International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(4): 3597-3601

Received: 01-05-2020
Accepted: 28-06-2020

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Influence of plant geometry, fertilizer level and cycocel on biometric growth parameters and yield of niger (*Guizotia abyssinica* Cass.)

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DOI: https://doi.org/10.22271/chemi.2020.v8.i4as.10209

Abstract
A field experiment was carried out during *kharif*, 2014 in Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka under rainfed conditions. The experiment was laid out in split plot design with three replications. The experiment consists of three factors *viz*., three fertilizer dozes (75%, 100% and 125% RDF), three plant geometries (30cm x10cm, 45cm x10cm and 60cm x10cm) and two cycocel concentrations (500 and 1000 ppm). The results revealed that the treatment combination of 45 X 10 cm plant geometry with fertilizer doze of 25: 50: 25 kg N, P_2O_5, K_2O ha^{-1} (125 per cent RDF) and application of cycocel at 1000 ppm concentration recorded significantly higher total dry matter production (57.0 g plant^{-1}), highest values of biometric parameters *viz*., LAI (0.761), NAR (0.827 g dm^2 day^{-1}), CGR (0.0015 g dm^2 day^{-1}) and RGR (1.704 g day^{-1}), seed yield (726 kg ha^{-1}), stalk yield (2606 kg ha^{-1}) and harvest index (21.8 per cent) compared to other treatment combinations.

Keywords: Cycocel, growth parameters, niger, plant geometry, fertilizer levels

Introduction

Niger (*Guizotia abyssinica* Cass.) is one of the important minor oilseed crops of India.In World, niger is grown over an area of about 1.74 m ha with a production and productivity of 0.56 m t and 382 kg ha^{-1} respectively (Anon., 2017) [2]. India is considered to be the chief niger producing country in the world and it ranks first with respect to area, production and productivity. In India, it contributes to about 2% of total edible oil production. It is mainly grown in the states of Madhya Pradesh, Bihar, Maharashtra, Orissa, Karnataka and Tamil Nadu. In Karnataka, niger is cultivated over an area of about 14000 ha with a production and productivity of 5000 tonnes and 357 kg ha^{-1}, respectively (Anon., 2017) [2].

Among the different cultivation practices, optimum plant density plays an important role in obtaining the good yield. A crop would express its full potential only when it is backed up by good agronomic practices. Optimum plant density provides conditions for proper light interception throughout the crop growth period. Fertilizers are the substances which play a major role in improving the productivity of niger. Among different elements, macro elements such as N, P and K are important sources in increasing the yield. Plant growth regulators may be considered as a new generation of agrochemicals after fertilizers, pesticides and herbicides. These are chemical substances, when added in small quantity, modify the growth of plants usually by stimulating or inhibiting part of the natural growth regulatory system. Cycocel are known to reduce internodal distance, thereby enhancing the source-sink relationship and stimulates the translocation of photo assimilates to the seeds (Luib *et al*., 1987) [6].

In Northern Transition Zone of Karnataka, niger is sown during II fortnight of June at 30 × 10 cm plant geometry with recommended dose of fertilizer of 20:40:20 kg N, P_2O_5, K_2O ha^{-1}. With this practice, there will be more of vegetative growth compared to reproductive growth due to excess soil moisture which results in lower crop productivity. Thus, there is need to check its excessive vegetative growth by using a growth retardant (cycocel) to divert the photosynthates to the sink. Being highly branched with elastic growth habit of the plant, the present recommended plant geometry of 30 × 10 cm appears to be less which restricts production of branches and capitula.

It requires wider plant geometry which helps in better growth of plant and production of more number of branches, capitula, seeds and yield. Jadhav and Deshmukh (2008) [5] reported the significant response of niger to higher fertilizer levels which indicates the need to study its response to higher fertilizer levels. The methodologies of physiological analysis of plant growth have been used for optimizing the cultural requirements of crop plant (Redford, 1967) [9]. This technique of growth analysis is widely used in breeding programme to identify the important palnt growth phases related to dry matter production and its translocation to economic plant parts (Srivastava and Verma, 1983) [10]. Such research studies were quite meagre in niger and hence the present study was therefore carried out with objective to study the effects of varying levels of plant geometry, fertilizer and cycocel on biometric growth parameters and yield of niger (*Guizotia abyssinica* Cass.) under rainfed conditions.

Materials and Methods

A field experiment was conducted on medium deep black soil at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka, during *kharif* 2014. The experiment was laid out in randomized completely block design with factorial concept with 18 treatment combination with single control and three replications. The treatment consisted of three planting geometries (30 x 10 cm, 45 x 10 cm and 60 x 10 cm), three fertilizer levels (75% RDF, 100% RDF and 125% RDF) and two doses of cycocel spraying (500 ppm and 1000 ppm at 30 days after sowing). The soil of the experimental site had a pH 7.2 with low available nitrogen (190 kg ha^{-1}), medium available phosphorous (31.2 kg ha^{-1}) and high available potassium (370 kg ha^{-1}). Niger cv 'DNS-4' was sown @ 1.5 kg ha^{-1} on 13th July 2014 at a shallow depth of 2 cm at different planting geometries and different levels of fertilizers were applied as per the treatments in the form of urea, diammonium phosphate and muriate of potash at the time of sowing. The crop was raised by following the recommended package of practice. The total rainfall received during the crop period was 652 mm which ensured adequate stored moisture for germination, emergence, early establishment of seedlings and better crop expression. Gap filling was done at 9 days after sowing to maintain optimum plan population. Thinning was carried out at twenty days after sowing retaining one healthy seedling per hill. Cycocel @ 500 ppm and 1000 ppm was sprayed at 30 DAS (Days after sowing) to each treatment except control plot. All the agronomic operations except those under study were kept uniform for all the treatments. The crop was harvested on 1st and 2nd of November 2014. The observations were recorded as per the established norms. The data collected on different parameters were subjected to statistical analysis (Gomez and Gomez, 1984) [3] for proper analysis and better interpretation of the results.

Results and Discussion

Plant geometry

Plant geometry had significant influence on dry matter accumulation in niger plant parts and total dry matter accumulation. Thus, the wider plant geometry of 45 cm × 10 cm recorded significantly higher dry matter accumulation in leaf, stem, capsule and total dry matter production (12.95, 28.26, 11.59 and 52.8 g $plant^{-1}$ respectively) compared to 60 cm × 10 cm (12.85, 27.91, 11.57 and 52.3 g $plant^{-1}$ respectively) and control (12.18, 25.78, 10.52 and 48.5 g $plant^{-1}$ respectively) (Table-1). The leaf area index(LAI), net assimilation rate(NAR), crop growth rate(CGR) and relative growth rate(RGR) differed significantly due to plant geometry. Significantly higher LAI(0.807) and CGR(0.0020 g dm^2 day^{-1}) was recorded at 30x10 cm plant geometry compared to 45x10cm and 60x10 cm plant geometry. While the plant geometry of 45x10cm and 60x10cm recorded significantly higher RGR (1.671 g dm^2 day^{-1}) and NAR (0.808 g dm^2 day^{-1}) respectively over others (Table-2). Patil *et al*. (2006) [7] also observed that number of branches were significantly increased with increased inter row spacing which reflected in more number of branches, leaves, stem, capitula and resulted in higher dry matter production.

The seed yield of niger differed significantly due to plant geometries (Table-3). The plant geometry of 45 cm × 10 cm recorded significantly higher seed yield (531 kg ha^{-1}) compared to control (423 kg ha^{-1}) and other plant geometries. The seed yield at 45 cm x 10 cm was 19.2, 14.5 and 20.3 per cent higher over 60 cm × 10 cm, 30 cm × 10 cm and control (30 cm × 10 cm plant geometry) respectively. Vasanth Kumar (2012) [13] also reported that wider row plant geometry of 45 cm recorded higher seed yield (615 kg ha^{-1}) in niger over 60 cm and 30 cm. Significantly higher stalk yield was recorded with 45 X 10 cm (2038 kg ha^{-1}) compared to control (1650 kg ha^{-1}). Further, significantly higher oil content was recorded at 45 cm × 10 cm (39.0 per cent) followed by 30 cm × 10 cm plant geometry (38.5 per cent) and 60 cm × 10 cm plant geometry (38.1 per cent). This may be due to the favorable environmental conditions in wider spacing and less competition between plants as well as increase light penetration within plant canopy which increased assimilation rate and oil content as reported by Tenebe *et al.* (2008) [11] in safflower.

Fertilizer doze

Dry matter production and its accumulation in different plant parts varied significantly due to different fertilizer levels. The data indicated that there was linear increase in dry matter accumulation in leaf, stem and capsule and was higher than control (Table-1). At 125% RDF, the dry matter accumulation in leaf (12.94 g $plant^{-1}$), stem (28.39 g $plant^{-1}$), capsule (11.85 g $plant^{-1}$) and total dry matter production (52.4g $plant^{-1}$) was significantly higher over 75% RDF and was at par with 100% RDF. The results clearly indicated increased photosynthetic area of the crop that might resulted in higher total dry matter production at higher levels of fertilizers as reflected in higher LAI and NAR. (Thakur *et al*., 2005) [12].

Biometric growth parameters like, Leaf area index (LAI), crop growth rate (CGR) and relative growth rate (RGR) were significantly varied with different treatments and followed the same trend as that of dry matter production and its translocation (Table-2). Nutrient application @ 125% RDF recorded significantly higher LAI (0.717), CGR (0.0015 g $dm^2 day^{-1}$) and RGR (1.668 g day^{-1}) compared to 75% RDF, control and was at par with 100% RDF. This may be due to higher uptake of nutrients lead to more photosynthetic activity, better growth of plant and dry matter accumulation per unit leaf area and thus lead to more dry matter accumulation in different plant parts of niger (Patil *et al*., 2010) [8].

In the present study, the data revealed that application of 125% RDF recorded significantly higher seed yield (508 kg ha^{-1}), stalk yield (1879 kg ha^{-1}) and oil content (39.1%) over control 75%, 100% and control treatments. The increase in grain yield with 125% RDF was to the tune of 6.5, 15.16 and 16.74 per cent over 100% RDF, 75% RDF and control respectively (Table-3). The optimum availability of nutrients has favoured the growth and development of better root system, which helped in better uptake of nutrients. Further, it improved the rate of photosynthesis, dry matter accumulation and its translocation to reproductive parts as indicated by higher values of growth and yield components that resulted in better seed and stalk yield of niger as reported by Jadhav and Deshmukh (2008) [5]. Fertilizer applied at different levels had significant effect on oil content of niger. Maximum oil content (39.1%) was recorded at 125% RDF which was 2.4, 2.4 and 2.8 per cent higher over 100% RDF, 75% RDF and control respectively (Table-3). The higher oil content may be attributed to availability of more quantity of nutrients in soil. This might be due to higher nitrogen uptake and higher seed yield at 125% RDF as compared to 100% RDF, 75% RDF and control. This also can be related to phosphorus which is a major constituent of fatty acids, higher accumulation of phosphorus must have resulted in higher seed oil content and protein content as reported by Amare *et al.* (2015) [1].

Cycocel

The total dry matter production per plant at harvest was significantly higher with the application of cycocel @ 1000 ppm (52.4 g plant^{-1}) which was 2.5 and 7.5% higher over control (48.5 g plant^{-1}) and 500 ppm (51.1 g plant^{-1}) respectively (Table-1). Application of cycocel @ 1000 ppm resulted in higher dry matter accumulation to the extent of 2.2% in leaf, 3.0% in stem and 2.0% in capsule over cycocel @ 500 ppm. The same treatment recorded 5.3%, 9.1% and 9.1% in leaf, stem and capsule over control respectively. Higher total dry matter production per plant at harvest can be related to higher values of growth indices like leaf area, LAI, NAR, CGR and RGR. In the present study, application of cycocel @ 1000 ppm recorded higher LAI (0.717), NAR (0.724 g dm^2 day^{-1}), CGR (0.0015 g dm^2 day^{-1}) and RGR (1.668 g day^{-1}) at harvest compared to application of cycocel @ 500 ppm and control. The lower LAI at harvest was due to lesser dry matter accumulation in leaf which could be related to lower leaf area due to leaf senescence. (Table-2). These results were in conformity with the findings of Vasanth Kumar (2012) [13] in niger. Application of cycocel had no significant influence on oil content. The results indicated that the application of cycocel @ 1000 ppm recorded significantly higher seed yield (486 kg ha^{-1}) over 500 ppm (456 kg ha^{-1}) and control (423 kg ha^{-1}). The increase in seed yield with application of cycocel @ 1000 ppm was 6.2 and 12.9 per cent higher over 500 ppm and control respectively (Table-3). The increase in seed yield with cycocel treatment was attributed to its reduction in plant height which was found to be useful in increasing the efficiency of translocation of food material towards capitulum. Similar results of cycocel on seed yield of niger were reported by Vasanth Kumar (2012) [13].

Interaction effect of plant geometry, fertilizer levels and cycocel

A treatment combination of 45 X 10 cm plant geometry with fertilizer level of 125 per cent RDF and application of cycocel at 1000 ppm concentration recorded significantly higher total dry matter production (57.0 g plant^{-1}) as compared to rest of the treatment combinations (Table-1). The increase can be related to highest values of biometric parameters *viz*., LAI (0.761), NAR (0.827 g dm^2 day^{-1}), CGR (0.0015 g dm^2 day^{-1}) and RGR (1.704 g day^{-1}) (Table-2). Thus, it reflected in higher seed yield (726 kg ha^{-1}), stalk yield (2606 kg ha^{-1}) and harvest index (21.8 per cent) compared to other treatment combinations (Table-3). The higher seed yield, stalk yield and harvest index was mainly attributed to higher uptake of nitrogen, phosphorus and potassium as reported by Jadhav and Deshmukh (2008) [5]. The increase in nutrient uptake of crop can be related to higher biomass yield of niger (2606 kg ha^{-1}) which in turn increased the harvest index (21.8%) as compared to other treatment combinations. Thus, the higher N and P supply through RDF resulted in higher seed yield, stalk yield and harvest index in niger. These results were in conformity with the findings of Amare *et al*., (2015) [1].

Table 1: Total dry matter production (g plant^{-1}) and its distribution in niger at harvest as influenced by plant geometry, fertilizer levels and cycocel

Treatments		Cycocel											
		Leaf			Stem			Capsule			Total		
Plant geometry	Fertilizer levels	500 ppm	1000 ppm	Mean	500 ppm	1000 ppm	Mean	500 ppm	1000 ppm	Mean	500 ppm	1000 ppm	Mean
30 cm x 10 cm	75 % RDF	11.58	11.97	11.78	25.91	27.57	26.74	10.88	10.81	10.85	48.8	51.0	49.9
	100 % RDF	12.34	12.70	12.52	27.29	26.69	26.99	10.59	11.18	10.89	51.0	50.3	50.6
	125 % RDF	12.32	12.77	12.54	26.64	27.82	27.23	11.39	10.87	11.13	49.1	51.2	50.1
	Mean	12.08	12.48	12.28	26.62	27.36	26.99	10.95	10.95	10.95	49.6	50.8	50.2
45 cm x 10 cm	75 % RDF	12.69	12.60	12.65	26.07	27.26	26.67	10.64	11.20	10.92	49.4	51.1	50.2
	100 % RDF	12.80	13.03	12.92	28.17	29.25	28.71	11.20	11.95	11.58	52.2	54.2	53.2
	125 % RDF	13.00	13.59	13.30	27.98	30.80	29.39	11.91	12.65	12.28	52.9	57.0	55.0
	Mean	12.83	13.08	12.95	27.41	29.10	28.26	11.25	11.93	11.59	51.5	54.1	52.8
60 cm x 10 cm	75 % RDF	12.69	12.80	12.75	27.58	27.43	27.50	11.30	11.55	11.43	52.2	52.2	52.2
	100 % RDF	12.70	13.01	12.86	27.69	28.00	27.85	11.55	11.34	11.44	52.4	52.7	52.6
	125 % RDF	12.86	13.02	12.94	28.44	28.34	28.39	11.93	11.77	11.85	52.1	52.4	52.2
	Mean	12.75	12.94	12.85	27.90	27.92	27.91	11.59	11.55	11.57	52.2	52.4	52.3
Mean of 75 % RDF		12.33	12.53	12.43	26.76	27.51	27.13	11.05	11.38	11.22	50.1	51.4	50.8
Mean of 100 % RDF		12.61	12.84	12.73	27.20	28.79	27.99	11.30	11.46	11.38	51.9	52.4	52.1
Mean of 125 % RDF		12.73	13.13	12.93	27.97	28.09	28.03	11.44	11.60	11.52	51.4	53.5	52.4
Cycocel Mean		12.55	12.83		27.31	28.13		11.26	11.48		51.1	52.4	
Control		12.18			25.78			10.52			48.5		
		S.Em±		CD (P= 0.05)	S.Em±		CD (P= 0.05)	S.Em±		CD (P= 0.05)	S.Em±		CD (P= 0.05)
Plant geometry		0.11		0.30	0.20		0.59	0.08		0.22	0.28		0.79
Fertilizer levels		0.11		0.30	0.20		0.59	0.08		0.22	0.28		0.79
Cycocel		0.09		0.25	0.17		0.48	0.06		0.18	0.22		0.65
Plant geometry x Fertilizer levels x Cycocel		0.26		NS	0.50		NS	0.19		NS	0.67		NS
Control Vs Treatments		0.26		0.75	0.49		1.42	0.19		0.54	0.67		1.91

DAS = Days after sowing NS = Non significant Control = 30 cm × 10 cm + 100 % RDF

Table 2: Biometric growth parameters of niger at harvest as influenced by plant geometry, fertilizer levels and cycocel

Treatments		**Cycocel**											
		Leaf area index			**Net assimilation rate ($g\ dm^2\ day^{-1}$)**			**Crop growth rate ($g\ dm^2\ day^{-1}$)**			**Relative growth rate ($g\ day^{-1}$)**		
Plant geometry	**Fertilizer levels**	**500 ppm**	**1000 ppm**	**Mean**	**500 ppm**	**1000 ppm**	**Mean**	**500 ppm**	**1000 ppm**	**Mean**	**500 ppm**	**1000 ppm**	**Mean**
30 cm x 10 cm	75 % RDF	0.744	0.789	0.767	0.471	0.546	0.509	0.0019	0.0020	0.0020	1.638	1.657	1.648
	100 % RDF	0.789	0.856	0.822	0.567	0.552	0.560	0.0021	0.0020	0.0020	1.657	1.651	1.654
	125 % RDF	0.800	0.867	0.833	0.583	0.589	0.586	0.0018	0.0020	0.0019	1.641	1.658	1.649
	Mean	0.778	0.837	0.807	0.540	0.562	0.551	0.0019	0.0020	0.0020	1.645	1.655	1.650
45 cm x 10 cm	75 % RDF	0.628	0.710	0.669	0.703	0.762	0.732	0.0012	0.0012	0.0012	1.643	1.656	1.650
	100 % RDF	0.742	0.753	0.747	0.797	0.800	0.798	0.0014	0.0015	0.0014	1.667	1.683	1.675
	125 % RDF	0.721	0.800	0.761	0.772	0.827	0.799	0.0014	0.0015	0.0015	1.672	1.704	1.688
	Mean	0.697	0.754	0.726	0.757	0.796	0.777	0.0013	0.0014	0.0014	1.661	1.681	1.671
60 cm x 10 cm	75 % RDF	0.550	0.587	0.568	0.774	0.802	0.788	0.0010	0.0010	0.0010	1.667	1.667	1.667
	100 % RDF	0.529	0.546	0.537	0.829	0.795	0.812	0.0010	0.0010	0.0010	1.666	1.667	1.667
	125 % RDF	0.568	0.549	0.558	0.803	0.848	0.826	0.0010	0.0009	0.0010	1.669	1.671	1.670
	Mean	0.549	0.560	0.555	0.802	0.815	0.808	0.0010	0.0010	0.0010	1.667	1.668	1.668
Mean of 75 % RDF		0.641	0.695	0.668	0.659	0.718	0.689	0.0014	0.0014	0.0014	1.649	1.660	1.655
Mean of 100 % RDF		0.690	0.722	0.706	0.713	0.718	0.715	0.0014	0.0015	0.0014	1.664	1.668	1.666
Mean of 125 % RDF		0.693	0.735	0.714	0.728	0.737	0.732	0.0015	0.0015	0.0015	1.660	1.677	1.668
Cycocel Mean		0.675	0.717		0.700	0.724		0.0014	0.0015		1.658	1.668	
Control		0.711			0.523			0.0010			1.636		

	S.Em±	CD (P= 0.05)	S.Em±	CD (P= 0.05)	S.Em±	CD (P= 0.05)	S.Em±	CD (P= 0.05)
Plant geometry	0.010	0.028	0.014	0.040	0.00003	0.00007	0.002	0.007
Fertilizer levels	0.010	0.028	0.014	NS	0.00003	0.00007	0.002	0.007
Cycocel	0.008	0.023	0.011	NS	0.00002	NS	0.002	0.006
Plant geometry x Fertilizer levels x Cycocel	0.024	NS	0.034	NS	0.00006	NS	0.006	NS
Control Vs Treatments	0.023	0.067	0.033	0.096	0.00006	0.00018	0.006	0.016

DAS = Days after sowing NS = Non significant Control = 30 cm × 10 cm + 100 % RDF

Table 3: Yield, oil content and oil yield of niger at harvest as influenced by plant geometry, fertilizer levels and cycocel

Treatments		**Cycocel**											
		Oil content (%)			**Seed yield (kg/ha)**			**Stalk yield (kg/ha)**			**HI (%)**		
Plant geometry	**Fertilizer levels**	**500 ppm**	**1000 ppm**	**Mean**	**500 ppm**	**1000 ppm**	**Mean**	**500 ppm**	**1000 ppm**	**Mean**	**500 ppm**	**1000 ppm**	**Mean**
30 cm x 10 cm	75 % RDF	37.6	38.5	38.0	437	450	443	1629	1663	1646	21.2	21.3	21.2
	100 % RDF	38.5	38.3	38.4	438	469	454	1630	1683	1657	21.2	21.8	21.5
	125 % RDF	39.0	39.3	39.1	430	498	464	1383	1953	1668	23.7	20.3	22.0
	Mean	38.3	38.7	38.5	435	472	454	1548	1766	1657	22.0	21.1	21.6
45 cm x 10 cm	75 % RDF	38.9	38.1	38.5	449	399	424	1845	1551	1698	19.6	20.5	20.0
	100 % RDF	38.8	38.4	38.6	519	562	540	2031	2155	2093	20.3	20.7	20.5
	125 % RDF	39.6	40.1	39.8	529	726	628	2041	2606	2324	20.6	21.8	21.2
	Mean	39.1	38.9	39.0	499	562	531	1972	2104	2038	20.2	21.0	20.6
60 cm x 10 cm	75 % RDF	38.2	37.4	37.8	412	420	416	1660	1392	1526	20.7	20.5	20.6
	100 % RDF	37.7	38.5	38.1	432	430	431	1574	1628	1601	21.3	20.3	20.8
	125 % RDF	38.4	38.6	38.5	457	424	440	1601	1687	1644	21.6	23.4	22.5
	Mean	38.1	38.2	38.1	433	425	429	1612	1569	1590	21.2	21.4	21.3
Mean of 75 % RDF		38.0	38.5	38.2	433	429	431	1683	1621	1652	20.5	20.9	20.7
Mean of 100 % RDF		38.5	38.0	38.2	471	478	475	1773	1737	1755	21.9	20.8	21.3
Mean of 125 % RDF		39.0	39.3	39.1	464	551	508	1675	2082	1879	21.0	21.8	21.4
Cycocel Mean		38.5	38.6		456	486		1711	1813		21.1	21.2	
Control		38.0			423			1650			20.4		

	S.Em±	CD (P= 0.05)	S.Em±	CD (P= 0.05)	S.Em±	CD (P= 0.05)	S.Em±	CD (P= 0.05)
Plant geometry	0.13	0.37	3	9	14	40	0.15	0.44
Fertilizer levels	0.13	0.37	3	9	14	40	0.15	0.44
Cycocel	0.10	NS	3	7	12	33	0.12	NS
Plant geometry x Fertilizer levels x Cycocel	0.31	NS	8	22	35	99	0.37	1.07
Control Vs Treatments	0.30	0.87	7	21	34	97	0.36	1.04

DAS = Days after sowing NS = Non significant Control = 30 cm × 10 cm + 100 % RDF

Conclusion
Based on the results, it may be concluded that the plant geometry of 45cmx10cm, fertilizer doze of 125% RDF and cycocel spray @ 1000 ppm at 30 days after sowing to niger found optimum to get maximum dry matter production, leaf area, leaf area index, relative growth rate, crop growth rate, net assimilation rate, grain and fodder yield under rainfed condition.

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