recommended dose of fertilizer, biomass addition from dhaincha and inoculums of biofertilizer were calculated according to Fertilizer Recommendation Guide, 2005 on integrated plant nutrient system (IPNS). Fertilizer doses (kg ha^{-1}) of T1, T2, T3, T4, T5 and T6 were: (i) urea 34 kg, TSP 84 kg, MoP 13 kg, (ii) TSP 58 kg and cow dung 5 t ha^{-1}, (iii) urea 31 kg, TSP 83 kg, 10 kg MoP and Dhaincha 0.6 t ha^{-1}, (iv) TSP 84 kg, TSP 13 kg and biofertilizer inoculums @ 1.6 kg, (v) urea 208 kg, and (vi) no chemical fertilizer or manure.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experimental field was first opened on November 2012 with a power tiller. The land was ploughed and cross ploughed 4 times followed by laddering. Field was then divided into three blocks. Each block was divided into six plots. Each block represents a replication and each plot represents an experimental plot. The size of the unit plot was 3 m × 4 m. The blocks were 1 m apart and distance between unit plots was 0.5 m. The borders were 1 m wide and total area of the experimental field was 65 m × 15 m. Rows of plots were oriented in north-south directions.

Three plots from each block were sown dhaincha. At that time rest of the plots were also ploughed and leveled. Then seeds of cowpea were sown on 15 December 2012 by hand into the plots in continuous furrow keeping furrow to furrow distance 40 cm and depth of seeds was 2 - 3 cm. Seeds were covered with soils. Amount of seeds were calculated as on seed rate of 40 kg ha^{-1} (FRG, 2005). Emergence occurred 5 days after sowing. Plant to plant distance was adjusted to 10 cm through thinning. Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MoP) were applied as a source of N, P and K. Well decomposed cow dung was applied at land preparation. Scraping the crust of soils following by weeding was done three times at 40, 60 and 80 days after sowing. Irrigation was done 3 times at 15, 60 and 75 days after sowing.

Ten plants were tagged from each plot for recording data. Plant flowers first after 76 to 78 days of sowing and first pods were seen after 82 to 84 days of sowing varying on treatment to treatment. Pods were collected after 120 days of sowing. Pods of the selected plants were collected and recorded data carefully. Total dry matter was obtained by collecting all the dried plant parts. Seed-shoot ratio was calculated by dividing seed dry matter $plot^{-1}$ by total shoot dry matter $plot^{-1}$ multiplying with 100, expressed in percentage. The ratio of seed weight to the weight of pod multiplying by 100 expressed as seed-pod ratio percentage. The means for all the characters were calculated and evaluated following RCBD with the help of MSTAT-C computer package program (Gomez and Gomez, 1984). The pair of means was evaluated by least significance difference (LSD) test.

Results and Discussion

Plant heights differed significantly in all observations (Table 1). Up to 60 days of sowing, the highest plant height was in T3 followed by T4. After 75 days of sowing, T4 showed the highest plant height (29.5 cm) followed by T2 (27.3 cm). After 90 days of sowing, the highest plant height (43.6 cm) was in T2 followed by T4 (41.1 cm) and T1 (39.3 cm). After 105 to 120 days of sowing, the highest plant height was in T4 (54.7 cm) which is statistically similar to T2 (54.2 cm) and T1 (51.1 cm). T6 showed better performance than T5 in plant height. The plant height of IPNS approaches ranged from 7.3 to 54.7 cm, which agrees with the findings of Mondal *et al.* (2014) where they found plant height of BARI Fallon-1 ranged from 50 to 75 cm.

The above results indicated that plant height gradually increased up to 120 DAS. T3 showed better performance up to 60 days of planting, whereas plant height of T2 and T4 increased after 60 days of sowing. It may be possible due to fast released of nutrients from dhaincha up to 60 days after sowing and then declined, while release of nutrients from cow dung in T2 and nitrogen fixation by inoculums in T4 was gradually increased.

The highest number of primary branches $plant^{-1}$ was found in T2 (4.5) which was statistically similar to T1 (4.3) and T3 (4.2) followed by T4 (3.9) (Table 2). The lowest number of branches was found in T5 (2.8). The branches $plant^{-1}$ ranged from 2.8 to 4.5 which agree with the findings of Abayomi *et al.* (2004) who found the branches $plant^{-1}$ varied from 4.1 to 4.9 in five genotypes of cowpea in a compound fertilizer trial in Nigeria. It is noted that comparatively higher number of branches $plant^{-1}$ were found in integrated nutrient management practices than single or no chemical fertilizer application practices.

The highest effective plants $plot^{-1}$ was recorded in T3 treatment (176.3) followed by T2 (150.0) and T6 (144.0), and the lowest number of effective plants was found in T5 (118.7) (Table 2). Effective plants of T1 (134.3), T4 (128.7) and T5 (118.7) treatments were lower in descending manner.

Table 1. Effect of fertilizer management practices on the plant height and branches and effective plants of cowpea at Gabua, Noakhali

Treatments	Plant height (cm) at different days after sowing						Primary branches $plant^{-1}$	Effective plants $plot^{-1}$
	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	120 DAS		
T1	7.6 c	16.6 b	25.5 b	39.3 b	41.3 b	53.1 a	4.3 a	134.3 c
T2	7.3 cd	18.0 ab	27.3 ab	43.6 a	49.6 a	54.2 a	4.5 a	150.0 b
T3	9.1 a	18.6 a	26.7 b	36.4 c	40.7 b	43.8 b	4.2 a	176.3 a
T4	8.2 b	18.2 a	29.5 a	41.1 b	49.7 a	54.7 a	3.9 ab	128.7 c
T5	7.5 c	13.0 d	22.0 c	23.8 e	33.2 c	38.6 c	2.8 c	118.7 d
T6	6.8 d	14.9 c	22.3 c	30.1 d	33.1 c	35.7 d	3.3 bc	144.0 b
CV%	4.39	4.96	5.35	3.32	2.81	3.20	9.39	2.97

In a column, the figures bearing same letter(s) do not differ significantly at 5% level of significance by DMRT.
T1 = Soil test based chemical fertilizer dose, T2 = T1 along with C/D @ 5 t ha-1 in IPNS approach, T3 = T1 along with dhaincha @ 0.6 t ha-1 in IPNS approach, T4 = T1 along with B/F inoculums @ 1.6 t ha-1 in IPNS approach, T5= Dose followed by farmers, T6 = No chemical fertilizer or manure was applied. Plot size = 12 Square metre.

After 45 days of sowing, the highest number of nodules were recorded in T3 (9.1) while T4 (20.5) produced the highest number of nodules after 75 days of sowing (Table 2). The lowest number of nodules (15.2) was found in both T1 and T2. After 105 days of sowing, the highest number of nodules was found in T4 (12.4) which was statistically similar to T2 (11.3) and T3 (11.1). The lowest number of nodules was found in T6 (6.4).

After 75 days of sowing, nodule numbers ranged from 15.2 to 20.5, which agrees with the findings of Abayomi *et al.* (2004), where it ranged from 13.6 to 19.3. The nodule numbers $plant^{-1}$ increased from 45 DAS to 75 DAS and then decreased. Chowdhury (2001) found that nodule numbers of cowpea cv. BARI Fallon-1 reduced after 75 days of sowing. Cowpea nodules weights were found highest from about anthesis to mid pod fill (Summerfield *et al.*, 1977).

The maximum fresh weight of a whole plant was found in T4 (130.1 g) which is similar to T2 (124.9 g) (Table 2). Total fresh weights of T6 (113.0 g), T1 (111.2 g) and T3 (110.2 g) were statistically similar to each other. The minimum fresh weight (90.7 g) was found in T5. Barrios *et al.* (2014) stated that bio-fertilizer inoculums showed better results in fresh weight gaining than cowdung and dhaincha. The highest total dry matter (TDM) was recorded in T2 (31.8 g) and the lowest TDM was found in T5 (14.6 g). TDMs of T3 (23.6 g) and T4 (22.7 g) were statistically identical.

Table 2. Effect of fertilizer management practices on the number of nodules, total fresh weight, total dry matter (TDM) and its partitioning

Treatments	Number of nodules $plant^{-1}$ after different days of sowing			Total fresh weight (g $plant^{-1}$)	Total dry matter (g $plant^{-1}$)	Dry matter partitioning (%)			
	45 DAS	75 DAS	105 DAS			Leaf	Stem	Root	Pod
T1	4.0 d	15.2 c	7.2 b	111.2 b	17.2 cd	7.9 d	29.0 b	13.1 bc	50.0 a
T2	6.2 c	17.2 bc	11.3 a	124.9 a	31.8 a	8.9 d	33.1 a	9.4 d	48.6 a
T3	9.1 a	15.2 c	11.1 a	110.2 b	23.6 b	13.1 c	34.1 a	10.6 cd	42.2 b
T4	8.8 a	20.5 a	12.4 a	130.1 a	22.7 b	13.9 c	25.1 c	13.6 b	47.4 a
T5	3.6 d	18.7 ab	6.9 b	90.7 c	14.6 d	20.2 a	28.3 b	19.6 a	31.9 c
T6	7.5 b	17.8 b	6.4 b	113.0 b	18.1 c	16.1 b	27.9 bc	13.0 bc	42.0 b
CV%	10.01	6.95	9.79	5.18	6.97	7.04	6.22	10.85	3.48

In a column, the figures bearing same letter(s) do not differ significantly at 5% level of significance by DMRT.
T1 = Soil test based chemical fertilizer dose, T2 = T1 along with C/D @ 5 t ha-1 in IPNS approach, T3 = T1 along with dhaincha @ 0.6 t ha-1 in IPNS approach, T4 = T1 along with B/F inoculums @ 1.6 t ha-1 in IPNS approach, T5= Dose followed by farmers, T6 = No chemical fertilizer or manure was applied. Plot size = 12 Square metre.

Fertilizer management practices influenced the partitioning of DM significantly (Table 2). The highest dry matter percent was found in leaf of T5 (20.2) and the lowest dry matter percent was in leaf of T1 (7.9). Dry matter percent in leaf of T3 (13.1) was statistically similar to that of T4 (13.7). Dry matter accumulation into the stem was found highest in T3 (34.1) and the lowest in T4 (25.1). Dry matter accumulated into the roots was found the highest in T5 (19.6) and lowest was in the roots of T2 (9.4). The maximum dry matter partitioning into pod was found in T1 (50.0) and the lowest percent (31.9) found in T5. The above results partially corroborates with findings of Abayomi *et al.* (2004), where they found partitioning of dry matter into different parts of yard long bean were 22.3 to 23.6 % in leaf, 44.5 to 46.1 % in stem, 2.8 to 3.1 % in roots and 27.5 to 30.2 % in pod.

Yield contributing characters was differed significantly by nutrient management practices (Table 3). The highest pod length (12.0 cm) was found in T1 practice and the smallest in T5 (10.6 cm). Pod length of T3 treatment (11.1 cm) was similar to that in T2 treatment (10.9 cm). It is noted that chemical fertilizer dose produced the longest pod followed by integrated nutrient management practices. Farmer's practice used only urea that yielded to lower pod length. Pod length ranged from 10.6 to 12.0 cm, which agrees with the findings of Ullah *et al.* (2007) where it ranged from 9.5 to 13.2 cm and partially agrees with Mondol *et al.* (2014) where they reported pod length from 13 to 17 cm.

The highest number of pods plant^{-1} was found in T4 (22.6) followed by T3 (21.8) and T6 (21.1) (Table 3). The lowest number of pods plant^{-1} recorded in T5 (7.4). The effects of T2, T3 and T4 practices on the number of pod formation were very close. The number of pods plant^{-1} ranged from 7.4 to 22.6 which is very close to the findings of Mondal *et al.* (2014) where they found 10 to 20 pods plant^{-1}. When dhaincha was used as for nutrient management, the highest number of seeds pod^{-1} (11.2) achieved in T3 followed by T4 (10.6) (Table 3). The lowest number of seeds pod^{-1} (7.7) achieved in Farmer's plot (T5). Number of seeds pod^{-1} ranged from 7.7 to 11.2 which is close to the findings of Mondal *et al.* (2014) where it ranged from 12 to 16.

The highest seed weight plant^{-1} (21.1 g) was obtained from T4 (Table 3). The seed weight of T1 (19.2 g), T2 (19.0 g), T3 (18.9 g) and T6 (18.8 g) were statistically identical to each other. The lowest seed weight was in T5 (14.4 g). It was found that application of chemical fertilizer along with biofertilizer inoculums gave the highest seed weight. The maximum thousand seed weight recorded in T1 (97.1 g) and the lowest 1000 seed weight traced in T3 (78.9 g). Thousand seed weight ranged from 78.9 to 97.1 g which agrees with the results of Mondal *et al*. (2014) where it ranged from 90 to 95 g. The highest seed dry weight was in T1 (1709.0 g) which is similar to T4 (1690.1 g) and followed by T3 (1505.3 g) (Table 3). The seed dry weights found in T1 (1231.0 g), T6 (988.4 g) and T5 (306.0 g) were arranged in descending order. The lowest dry weight (306.0 g) was in T5.

The seed-pod ratio was influenced significantly by fertilizer management practices (Table 3). The highest seed-pod ratio (74.4) was in present T2 which is statistically similar with T5 (74.2) and T4 (73.9). The lowest seed-pod ratio was in T5 (59.5). The highest shoot dry weight was in T2 (4313.0 g) followed by T3 (3718.9 g) (Table 3). The lowest shoot dry weight plot^{-1} was in T5 (1517.3 g).

The highest seed-shoot ratio was in T4 (61.25%) followed by T3 (56.98%) and the lowest seed-shoot was in T5 (20.17%). The seed-shoot ratio of T2 (39.62%), T4 (42.63%) and T6 (43.67%) were statistically similar. The lowest seed-shoot ratio was in in T5 (20.17%).

Seed yield differed significantly among the practices (Table 4). The highest seed yield was in T3 (2.445 t ha^{-1}) followed by T4 (2.014 t ha^{-1}) and T2 (2.079 t ha^{-1}). The lowest yield was in T5 (1.309 t ha^{-1}). The seed yield of T1 (1.895 t ha^{-1}) was lower than IPNS practices, but higher than that of T6. Results revealed that green manure crop based IPNS practice produced the highest yield, followed by cow dung based IPNS practice and biofertilizer inoculums based IPNS practice. The highest yield production by T3 is probably due to the contribution of higher plant height, number of primary branches plant^{-1}, effective plants plot^{-1}, number of pods plant^{-1} and number of seeds pod^{-1}.

Abayomi *et al.* (2004) reported that seed yield is positively correlated with plant height, number of branches plant^{-1} and pod weight. The research results of Bationo *et al*. (2000) showed that proper management of organic amendments such as crop residue, green manure can increase yields of cowpea. Ayoola and Makinde (2007) realized the highest cowpea yield from inorganic plus organic fertilizer treatment. Purohit *et al.* (2003) stated that combined effect of NPK and FYM increased the grain and stover yield of cowpea. It also revealed that about 25% of nutrient requirement of both crops could be supplemented by making the combination of chemical fertilizers with FYM and biofertilizers.

Table 3. Effect of fertilizer management practices on the yield contributing characters of cowpea at Gabua, Noakhali

Treatment	Pod length (cm)	Number of pods $plant^{-1}$	Number of seeds pod^{-1}	Seed weight (g $plant^{-1}$)	1000 Seed weight (g)	Seed dry weight (g $plot^{-1}$)	Seed - pod ratio (%)	Shoot dry weight (g $plot^{-1}$)	Seed-shoot ratio (%)	Seed yield (t ha^{-1})
T1	12.0a	19.1b	10.2b	19.2b	97.1a	1231.0c	67.4c	2009.8d	61.25a	1.895 bc
T2	10.9bc	19.7b	10.1b	19.0b	96.5a	1709.0a	74.4a	4313.0a	39.62c-e	2.079 b
T3	11.1bc	21.8ab	11.2a	18.9b	78.9b	1505.3b	70.9b	3718.9b	55.98ab	2.445 a
T4	11.4ab	22.6a	10.6ab	21.1a	83.6b	1690.1a	73.9a	2522.2c	42.63cd	2.014 b
T5	10.6c	7.4c	7.7c	14.4c	82.8b	306 .0e	74.2a	1517.3e	20.17 f	1.309 d
T6	10.7c	21.1ab	10.3b	18.8b	89.6b	988.4d	59.5d	2263.2cd	43.67 c	1.732 c
CV%	3.05	8.08	3.91	4.51	7.55	6.06	1.64	7.83	7.73	2.26

In a column, the figures bearing same letter(s) do not differ significantly at 5% level of significance by DMRT.
T1 = Soil test based chemical fertilizer dose, T2 = T1 along with C/D @ 5 t ha-1 in IPNS approach, T3 = T1 along with dhaincha @ 0.6 t ha-1 in IPNS approach, T4 = T1 along with B/F inoculums @ 1.6 t ha-1 in IPNS approach, T5= Dose followed by farmers, T6 = No chemical fertilizer or manure was applied. Plot size = 12 Square metre.

Changes in soil fertility

Soil test values and their interpretation are shown in Table 4. Initial soil samples were non saline (0.60 dS m^{-1}), neutral in soil reaction (pH 7.2), very low in total nitrogen (0.08 %), very low in available phosphorus, medium in potash (0.27 meq $100g^{-1}$ soil), very high in sulfur (76 ppm), low in zinc, medium in B and low in organic matter (1.22%) content. Among them values of total nitrogen and available phosphorus were below to the critical levels according to FRG (2012). After completion of the experiment the average soil test values indicated that soils were non saline (0.16 dS m^{-1}), neutral in reaction (pH 7.24), low in total N (0.10 %), medium in available P (14.4 ppm), optimum in K (0.33 meq $100g^{-1}$ soil), high in S (36.3 ppm), low in Zn (0.63 ppm), very high in B (0.98 ppm) and medium in organic matter (1.73%). Results revealed that soil reaction remained neutral before and after the experiment.

Total nitrogen percent changed from very low to low class may be due to addition of organic materials, green manures and biofertilizer. Phosphorus status changed from very low to medium. In T3 and T5 practices fertility status shifted from very low to low, whereas T4 practice improved fertility status from very low to medium. Overall status of K was improved and shifted from medium to optimum. The fertility status of the treatment T1, T2, T3 and T4 was optimum, whereas it shifted from medium to high in T6 and no change was found in T5. Sulfur status decreased from very high to high. Fertility status of T1 remained same as initial, although its value declined from 76 to 47.29. Fertility classes of T2, T3, T4, T5 and T6 were shifted from very high to high. Zn status of T2 treatment improved, while it shifted from low to medium. Soil test values of T1, T3, and T4 remained below critical limit. Soil test values of the soils of the treatments T5, T6 and average of all the treatments remained above critical limit.

B status shifted from medium to optimum status. B status in T1 and T4 found optimum, whereas T2, T3, T5 and T6 showed very high status. It may be due to genetic characteristics of cowpea. The above results corroborates with the assumptions of FRG (2012), where it stated that most of the soils and crops were responsive to N fertilizers. Upland and rabi crops under alkaline soil conditions were more responsive to P fertilizers. Crops grown in saline soils respond more to Zn fertilizers (FRG, 2012)

Table 4. Changes in soil fertility as influenced by fertilizer management practices at Gabua, Noakhali during 2012-13

Source of sample	Para meters	Critical Limit	Before Sowing		After harvest													
					T1		T2		T3		T4		T5		T6		Average	
			STV	Status	STV	Status	STV	Status	STV	Status	STV	Status	STV	Status	STV	Status	STV	Status
Sub soil	EC (dSm^1)	8.0	-	-	0.09	NS	0.07	NS	0.17	NS	0.08	NS	0.11	NS	0.15	NS	0.11	NS
	pH	>5.5	-	-	7.57	SA	7.76	SA	7.66	SA	7.81	SA	7.70	SA	7.75	SA	7.71	SA
Top soil	EC ($dS\ m^{-1}$)	8.0	0.60	NS	0.16	NS	0.14	NS	0.09	NS	0.14	NS	0.15	NS	0.25	NS	0.16	NS
	pH	>5.5	7.2	N	7.19	N	7.22	N	7.22	N	7.24	N	7.30	N	7.28	N	7.24	N
	Total N (%)	0.12	0.08	VL	0.11	L	0.10	L	0.08	VL	0.10	L	0.11	L	0.11	L	0.10	L
	P (ppm)	7.0	5.0	VL	17.95	OP	16.21	OP	9.91	L	13.44	M	10.05	L	18.75	OP	14.39	M
	K(meq $100g^{-1}$)	0.12	0.27	M	0.33	OP	0.35	OP	0.29	OP	0.33	OP	0.27	M	0.38	H	0.33	OP
	S (ppm)	10.0	76.0	VH	47.29	VH	35.29	H	29.70	OP	33.59	H	35.27	H	36.48	H	36.27	H
	Zn (ppm)	0.60	0.81	L	0.50	L	0.92	M	0.49	L	0.59	L	0.63	L	0.63	L	0.63	L
	B (ppm)	0.20	0.45	M	0.60	OP	0.94	VH	1.98	VH	0.56	OP	0.86	VH	0.96	VH	0.98	VH
	OM (%)	C:N = 10:1	1.22	L	1.88	M	1.68	M	1.41	M	1.68	M	1.81	M	1.94	M	1.73	

Legend: Top soil: 0-15 cm, Sub soil: 15-30 cm. STV = Soil test value, L = Low, M = Medium, OP = Optimum, H = High, VH = Very high, NS = Non saline, N = Neutral, SA = Slightly alkaline, T1 = Soil test based chemical fertilizer dose, T2 = T1 along with C/D @ 5 t ha^{-1} in IPNS approach, T3 = T1 along with dhaincha @ 0.6 t ha^{-1} in IPNS approach, T4 = T1 along with B/F inoculums @ 1.6 t ha^{-1} in IPNS approach, T5= Dose followed by farmers, T6 = No chemical fertilizer or manure was applied. Plot size = 12 Square metre.

Conclusion

The highest seed yield obtained from dhaincha based IPNS practice. The lowest yield was recorded in farmer's practice. It is perhaps due to contributions of highest plant height up to flowering stage, maximum number of branch $plant^{-1}$, effective plants $plot^{-1}$, number of pods $plant^{-1}$ and number of seeds pod^{-1}. It can be concluded that cowpea cv. BARI Fallon-1 showed the highest yield on man-made highland under chemical fertilizer along with green manure crop dhaincha (*Sesbania esculenta L*) based IPNS practice with improving fertility status of the soil. It is also found that integrated plant nutrient system practices showed better performance than other practices.

Acknowledgement

I express my gratitude to Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh to support for supplying biofertilizer inoculums and to On Farm Research Division, Bangladesh Agricultural Research Institute, Noakhali for providing cowpea seeds.

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