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Effect of Organic Amendment and Chemical fertiliser on Growth, Yield and Fodder Quality of a Forage Sorghum (*Sorghum bicolor* L. Moench)

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Abstract: This sorghum experiment was carried out at Khon Kaen University Experimental Farm, Northeast Thailand during June-September 2000 to investigate effects due to application of organic amendment and chemical fertiliser (15-15-15 and 13-13-21 NPK) on growth, yield and fodder quality of a forage sorghum, IS 23585 cultivar (*Sorghum bicolor* L. Moench). The experiment consisted of nine treatments and was laid in a randomised complete block design with four replications. The results showed that the application of chemical fertiliser significantly increased total dry weight ha^{-1}, stem dry weight, leaf dry weight, leaf area/plant and leaf area index (LAI) of the sorghum plants. The application of chemical fertiliser plus organic amendment, in most cases, gave significantly greater growth parameters, than adding chemical fertiliser alone. Total dry weight and seed yield were significantly correlated to leaf area duration (D). Crude protein (CP) significantly increased with an application of chemical fertiliser alone and chemical fertiliser, plus organic amendment. All treatments had no significant effect on neutral detergent fibre (NDF), acid detergent fibre (ADF) and dry matter degradability (DMD). The highest total dry weight was attained from the highest rate of chemical fertiliser (15-15-15) plus cattle manure (14,595 kg ha^{-1}), whilst the highest seed yield was obtained from the highest rate of 13-13-21, plus municipal compost (3,055 kg ha^{-1}).

Key words: Chemical fertiliser, crude protein, forage sorghum, leaf area duration, organic amendments

INTRODUCTION

Forage sorghum (*Sorghum bicolor* L. Moench) plays an important role in the Thai economy particularly during the past decade, since it tremendously aids in livestock production both dairy and beef. Growers of sorghum for livestock production in the different regions of Thailand have realised how this forage sorghum has been assisted them in producing beef and dairy particularly after the annual rainy season terminates. Thai farmers normally use sorghum, apart from its grain, as a livestock fodder and silage, since the crop can thrive in most regions of the country and the annual production/ha has been moderately attained[1-3]. One of the many desirable characteristics of the sorghum crop is the ability to thrive under drought conditions whenever erratic rainfall pattern is experienced[4].

From the previous results of sorghum experiments carried out at Khon Kaen University Experimental Farm, Pholsen *et al.*[1,2] showed that Yasothon soil series (Oxic Paleustults) is a poor soil for the cultivation of many cash crops, exhibiting a high degree of soil acidity due to low organic matter%, high annual leaching rate of nutrients and the effects of the previous crop cultivation. Therefore, it is of significant value to carry out further experiments with respect to organic amendments and chemical fertiliser on growth, yield and fodder quality of the sorghum plants. The aims of this work emphasize on how sorghum crop responds to application of organic amendments, both cattle manure, Municipal Compost #2 and chemical fertiliser in terms of growth, yield and fodder quality when grown on Yasothon soil series, a member of a great soil group of Oxic Paleustults, under the order of Ultisol[5,6].

MATERIALS AND METHODS

This work was carried out on Yasothon soil series (Oxic Paleustults) at the Experimental Farm, Faculty of Agriculture, Khon Kaen University, Northeast Thailand during June to September 2000. The experiment was laid in a randomised complete block design with four replications.

Two weeks before sowing, dolomite at a rate of 3,125 kg ha^{-1} was evenly applied to the soil. The land was ploughed twice followed by harrowing once. The plot size

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used was a 3x4 m with a footpath of 1.5 m in between the plots. Initial soil samples were taken from each plot before the application of dolomite and the second one at the final sampling period. Each plot was divided into five subplots for five sampling periods. Four to five sorghum seeds were sown directly into the soil by hand to a depth of approximately 3-5 cm followed by an application of Carbofuran 3 %G insecticide at a rate of 37.5 kg ha^{-1}. The sowing distance used was a 50x10 cm between rows and within rows, respectively. After sowing, Atrazine herbicide at a rate of 2.2 kg ha^{-1} was sprayed to the soil to control pre-emergence of weed seeds. One week after emergence, seedlings were thinned out leaving only one per ditch. Weeding was carried out once by mechanical means (hoeing) at two weeks after emergence. Initial plant samples were taken at 3 weeks after emergence and subsequent plant sampling periods were taken at two-week intervals for another four sampling periods, i.e. at 5, 7, 9 and 11 weeks after emergence. Ten plant samples were taken at random from each subplot. Sorghum plant samples were cut at 15 cm above ground level. The plant samples were used for the determination of total dry weight ha^{-1}, stem dry weight/plant, leaf dry weight/plant, dead leaf dry weight/plant, leaf area/plant, brix% including chemical components for fodder quality, which were carried out at 11 weeks after emergence. For dry weight, the plant samples were oven dried for 72 h at 75°C, whilst the plant samples being used for the determination of chemical components were also oven dried for 72 h at 65°C and were ground to pass through 1 mm screen grinder. The technique of growth analysis was used to measure the changes in growth with time of the aerial plant parts[7-10]. The plant analysis methods for crude protein, neutral detergent fibre (NDF), acid detergent fibre (ADF), dry matter degradability (DMD) in rumen for 48 h and brix value were carried out according to Pholsen *et al.*[2]. Soil pH, organic matter%, total soil N, available P and extractable K were carried out according to Chuasavathi and Trelo-ges[11]. The attained data were statistically analysed using a SAS Computer Programme[12]. However, only data taken at 3, 7 and 11 weeks after emergence are included in this publication, because they gave a similar effect due to fertiliser treatments. Other data are presented fully in Khon Kaen University, Faculty of Agriculture[13].

RESULTS

Soil analysis: Initial soil analysis data revealed that mean values of soil pH (1:2.5 soil:water by volume), organic matter (%), total soil nitrogen (%), available phosphorous (ppm) and extractable potassium (ppm) were 5.4, 0.46, 0.032, 33 and 36, respectively. Similarly, mean values of soil analysis data attained at the final sampling period ranged from 6.00-6.90, 0.40-0.73, 0.036-0.063, 37-46 and 22-31, respectively.

Total dry weight, stem dry weight, leaf dry weight, leaf area, leaf area index (LAI) and crop growth rate (CGR): At the initial sampling period, 3 weeks after emergence, total dry weights of the sorghum plants applied with chemical fertiliser plus organic amendments (both municipal compost and cattle manure) were significantly greater than those of the control treatment and also the chemical fertiliser treatments alone. Total dry weights ranged from 513 to 979 kg ha^{-1} for T1 and T9, respectively (Table 1). A similar trend to that of total dry weight was found with leaf dry weight, leaf area and LAI. Leaf dry weight ranged from 2.03 to 3.79 g plant^{-1}, leaf area ranged from 517 to 967 cm^2 plant^{-1} and LAI from 1.03 to 1.93 for T1 and T9, respectively.

At 7 weeks after emergence, total dry weights of the sorghum plants treated with chemical fertiliser alone and chemical fertiliser plus organic amendments were significantly greater than that of the control treatment with values ranged from 2,466 to 4,031 kg ha^{-1} for T1 and T9, respectively (Table 2). The highest total dry weight was found with treatments applied with the highest rates of chemical fertiliser plus organic amendments. A similar trend to that of total dry weight was found with stem dry

Table 1: Mean values of total dry weight, stem dry weight, leaf dry weight, leaf area and leaf area index of the sorghum plants at 3 weeks after emergence as influenced by fertiliser treatments

Treatment	Total dry weight (kg ha^{-1})	Stem dry weight (g pl^{-1})	Leaf dry weight (g pl^{-1})	Leaf area (cm^2 pl^{-1})	Leaf area index
T1. Control	513^e	0.54^e	2.03^e	517^e	1.03^e
T2. 15-15-15 NPK @187.5 kg ha^{-1}	558de	0.64^d	2.15^e	549^e	1.10^e
T3. 15-15-15 NPK @312.5 kg ha^{-1}	615de	0.65^d	2.43^d	619^d	1.24^d
T4. 13-13-21 NPK @187.5 kg ha^{-1}	544^e	0.62^{de}	2.11^e	538^e	1.07^e
T5. 13-13-21 NPK @312.5 kg ha^{-1}	559de	0.64^d	2.15^e	549^e	1.10^e
T6. 13-13- 21 NPK @187.5 kg ha^{-1} plus municipal compost	801^c	0.90^c	3.11^c	793^c	1.59^c
T7. 13-13-21 NPK @312.5 kg ha^{-1} plus municipal compost	896^b	1.03^{ab}	3.46^b	884^b	1.77^b
T8.15-15-15 NPK @187.5 kg ha^{-1} plus cattle manure	922^{ab}	1.00^b	3.62^{ab}	924^{ab}	1.85^{ab}
T9. 15-15-15 NPK @312.5 kg ha^{-1} plus cattle manure	979^a	1.11^a	3.79^a	967^a	1.93^a
LSD (0.05)	60.77	0.09	0.26	65.81	0.13
CV (%)	5.87	7.86	6.40	6.40	6.38

Remarks: Letters within the same column indicate least significant differences (LSD) at P = 0.05, CV = Coefficient of variation, Municipal compost and cattle manure, both at a rate of 31.25 tonnes ha^{-1}

Table 2: Mean values of total dry weight, stem dry weight, leaf dry weight and dead leaf dry weight of the sorghum plants at 7 weeks after emergence as influenced by fertiliser application

Treatment	Total dry weight (kg ha^{-1})	Stem dry weight (g pl^{-1})	Leaf dry weight (g pl^{-1})	Dead leaf dry weight (g pl^{-1})
T1. Control	2466^{h}	4.65^{e}	4.99^{g}	2.69
T2. 15-15-15 NPK @187.5 kg ha^{-1}	3273^{f}	7.08^{cd}	6.60^{e}	2.69
T3. 15-15-15 NPK @312.5 kg ha^{-1}	3565^{de}	7.39^{c}	7.69^{cd}	2.75
T4. 13-13-21 NPK @187.5 kg ha^{-1}	3059^{g}	6.82^{d}	5.97^{f}	2.51
T5. 13-13-21 NPK @312.5 kg ha^{-1}	3407^{ef}	7.05^{cd}	7.37^{d}	2.62
T6. 13-13- 21 NPK @187.5 kg ha^{-1} plus municipal compost	3729^{cd}	7.96^{b}	7.86^{bcd}	2.83
T7. 13-13-21 NPK @312.5 kg ha^{-1} plus municipal compost	3925^{ab}	8.45^{ab}	8.42^{ab}	2.76
T8.15-15-15 NPK @187.5 kg ha^{-1} plus cattle manure	3753^{bc}	8.05^{ab}	7.98^{bc}	2.75
T9. 15-15-15 NPK @312.5 kg ha^{-1} plus cattle manure	4031^{a}	8.57^{a}	8.69^{a}	2.90
LSD (0.05)	187.19	0.56	0.57	-
CV (%)	3.70	5.24	5.33	8.63

Remarks: Letters within the same column indicate least significant differences (LSD) at P = 0.05, CV=Coefficient of variation, Municipal compost and cattle manure, both at a rate of 31.25 tonnes ha^{-1}

Table 3: Mean values of leaf area, leaf area index (LAI) and crop growth rate (CGR) of the sorghum plants at 7 weeks after emergence as influenced by fertiliser application

Treatment	Leaf area (cm^2 pl^{-1})	Leaf area index (LAI)	CGR (g m^{-2} $week^{-1}$)
T1. Control	1050^{g}	2.10^{g}	47.80
T2. 15-15-15 NPK @187.5 kg ha^{-1}	1388^{e}	2.78^{e}	61.38
T3. 15-15-15 NPK @312.5 kg ha^{-1}	1616^{cd}	3.23^{cd}	66.58
T4. 13-13-21 NPK @187.5 kg ha^{-1}	1256^{f}	2.51^{f}	50.56
T5. 13-13-21 NPK @312.5 kg ha^{-1}	1550^{d}	3.10^{d}	65.68
T6. 13-13- 21 NPK @187.5 kg ha^{-1} plus municipal compost	1653^{bcd}	3.31^{bcd}	66.09
T7. 13-13-21 NPK @312.5 kg ha^{-1} plus municipal compost	1770^{ab}	3.54^{ab}	57.62
T8.15-15-15 NPK @187.5 kg ha^{-1} plus cattle manure	1677^{bc}	3.35^{bc}	56.57
T9. 15-15-15 NPK @312.5 kg ha^{-1} plus cattle manure	1827^{a}	3.65^{a}	57.16
LSD (0.05)	119.33	0.24	-
CV (%)	5.34	5.32	15.76

Remarks: Letters within the same column indicate least significant differences (LSD) at P = 0.05, CV=Coefficient of variation, Municipal compost and cattle manure, both at a rate of 31.25 tonnes ha^{-1}

weight and leaf dry weight. Stem dry weight ranged from 4.65 - 8.57 g $plant^{-1}$ and leaf dry weight ranged from 4.99 - 8.69 g $plant^{-1}$ for T1 and T9, respectively. Dead leaf dry weight was not significantly affected by treatments with values ranged from 2.51-2.90 g $plant^{-1}$ for T4 and T9, respectively.

Leaf areas of the treatments with chemical fertiliser alone and chemical fertiliser plus organic amendments were significantly greater than that of the control treatment with values ranged from 1,050 - 1,827 cm^2 $plant^{-1}$ for T1 and T9, respectively (Table 3). LAI values followed a similar trend to that of leaf area with values ranged from 2.10 - 3.65 g $plant^{-1}$ for T1 and T9, respectively. Crop growth rates (CGR) were not significantly affected by treatments. CGR values ranged from 47.80-66.58 g m^{-2} $week^{-1}$ for T1 and T3, respectively.

At 11 weeks after emergence, total dry weights of the sorghum plants treated with chemical fertiliser alone and chemical fertiliser plus organic amendments were significantly greater than that of the control treatment. In most cases, total dry weight was significantly greater for chemical fertiliser plus organic amendments than that of chemical fertiliser alone, with values ranged from 7,949 - 14,595 kg ha^{-1} for T1 and T9, respectively (Table 4). Chemical fertiliser plus organic amendment treatments, in most cases, gave higher stem dry weights than those of chemical fertiliser alone and also the control treatment with values ranged from 27.07 - 50.34 g $plant^{-1}$ for T1 and T9, respectively. Leaf dry weights treated with chemical fertiliser alone and chemical fertiliser plus organic amendments were significantly greater than that of the control treatment with values ranged from 5.51 to 12.71 g $plant^{-1}$ for T1 and T9, respectively. Nevertheless, dead leaf dry weight was not significantly affected by treatments.

Chemical fertiliser alone and chemical fertiliser plus organic amendments gave significantly greater head dry weight than that of the control treatment. The highest head dry weights were found with the highest rate of chemical fertiliser plus organic amendments with values ranged from 1.39-4.37 g $plant^{-1}$ for T1 and T9, respectively (Table 5). Leaf areas of the chemical fertiliser treated alone and chemical fertiliser plus organic amendments were significantly greater than that of the control treatment. The highest rates of chemical fertiliser plus organic amendment treatments gave the highest leaf areas with values of 2,275 and 2,387 cm^2 $plant^{-1}$ for T7 and T9, respectively. LAI also had a similar trend to that of leaf area. LAI values ranged from 2.07-4.78 for T1 and T9, respectively. CGRs of the chemical fertiliser treatments alone and chemical fertiliser plus organic amendments were significantly greater than that of the control treatment with values ranged from 128.75-279.31 g m^{-2} $week^{-1}$ for T1 and T9, respectively.

Table 4: Mean values of total dry weight, stem dry weight, leaf dry weight and dead leaf dry weight of the sorghum plants at 11 weeks after emergence as influenced by fertiliser application

Treatment	Total dry weight (kg ha^{-1})	Stem dry weight (g pl^{-1})	Leaf dry weight (g pl^{-1})	Dead leaf dry weight (g pl^{-1})
T1. Control	7949^{h}	27.07^{e}	5.51^{f}	5.79
T2. 15-15-15 NPK @187.5 kg ha^{-1}	10704^{fg}	37.83^{d}	8.05^{de}	5.25
T3. 15-15-15 NPK @312.5 kg ha^{-1}	12019^{de}	42.54^{c}	9.23^{c}	5.62
T4. 13-13-21 NPK @187.5 kg ha^{-1}	10341^{g}	36.26^{d}	7.57^{e}	5.38
T5. 13-13-21 NPK @312.5 kg ha^{-1}	11599^{ef}	40.44^{cd}	9.11^{cd}	5.42
T6. 13-13- 21 NPK @187.5 kg ha^{-1} plus municipal compost	12671^{cd}	44.40^{bc}	9.93^{bc}	5.50
T7. 13-13-21 NPK @312.5 kg ha^{-1} plus municipal compost	14155^{ab}	48.69^{ab}	12.09^{a}	5.62
T8.15-15-15 NPK @187.5 kg ha^{-1} plus cattle manure	13395^{bc}	47.16^{ab}	10.72^{b}	5.69
T9. 15-15-15 NPK @312.5 kg ha^{-1} plus cattle manure	14595^{a}	50.34^{a}	12.71^{a}	5.63
LSD (0.05)	967.49	4.41	1.13	-
CV (%)	5.55	7.25	8.21	6.62

Table 5: Mean values of head dry weight, leaf area, leaf area index and crop growth rate (CGR) of the sorghum plants at 11 weeks after emergence as influenced by fertiliser application

Treatment	Head dry weight (g pl^{-1})	Leaf area (cm^2 pl^{-1})	Leaf area index	CGR (g m^{-2} week^{-1})
T1. Control		1.39^{f}	1034^{f}	2.07^{f}
128.75^{d}				
T2. 15-15-15 NPK @187.5 kg ha^{-1}	2.39^{e}	1512^{de}	3.03^{de}	203.78^{bc}
T3. 15-15-15 NPK @312.5 kg ha^{-1}	2.71^{de}	1734^{c}	3.47^{c}	259.20^{a}
T4. 13-13-21 NPK @187.5 kg ha^{-1}	2.51^{e}	1422^{e}	2.84^{e}	188.51^{c}
T5. 13-13-21 NPK @312.5 kg ha^{-1}	3.04^{cd}	1711^{cd}	3.42^{cd}	240.16^{ab}
T6. 13-13- 21 NPK @187.5 kg ha^{-1} plus municipal compost	3.53^{b}	1866^{bc}	3.73^{bc}	258.63^{a}
T7. 13-13-21 NPK @312.5 kg ha^{-1} plus municipal compost	4.39^{a}	2275^{a}	4.54^{a}	265.34^{a}
T8.15-15-15 NPK @187.5 kg ha^{-1} plus cattle manure	3.42^{bc}	2014^{b}	4.03^{b}	277.81^{a}
T9. 15-15-15 NPK @312.5 kg ha^{-1} plus cattle manure	4.37^{a}	2387^{a}	4.78^{a}	279.31^{a}
LSD .05	0.45	212.19	0.42	40.97
CV (%)	10.14	8.20	8.19	12.02

Remarks: Letters within the same column indicate least significant differences at P = 0.05, CV = Coefficient of variation, Municipal compost and cattle manure both at a rate of 31.25 tonnes ha^{-1}

Table 6: Mean values of leaf area duration (D) at 11 weeks after emergence, seed head dry weight, seed yield and 1000-seed weight of the sorghum plants as influenced by fertiliser application

Treatment	D (m^2.week)	Seed head dry weight (g pl^{-1})	Seed yield (kg ha^{-1})	1000-seed weight (g)
T1. Control	0.80^{f}	8.60^{d}	1359^{d}	21.42^{b}
T2. 15-15-15 NPK @187.5 kg ha^{-1}	1.03^{e}	15.97^{c}	2523^{c}	25.50^{a}
T3. 15-15-15 NPK @312.5 kg ha^{-1}	1.17^{c}	16.39^{bc}	2590^{bc}	27.34^{a}
T4. 13-13-21 NPK @187.5 kg ha^{-1}	0.99^{e}	16.70^{bc}	2639^{bc}	26.41^{a}
T5. 13-13-21 NPK @312.5 kg ha^{-1}	1.10^{d}	16.74^{bc}	2645^{bc}	27.36^{a}
T6. 13-13- 21 NPK @187.5 kg ha^{-1} plus municipal compost	1.20^{c}	17.45^{b}	2756^{b}	26.41^{a}
T7. 13-13-21 NPK @312.5 kg ha^{-1} plus municipal compost	1.42^{a}	19.34^{a}	3055^{a}	27.32^{a}
T8.15-15-15 NPK @187.5 kg ha^{-1} plus cattle manure	1.30^{b}	16.94^{bc}	2676^{bc}	27.73^{a}
T9. 15-15-15 NPK @312.5 kg ha^{-1} plus cattle manure	1.46^{a}	18.87^{a}	2982^{a}	27.46^{a}
LSD (0.05)	0.06	1.26	198.30	2.30
CV (%)	3.82	5.27	5.27	5.98

Table 7: Mean values of crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF) and dry matter degradability (DMD) of the sorghum plants at 11 weeks after emergence as influenced by fertiliser application

Treatment	CP (%DM)	NDF (%DM)	ADF (%DM)	DMD (%)
T1. Control	4.08^{d}	72.31	39.48	57.90
T2. 15-15-15 NPK @187.5 kg ha^{-1}	7.01^{b}	70.84	42.16	60.73
T3. 15-15-15 NPK @312.5 kg ha^{-1}	6.82^{b}	72.52	41.03	58.74
T4. 13-13-21 NPK @187.5 kg ha^{-1}	5.67^{c}	71.86	41.89	58.96
T5. 13-13-21 NPK @312.5 kg ha^{-1}	6.89^{b}	72.07	42.01	59.84
T6. 13-13- 21 NPK @187.5 kg ha^{-1} plus municipal compost	6.76^{b}	71.23	40.16	61.47
T7. 13-13-21 NPK @312.5 kg ha^{-1} plus municipal compost	7.27^{ab}	70.83	41.36	57.70
T8.15-15-15 NPK @187.5 kg ha^{-1} plus cattle manure	6.48^{bc}	69.89	40.54	59.06
T9. 15-15-15 NPK @312.5 kg ha^{-1} plus cattle manure	7.96^{a}	70.98	41.38	58.00
LSD (0.05)	0.82	-	-	-
CV (%)	8.62	2.32	7.54	4.22

Remarks: Letters within the same column indicate least significant differences at P = 0.05, CV=Coefficient of variation, Municipal compost and cattle manure both at a rate of 31.25 tonnes ha^{-1}

Leaf area duration (D), seed head dry weight, seed yield, 1000-seed weight and fodder quality: The highest rate of chemical fertiliser plus organic amendment treatments gave significantly greater leaf area duration (D) than chemical fertiliser alone and the control treatment with values ranged from 0.80 - 1.46 m^2. week for T1 and T9, respectively (Table 6). The highest seed yields were attained from the highest rates of chemical fertiliser plus organic amendments with values of 2,982 and 3,055 kg ha^{-1} for T9 and T7, respectively. All fertiliser treated plants gave significantly greater 1000-seed weight than the control treatment.

For fodder quality, all fertiliser treated plants (T2-T9) attained significantly greater values of crude protein (CP) than that of the control treatment with values ranged from 4.08 - 7.96 % for T1 and T9, respectively (Table 7). The highest CP value was found with the highest rate of chemical fertiliser plus organic amendments. Nevertheless, there was no significant effect due to treatments found among the treated plants on NDF, ADF and DMD.

Relationship between total dry weight and leaf area duration (D) and between seed yield and D: The results showed that there was a positive and significant relationship between total dry weight and D (Y = 9770.7X + 569.83, R^2 = 0.98**) and between seed yield and D (Y = 1950X + 312.08, R^2 = 0.71**).

DISCUSSION

Soil analysis data revealed that soil pH, OM, soil N and extractable K were relatively low, with the exception of available P, for both initial and final sampling periods. This must be attributable to the previous history of crop cultivation and the high leaching rate of soil nutrients[14-16]. Soil nutrient levels were at critical values except soil P[17]. Mean soil pH of 5.4 (1:2.5 soil:water by volume) indicates inappropriate level for high crop yields. Nevertheless, after application of dolomite to the soil, mean values of soil pH ranged from 6.0 - 6.9. This range could be suitable for high crop yields as stated by Miller and Donahue[18] and Suksri[10]. The results also indicate the need to apply more chemical fertiliser, including the addition of large amounts of organic amendments annually.

With initial sampling period at three weeks after emergence, total dry weight, stem dry weight, leaf dry weight, leaf area and LAI depended most on the amount of chemical fertiliser, i.e. an increase in the amount of complete chemical fertiliser, both 13-13-21 and 15-15-15 (NPK), significantly increased sorghum growth parameters. It was found that Yasothon soil series is relatively poor[11]. The application of both chemical fertiliser gave lower growth parameters than that of the chemical fertiliser plus organic amendments. The results imply that sorghum plants require a large amount of nitrogen and organic amendments for growth. Thus chemical fertiliser plus organic amendments gave significantly greater growth parameters than that of the 13-13-21 alone, because organic amendments improved soil properties[18,10,19]. LAI was relatively small due to the early growth period of the seedlings reaching maximum value of 1.93, while there was no light competition among leaf canopies of the sorghum plants[10].

At 7 weeks after emergence, sorghum plants with the highest rate of chemical fertiliser plus organic amendments had the highest growth parameters. Dead leaf dry weights were not affected by treatments. The results suggest the depletion of soil nutrients or perhaps an inadequate amount of soil moisture content. LAI increased with time indicating an advance in age of the sorghum plants, apart from an increase in the amount of lower dead leaves. LAI were at sub-optimal values reaching a value of 3.65 for T9. Therefore, an increase in plant population per unit land area is needed for Yasothon soil for the next sowing when optimum LAI for the sorghum plants should be in a range of 8-9, as suggested by Suksri[10].

At 11 weeks after emergence, the highest rates of complete chemical fertiliser at 312.50 kg ha^{-1} plus organic amendments, in most cases, gave significantly greater total dry weight and other growth parameters than the rest. The results indicate the poor fertility of Yasothon soil and the need to increase a higher rate of chemical fertiliser and organic amendments. However, an adequate amount of soil moisture content must have been predominantly occurred. Dead leaf dry weights were relatively high in all treated plants. This must be due to an advance in age and a rapid grain filling since assimilate had re-translocated from source to sink and partly attributable to high environmental temperatures and a low rate of chemical fertiliser[20-25]. Sorghum with chemical fertiliser alone and the control treatment, in most cases, gave lesser amounts of head dry weight than those with chemical fertiliser plus organic amendments. CGRs were relatively high depending mostly on application rates of chemical fertiliser plus organic amendments.

Chemical fertiliser alone and chemical fertiliser plus organic amendments significantly affected leaf area duration (D). The highest D values were attained from the highest rate of chemical fertiliser plus organic amendments. The results indicate that organic amendments assist in prolonging the life of green leaves. Therefore, with Yasothon soil series, growers should apply high rates of chemical fertiliser plus organic amendments in order to attain a high amount of crop yield. The highest seed yields were attained from the highest rates of chemical fertiliser plus organic amendments. Seed yield and size were lesser than that of Pholsen *et al.*[2].

For fodder quality, chemical fertiliser and chemical fertiliser plus organic amendments significantly increased crude protein (CP) over the control treatment. The highest CP contents were attained from the highest rates of chemical fertiliser plus organic amendments. This indicates that a high quality of fodder could be obtained by a high rate of complete chemical fertiliser plus organic amendments, since a large amount of N is required and it is a constituent of protein. Nevertheless, all treatments had no significant effect on NDF, ADF and DMD. The results were similar to that of Pholsen *et al.*[2]. Total dry weight and seed yield were significantly correlated to D. Thus D of the sorghum plants could be prolonged with an adequate amount of chemical fertiliser plus organic amendments.

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