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The Influence of Seed Rate and Fertilizer Type on Growth of *Tridax procumbens* in Subhumid Nigeria

O.S. Onifade, A.T. Omokanye* & J.T. Amodu

Keywords: *Tridax procumbens* - Seed rate - Fertilizer - Stage of growth - Forage yield - Nigeria

Summary

Forage production of Tridax procumbens *was examined from three seed rates (20, 40 and 60 kg/ha), four types of fertilizer [(unfertilized control, single superphosphate (SSP, 18 %P), NPK (20:10:10), and calcium ammonium nitrate (CAN, 25 %N)] and four harvest stages (6, 9, 12 and 15 weeks post sowing, WPS). Fertilizer rates used were 20 kg/ha P for (SSP) and 50 kg/ha N for each of NPK and CAN. Plant height (cm), density (plants/m²) and spread (cm) were measured at 3, 6, 9, 12 and 15 WPS. Sampling for yield estimation in each plot was done at 6, 9, 12 and 15 WPS.*

Mean plant height with respect to seed rate, fertilizer type and growth stage significantly (P< 0.05) varied from 18.5 to 23.5 cm, 12.1 to 22.5 cm and 8.6 to 18.2 cm respectively. Plant density increased significantly (P< 0.05) with increase in seed rate from 46.0 plants/m² for seeds sown at a rate of 20 kg/ha to 64.0 plants/m² for 60 kg/ha seed rate. Fertilizer type significantly favoured plant density, with NPK giving higher density than did SSP, CAN or the control. Plant spread was significantly (P< 0.05) lowest 3 WPS, increased gradually with increase in the growth of T. procumbens *until a maximum density (48 plants/m²) was reached 12 WPS. Leaf and stem DM yields were significantly (P< 0.05) affected by seed rates, types of fertilizer and harvest stages. Mean total (whole) plant DM yield increased with increase in seed rate with only seeds sown at 60 kg/ha recording > 2000 kg DM/ha. Application of SSP, NPK and CAN gave more total DM yields than the unfertilized control plot respectively by about 69, 75 and 75 %. Total DM yield varied from 1024 kg DM/ha when* T. procumbens *was harvested at an earlier stage (6 WPS) to 2130 kg DM/ha at a later harvest (12 WPS). The main CP of leaf was significantly (P< 0.05) affected by all the treatments imposed.*

Résumé

Influence de la densité de semis et du type d'engrais sur la croissance de *Tridax procumbens* dans la zone sub-humide du Nigeria

L'étude de l'influence de la densité de semis (20 ; 40 et 60 kg graines/ha), de quatre types d'engrais [Témoin sans engrais, 20 kg/ha Superphosphate simple (SPS 18%P), 50 kg/ha N.P.K. (20 : 10 : 10), 50 kg/ha Nitrate de Calcium ammoniacal (NCA, 25% N)] et de quatres stades de récolte [(6 ; 9 ; 12 et 15 semaines après le semis (SAS)] a été réalisée en vue d'évaluer la production fourragère de Tridax procumbens. *La croissance en hauteur de plants (cm), la densité (plants/m²) et le tallage (cm) ont été mesurés 3, 6, 9, 12 et 15 SAS. La prise d'échantillons a été réalisée dans chaque parcelle à la 6, 9, 12 et 15 SAS en vue d'estimer le rendement. La moyenne de la croissance en hauteur a varié d'une manière significative (P< 0,05) en fonction de la densité de semis, du type d'engrais et du stade végétatif. Elle a varié respectivement de 18,5 à 23,5 cm ; de 12,1 à 22,5 cm et de 8,6 à 18,2 cm. La densité de plants a augmenté avec la densité de semis d'une manière significative (P< 0,05). Elle a été de 46 plants/m² pour la densité de semis de 20 kg graines/ha et de 64 plants/m² pour la densité de semis de 60 kg graines/ha. L'application d'engrais a influencé la densité de plants d'une manière significative, la densité la plus élevée a été obtenue avec l'application de la formule complète N.P.K. Le tallage des plants était le plus faible (P> 0,05) 3 SAS. Il a augmenté progressivement jusqu'à la 12ème SAS et a atteint une valeur maximale d'une densité de 48 tiges/m². Les rendements de la matière sèche (MS) des feuilles et des tiges ont varié significativement en fonction des densités de semis, de types d'engrais et des stades de récolte. La densité de semis la plus élevée (60 kg graines/ha) a induit une augmentation significativement supérieure du rendement moyen en MS pour la plante entière (> 2000 kg MS/ha) par rapport aux résultats obtenus pour les deux densités de semis les plus faibles. L'application de SPS, N.P.K. et NCA a permis une augmentation du rendement total en MS comparativement aux parcelles témoins qui n'ont pas reçu d'engrais (respectivement de 69; 75 et 75%). Le rendement total en MS de* T. procumbens *a varié de 1024 kg MS/ha pour la récolte au stade précoce (6 SAS) à 2130 kg MS/ha pour la récolte au stade tardif de 12 SAS. Le contenu en protéine brute (PB), des feuilles a varié d'une manière significative pour tous les traitements étudiés.*

National Animal Production Research Institute, Ahmadu Bello University, P.M.B. 1096, Shika, Zaria, Nigeria

*Correspondence and Present address: Centre for Farming Systems Research, University of Western Sydney, Locked Bag #1, Richmond NSW 2753, Australia

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Introduction

Tridax procumbens Linn. is known as Public Work Department (PWD) weed in south western Nigeria. It is native to central America but now occurs throughout the tropical and subtropical belt of the world (7). It is frequently found in annual crops, roadsides, pastures, fallow land and waste areas and occasionally in lawns, perennial crops and nurseries. Its wide distribution and importance as a weed are due to its spreading stems and abundant seed production (4). It reportedly was introduced into Nigeria as an ornamental in the early 1900s and after many years, the population began spreading to other areas, especially along roadsides and in artificial pastures (1). *Tridax procumbens* has been described botanically by Holm *et al.* (6).

Though considered a weed, this C3 plant is especially cherished by rabbits (2), and also sometimes used as green feed for poultry (5) and to stop bleeding in certain Indian villages (6). Kasture and Wododkar (10) in India analysed mature plants and found sugars, sterols, and tannins but no alkaloids or glycosides. In Nigeria studies carried out so far have been concerned with its germination (13), ecology (16), chemical composition (8, 9), intra-specific competition (15), and its value as dry season feed for rabbits (2). In the later studies, it was found that *T. procumbens* was most preferred out of the 16 tropical green forages offered to rabbits. Concomittant with this is the paucity of research data on forage production potential of *T. procumbens* as regard its establishment and management strategies. This study was therefore designed to examine the effect of seeding rate, harvest stage and fertilizer application on its dry matter yield and quality.

Material and methods

Site description

The study was carried out between July 1990 and November 1991 at the demonstration plot of the Forage and Crop Residue Research Program (FCRRP) of National Animal Production Research Institute (NAPRI), Shika (11°15'N, 7°32'E; altitude 610 m) in the subhumid zone of northern Nigeria. Shika soil type has been classified as belonging to the ferruginous tropical soils derived from sandy parent material and crystalline acid rock (11). Kowal (12) described the physical properties of the soil as well-drained sandy loam soil with a clay fraction consisting mainly of kaolinite and small quantities of illite deficient in N and P. Based on World Reference Base for Soil Resources (WRB) and the FAO/UNESCO Soil Map of the World (6), Shika soil could be classified as Arenosols. This site (0-15 cm topsoil) just before the trial consisted of 10 % clay; 11 % silt; 79 % sand; 5.6 pH; 0.030 % total N; 11.9 ppm total P; 2.17 meq/100 g Ca^{2+}; 0.098 meq/100 g K^{+} and 0.118 meq/100 g Mg^{2+}. The climate is characterised by a well-defined wet and dry season. The wet season begins in April/May, establishes in June and ends in late September/mid October to April with a low relative humidity and a dry north-east wind. The monthly weather observations during the trial years are shown in Table 1.

Field treatments and analyses

The seeds of *T. procumbens* used were collected within the premises of NAPRI by hand and stored at room temperature (25-29°C) in a sampling cloth bag for five to six months before sowing on the field. The experimental size (hitherto a fallow land) was ploughed, harrowed twice and manually leveled to give a fine seedbed. The experiment was laid out in a split-split plot experimental design with three seeding rates (20, 40 and 60 kg/ha) as main plot, four types of fertilizer [(unfertilized control, single superphosphate (SSP, 18 % P), NPK (20:10:10), and calcium ammonium nitrate (CAN, 25 % N)] served as the sub-plots and four harvest stages (6, 9, 12 and 15 weeks post sowing, WPS) constituted the sub-sub plots. Fertilizer rates used were 20 kg P/ha (for SSP) and 50 kg N/ha for each of NPK and CAN. The fertilizer was applied as a single dose at planting in both years. There were three replicates. The sub-sub plots size measured 4 m x 5 m with an allowance of 2 m as pathways between plots. The appropriate quantity of seeds/plot was drilled slightly in seven rows, 60 cm apart on 30 July, 1990 and 27 July,

Table 1
Weather observations at Shika and environs during the experimental periods (1990 and 1991)

Months	Total rainfall (mm) 1990	Total rainfall (mm) 1991	*Mean daily temp (0° C) Min	*Mean daily temp (0° C) Max	*Relat. humidity (%)	*Sunshine (hours)
April	15.3(1)	70.0(3)	N.A.	N.A.	N.A.	N.A.
May	143.5(10)	314.6(16)	21.3	30.8	68.6	6.4
June	125.7(13)	162.9(13)	20.7	30.1	71.3	6.9
July	212.7(13)	243.2(12)	20.0	28.1	75.1	5.7
August	231.7(18)	341.1(15)	19.7	27.9	78.5	5.0
September	187.3(15)	80.8(8)	20.0	31.3	65.8	8.1
October	6.4(2)	42.6(4)	18.0	32.0	44.5	8.5
November	-	-	12.9	31.6	19.0	8.9
December	-	-	12.6	28.6	18.7	7.7
Total	922.6(72)	1261.2(71)	N.A.	N.A.	N.A.	N.A

* Records (for 1991 only) from Institute for Agricultural Research, Samaru about 12 kilometers from Shika, Nigeria.
Values in parenthesis indicate number of rainy days
N.A., Not available/applicable

1991. The 3 sowing rates were based on a pre-trial germination test which gave 41 % germination. Two hand weedings were carried out between the rows three and six weeks post sowing (WPS).

Plant height (cm), density (plants/m^2) and spread (cm) were measured at 3, 6, 9, 12 and 15 WPS. Sampling for yield estimation in each plot was done at 6, 9, 12 and 15 WPS by cutting plants within a 1 m^2 quadrat at ground level. The samples were weighed as whole plant, leaf and stem components and thereafter dried in a unitherm oven at 60°C for 48 hours, and reweighed for estimation of dry matter (DM) yields. Subsamples were ground through a 1 mm sieve and analysed for crude protein content according to the Kjeldahl method described by AOAC (3). The statistical analysis was computed using the Proc GLM of SAS (21). Only the means of observations over the two years as affected by the treatments are presented, since the effect due to year was not significant (P> 0.05).

Results

Plant height, density and spread

Mean plant height with respect to seed rate, fertilizer type and stage significantly (P< 0.05) varied from 18.8 to 23.5 cm, 12.1 to 22.5 cm and 8.6 to 18.2 cm respectively (Table 2). Plant density increased significantly (P< 0.05) with increase in seed rate from 46.0 plant/m^2 for seeds sown at a rate of 20 kg/ha to 64.0 plants/m^2 for 60 kg/ha seed rate. Fertilizer type significantly favoured plant density, with NPK giving higher density than SSP and CAN. The unfertilized control plot recorded the least plant density. Plant density increased from 29 plants/m^2 3 WPS to 52 plants/m^2 9 WPS after which it declined. Plant spread was highest with the least seed rate and decreased with increase in seed rate. Plant spread with respect to fertilizer type followed the same trend with plant density (i.e. NPK> CAN> SSP> control). Plant spread was significantly (P< 0.05) lowest 3 WPS, increased gradually with increase in the growth of *T. procumbens* until a maximum density (48 plants/m^2) was reached 12 WPS.

Table 2
Mean of plant height, density and spread over the two years as influenced by seed rate, fertilizer type and growth stage at Shika, Nigeria

Treatments	Plant height (cm)	Plant density (No./m^2)	Spread (cm)
Seed rate (kg/ha):			
20	18.5^b	46^c	41.6^a
40	23.5^a	57^b	28.0^b
60	18.8^b	64^a	25.4^b
Fertilizer type:			
Control (no fertilizer)	12.1^d	44^c	15.0^c
SSP (20kg P/ha)	17.3^c	56^b	36.0^b
NPK (50kg N/ha)	22.5^a	67^a	41.1^a
CAN (50kg N/ha)	20.0^b	57^b	35.0^b
Growth stage (Weeks post sowing):			
3	8.6^d	29^c	4.6^d
6	13.4^c	45^b	23.9^c
9	16.9^b	52^a	37.8^b
12	19.0^a	49^a	47.5^a
15	18.2^{ab}	49^a	44.8^a

Means in a column for a particular treatment with different superscripts differ significantly (P< 0.05).

Dry matter yield

Leaf DM yield was significantly (P< 0.05) affected by seed rate varying from 584 kg/ha for seeds sown at 20 kg/ha to 1034 kg/ha for seeds sown at 60 kg/ha (Table 3). With respect to type of fertilizer application, leaf DM yield was least with unfertilized control (401 kg DM/ha) and highest with NPK. Both NPK and CAN had >1000 kg DM/ha, while SSP recorded <1000 kg DM/ha. As expected, leaf DM yield increased with increase in growth stage up to 12 WPS after which it suddenly decreased. Harvesting *T. procumbens* at 12 WPS recorded >1000 kg/ha while other stages at harvest produced <1000 kg DM/ha (Table 3).

Mean stem DM yield followed the same trend with leaf DM yield with respect to seed rate, fertilizer type and growth stage. Stem DM yield was however >1000 kg DM/ha with seeds sown at a rate of 60 kg/ha, NPK and CAN, and between harvest taken at 12 and 15 WPS (Table 3). Mean total (whole) plant DM yield increased with increase in seed rate with only seeds sown at 60 kg/ha recording >2000 kg DM/ha. The unfertilized control plots performed poorly when compared with plots that received different types of fertilizers. Application of SSP, NPK and CAN yielded more total DM yields than the unfertilized control plot respectively by about 69, 75 and 75 %. Both NPK and CAN had yields >2000 kg DM/ha while others had less values. Total DM yield varied from 1024 kg DM/ha when *T. procumbens* was harvested at an earlier stage (6 WPS) to 2130 kg DM/ha at a later harvest (12 WPS) (Table 3).

Table 3
Means of forage dry matter (DM) yields and crude protein contents of *Tridax procumbens* over the two years as influenced by seed rate, fertilizer type and growth stage at cutting at Shika, Nigeria

	Forage DM yields (kg/ha)			Crude protein contents (%)		
Treatments	Leaf	stem	Total	leaf	stem	whole plant
Seed rate (kg/ha):						
20	584^c	629^c	1213^c	21.8^a	12.3	14.6
40	802^b	929^b	1731^b	17.6^b	12.8	14.0
60	1034^a	1205^a	2239^a	15.6^c	11.2	12.0
Fertilizer type:						
Control (no fertilizer)	401^c	351^c	752^c	6.7^d	4.3^c	5.1^c
SSP (20kg P/ha)	742^b	917^b	1659^b	12.3^c	9.6^b	10.5^b
NPK (50kg N/ha)	1088^a	1233^a	2312^a	20.6^a	11.6^a	14.0^a
CAN (50kg N/ha)	1022^a	1182^a	2204^a	15.4^b	10.8^{ab}	11.1^b
Growth stage (Weeks post sowing):						
6	540^c	484^c	1024^c	18.5^a	11.8^a	14.3^a
9	986^a	883^b	1889^b	17.9^a	9.4^b	12.3^b
12	1010^a	1120^a	2130^a	13.0^b	8.1^b	10.0^c
15	740^b	1200^a	1940^b	5.6^c	7.1$_c$	4.0^d

Means in a column for a particular treatment with different superscripts differ significantly (P< 0.05)

Crude protein

The mean crude protein (CP) of leaf was significantly (P< 0.05) affected by all the treatments imposed. The CP content varied from 15.6 % for seed sown at a rate of 60 kg/ha to 21.8 % for seeds sown at 20 kg/ha (Table

3). The leaf of unfertilized control plots had 6.7 % CP content, a value lower by about 35, 45 and 30 % than what SSP, NPK and CAN had. As expected, CP content decreased with increase in growth.
The mean CP content of the stem with respect to seed rate did not differ significantly (P> 0.05). Stem CP content followed the same trend with leaf CP content when different types of fertilizer were applied and as the growth stage increased. The CP content of stem differed much from that of leaf for all the treatments imposed.
With the exception of seed rate, the CP content of whole plant followed the same trend with leaf and stem CP contents for all the treatments examined. The CP content of whole plant was highest with 14.6, 14.0 and 14.3 % respectively for seed rate, fertilizer type and growth stage (Table 3).

Discussion

The trend of plant height with respect to seed rate is unexpected. One would have expected a lower value in plant height with respect to increase in seed rate. Instead the lowest seed rate (20 kg/ha) had the least plant height. What is responsible for this is difficult to explain. The reason for the decrease in plant from 23.5 cm for seeds sown at a rate of 40 kg/ha to 18.8 for 60 kg/ha seed rate is clear. The plant heights were however not vigorous at 60 kg/ha seed rate possibly due to the higher competition for nutrients resulting from higher plant density (64 plants/m^2) than did at other seed rates with less densities. The beneficial effect of fertilizer application on plant height and density is obvious, especially the application of NPK, a compound fertilizer. As expected plant height increased gradually as the plant advanced in growth. The similarity in plant density between 9 and 15 WPS indicate that by 9 WPS all seeds had germinated, emerged and showed some evidence of survival.
For optimum forage (total) yields sowing at a rate of 60 kg/ha appeared to be beneficial. The leaf and stem components of *T. procumbens* were also better at this rate. Importantly, the results of this study suggest that NPK is better of in terms of fertilizer type. However, it is thought that CAN when added with little amount of SSP would also give better yield. There is the need to carry out further studies on different rates of NPK and CAN so as to determine the optimum level of requirement. In doing this, lower quantities of SSP could be tested with CAN. Observations of the plots showed that the application of NPK prolonged the growth period of *T. procumbens* by 8 days than did the control and other types of fertilizers applied.
The trend of the leaf, stem and total DM yields obtained in this study as the plant ages agrees with several reports in the same environment with other plants (16, 18) that, with advancing plant growth the proportion of stem increases at the expense of leaf due to an increase in the proportion of lignified structural tissues. The observation that yield declined after reaching a maximum (12 WPS) is similar to an earlier report by Ogbonnaya (16) on *T. procumbens* in southern Nigeria. Intra-specific competition studies by Oladokun (17) in Nigeria and Pemadasa (20) in India found that plant density greatly affected *T. procumbens* growth. The results of the present studies contradict earlier report by Oladokun (17) and Pemadasa (20) that root and shoot weight, plant height and number of leaves per plant dropped as the plant population increased. This dissimilarity could have resulted from differences in sites of studies, initial germination percentage after planting and fertilizer application.
As expected, leaf consistently had higher CP content than that of stem irrespective of treatments imposed. The similarity in the CP content of whole *T. procumbens* for the three seed rates indicate that optimum seed rate is yet to be attained. The only set back likely to be posed in achieving this is poor establishment resulting from poor germination of *T. procumbens*, as it was rightly observed in a pre-trial germination test which gave 41 % germination. Earlier findings also in Nigeria by Marks and Nwachuku (14) noted that *T. procumbens* seeds germinated over a prolonged period and in a variable pattern, and that only 44 % of freshly harvested seed was viable and seed germination in response to light was cyclic.
The impressive CP content obtained for the leaf and whole plant with NPK fertilized plots compared with those given SSP, CAN and the unfertilized control plots clearly showed the need to know the right type of fertilizer to apply. The CP content obtained 12 WPS was above 7 % considered for maintenance of livestock (14). The results therefore compliment DM yield 12 WPS. The CP content of leaf obtained in this study were slightly lower than amounts earlier reported by Kalu *et al* (9) between the 2nd and the 10th week of growth. On the other hand, the CP contents of the stem recorded in this study were higher than what Kalu and others reported.

Conclusion

From the results of this experiment, it is evident that further trials involving higher seed rate and different levels of NPK fertilizer are needed to determine optimum seed rate (in spite of seed germination problem) and NPK fertilizer requirements. It is obvious that competition between plant stands is minimal and fertilizer application in particular NPK is necessary.

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O.S. Onifade, Nigerian, Ph. D., Programme Leader. FCRRP. NAPRI based at Shika in Northern Nigeria

A.T. Omokanye, Nigerian, M. Sc. degree. Research Fellow 11 with FCRRP, NAPRI. PhD degree programme in Systems Agriculture at the University of Western Sydney, Australia

J.T. Amodu, Nigerian, M. Sc., Research Fellow 11 FCRRP, NAPRI