J. Farm Sci., 30(2): (172-176) 2017

Growth and yield of niger (*Guizotia abyssinica* Cass.) as influenced by planting geometry, fertilizer levels and cycocel spray

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(Received: August, 2016 ; Accepted: June, 2017)

Abstract: A field experiment was conducted to study the agrotechniques to enhance the productivity of niger (*Guizotia abyssinica* Cass.) under rainfed condition at Main Agricultural Research Station, Dharwad during *kharif,* 2014. The experiment was laid out in randomized completely block design (factorial concept) with 18 treatment combinations 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 spray (500 ppm and 1000 ppm at 30 days after sowing). Results showed that planting geometry of 45 x 10 cm recorded significantly higher number of branches plant^{-1} (10.5), leaf area (3.273), seed yield (531 kg ha^{-1}) and stalk yield (2038 kg ha^{-1}). Among the fertilizer levels, application of 125% RDF recorded significantly higher plant height (124.5 cm), number capitula plant^{-1} (55.2), seeds capitulam^{-1} (21.4), seed yield (508 kg ha^{-1}) and stalk yield (1879 kg ha^{-1}). Application of cycocel @ 1000 ppm at 30 DAS significantly decreased the plant height (121.7 cm) and increased seed weight plant^{-1} (2.77 g), test weight (3.792 g), seed yield 486 kg ha^{-1}) and stalk yield (1813 kg ha^{-1}) as compared to others. The interaction effects indicated that planting geometry of 45 x 10 cm with 125% RDF and 1000 ppm cycocel spray recorded significantly higher seed yield (726 kg ha^{-1}), gross returns (₹ 58061 ha^{-1}), net returns (₹ 39950 ha^{-1}) and B:C ratio (3.21) as compared to other treatment combinations.

Key words: Cycocel, Niger, Oilseed, Planting geometry

Introduction

Niger (*Guizotia abyssinica* Cass.) is one of the important minor oilseed crops of Inida. In the 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., 2013). India is considered to be the chief niger producing country in the world grown over an area of about 3.8 lakh ha with a production and productivity of 0.98 lakh tones and 329 kg ha^{-1} respectively. In India, it contributes to about 2% of total edible oil production (Hanson *et al.,* 2002). In Karnataka, niger is cultivated over an area of about 14000 ha with a production and productivity of 5000 tones and 357 kg ha^{-1}, respectively (Anon., 2013). Generally niger is being cultivated under rainfed situations both as sole and inter crop. Being a minor *kharif* oilseed crop, it is grown under lower or poor management practices leading to lower crop productivity. The productivity potential of any crop in general and niger in particular can be exploited by the adoption of better agrotechniques *viz.,* optimum sowing time, plant geometry, fertilizers, recommended variety *etc*. In Northern Transition Zone of Karnataka, niger is sown during II fortnight of June at 30 x 10 cm planting geometry. Further, 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 x 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 branches, capitula, seeds and yield. Jadhav and Deshmukh (2008) reported the significant response of niger to higher fertilizer levels. At present, the recommended dose of fertilizer to niger is 20:40:20 kg N, P_2O_5, K_2O ha^{-1} and there is need to study its response to higher fertilizer levels to increase the yield. Since the information on the above factors is quite meager, the present investigation was undertaken to study the response of niger to planting geometries, fertilizer levels and cycocel spray under rainfed condition.

Material 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 combinations 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 practices. 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 plant population. Thinning was carried out at 20 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 at different growth stages of crop were subjected to statistical analysis as described by Panse and Sukhatme (1967).

Results and discussion

Growth and yield parameters

Results obtained from present experiment indicated that the crop sown at 45 x 10 cm planting geometry recorded significantly lower plant height (119.4 cm) and higher number of branches plant^{-1} (10.5), LAI (0.727), number of capitula plant^{-1} (54.5), number of seeds capitulum^{-1} (21.4), seed weight plant^{-1} (2.78 g) as compared to other planting geometries. While test weight was significantly higher in 60 x 10 cm planting geometry (3.982 g) and it was on par with 45 x 10 cm planting geometry (3.976) (Table 1). This might be due to wider planting geometry produced significantly higher yield and growth parameters plant^{-1}, which was mainly due to better resource availability and reduced interplant competition in the population and also due to better performance of the individual plants as indicated by more growth and yield parameters as reported by Vasanth Kumar (2012).

Application of 125% RDF recorded significantly higher seed weight plant^{-1} (2.79 g) as compared to 100% RDF and 75% RDF. This might be due to more availability of nutrients resulting in producing well developed seeds. The increase in seed weight plant^{-1} at 125% RDF was to an extent of 2.9 and 4.0 per cent over 100% RDF and 75 RDF respectively (Table 1). The results were in agreement with findings of Jadhav and Deshmukh (2008) who reported that niger crop sown with higher fertilizer level of 30:60 kg N and P_2O_5 ha^{-1} recorded significantly higher capsules plant^{-1} (34.45) and number of seeds plant^{-1} (1000.50) compared to 20:40 kg N and P_2O_5 ha^{-1}. Further, increase in the seed weight plant^{-1} was attributed to higher yield components *viz.,* number of capitula plant^{-1}, number of seeds capitulum^{-1} and test weight. The increase in number of seeds capitulum^{-1} at 125% RDF (21.4) was to an extent of 3.7 and 6.5 per cent higher compared 100% RDF (20.6) and 75% RDF (20.0) respectively. The increase in number of seeds capitulum^{-1} might be due to translocation of more photosynthates to sink resulting in more number of seeds capitulum^{-1}. The increase in test weight at 125% RDF (3.848 g) was to the tune of 3.7 and 3.8 over 100% RDF (3.706 g) and 75% RDF (3.699 g) respectively (Table 1). The test weight at higher level of RDF was due to well developed bold seeds. These results were in agreement with the findings of Dhange *et al.* (2008) who found that crop applied with 60 kg P_2O_5 ha^{-1} recorded significantly more number of capsules plant^{-1} (39), number of grains capsule^{-1} (28), number of grains plant^{-1} (538) and test weight (4.1 g). Further, increase in number of seeds capitulum^{-1} are directly related to higher growth attributing parameter *viz.*, plant height (124.5 cm), branches plant^{-1} (10.6), leaf area (2.845 dm^2) and leaf area index (0.628). The parameters were significantly higher at 125% RDF as compared to 100% RDF and 75% RDF.

Significantly higher leaf area was recorded with 125% RDF (2.845 dm^2). The increase in leaf area was to the tune of 3.1 and 6.7 per cent higher over 100% RDF (2.752 dm^2) and 75% RDF (2.657 dm^2) respectively. The major objective of agronomic practices like fertilizer application is to obtain optimum leaf area and leaf area index for maximum crop productivity. In the present study, increase in the fertilizer level lead to significantly higher leaf area and leaf area index at different growth stages. These results clearly indicated that increased photosynthetic area of the crop that might have resulted in increased leaf area which in turn resulted in increased growth and yield parameters. These results were in accordance with the findings of Thakur *et al.* (2005) who observed that the crop sown with higher fertilizer level of 40 kg N and 40 kg P_2O_5 ha^{-1} + PSB recorded significantly higher plant height (103 cm), branches plant^{-1} (11) and leaf area index (1.68) as compared to 20 kg N and 20 kg P_2O_5 ha$^{-1.}$

Spraying of cycocel @ 1000 ppm at 30 DAS recorded significantly lesser plant height (121.7 cm) and higher number of branches plant^{-1} (10.3), leaf area (2.815 dm^2) and leaf area index (0.629) as compared to 500 ppm cycocel spray. This was mainly attributed to the maximum dry matter accumulation in leaf resulted in higher leaf area and leaf are index. Significantly higher test weight (3.792 g) was recorded with 1000 ppm cycocel spray (Table 1). Kashid *et al.* (2010) recorded a significant decrease in plant height from 153.0 to 145.9 cm, increase in total dry matter production from 85.7 to 88.1 g plant^{-1} and seed yield from 19.7 to 20.31 q ha^{-1} with the spraying of increased doze of cycocel from 500 to 1500 ppm over control. The higher test weight can be related to maximum seed weight plant^{-1} obtained with spraying of cycocel @ 1000 ppm (2.77 g plant^{-1}) over cycocel @ 500 ppm. The increase in seed weight plant^{-1} with spraying of cycocel @ 1000 ppm was to an extent of 3.25 per cent higher over cycocel @ 500 ppm (2.68 g plant^{-1}) respectively. The higher seed weight plant^{-1} was due to maximum number of seeds capitulum^{-1} produced with spraying of cycocel @ 1000 ppm (21.0) over cycocel @ 500 ppm. The increase in number of seeds capitulum^{-1} with spraying of cycocel @ 1000 ppm was 3.3 per cent cycocel @ 500 ppm (20.3) respectively (Table 1). These results corroborate with the findings of Kubsad *et al.* (2004) in safflower who reported the more number of capitula plant^{-1} (32.2) and 100-seed weight (6.7 g) with cycocel spraying @ 500 ppm at 50% flowering over control.

Yield and economics

The seed yield of niger at a planting geometry of 45 x 10 cm (531 kg ha^{-1}) was 19.2 and 14.5 per cent higher over 60 x 10 cm (429 kg ha^{-1}) and 30 x 10 cm (454 kg ha^{-1}) planting geometries. It was mainly due to optimum plants per unit area compared to 60 x 10 cm and 30 x 10 cm planting geometries as reported by Vasanth Kumar (2012) who revealed that niger crop sown at a

Table 1. Growth and yield attributes of niger as influenced by planting geometries, fertilizer levels and cycocel

Treatments	Plant height (cm)	No. of branches plant^{-1}	Leaf area (dm^2)	Leaf area index	No. of capitula plant^{-1}	No. of seeds capitulum^{-1}	Seed wt. plant^{-1} (g)	Test weight (g)
Planting geometry								
P_1 – 30 cm x 10 cm	126.1	9.6	1.653	0.538	51.6	20.5	2.63	3.294
P_2 – 45 cm x 10 cm	119.4	10.5	3.273	0.727	54.5	21.4	2.78	3.976
P_3 – 60 cm x 10 cm	123.2	10.2	3.328	0.561	53.7	20.1	2.78	3.982
S.Em±	0.5	0.1	0.047	0.011	0.4	0.3	0.03	0.033
C.D. (P=0.05)	1.4	0.3	0.136	0.032	1.2	0.9	0.09	0.095
Fertilizer levels								
F_1 - 75 % RDF	120.5	9.8	2.657	0.582	52.2	20.0	2.68	3.699
F_2 - 100 % RDF	123.6	9.9	2.752	0.617	52.3	20.6	2.71	3.706
F_3 - 125 % RDF	124.5	10.6	2.845	0.628	55.2	21.4	2.79	3.848
S.Em±	0.5	0.1	0.047	0.011	0.4	0.3	0.03	0.033
C.D. (P=0.05)	1.4	0.3	0.136	0.032	1.2	0.9	0.09	0.095
Cycocel								
C_1 - 500 ppm	124.1	9.9	2.688	0.589	52.7	20.2	2.68	3.710
C_2 - 1000 ppm	121.7	10.3	2.815	0.629	53.8	21.0	2.77	3.792
S.Em±	0.4	0.1	0.039	0.009	0.3	0.3	0.02	0.027
C.D. (P=0.05)	1.2	0.3	0.111	0.026	1.0	0.7	0.07	0.077

F_1: (75 % RDF): 15:30:15 kg N, P_2O_5, K_2O ha^{-1}, F_2: (100 % RDF):-20:40:20 kg N, P_2O_5, K_2O ha^{-1},

F_3 :(125 % RDF): 25:50:25 kg N, P_2O_5, K_2O ha^{-1}

Table 2. Yield and economics of niger as influenced by planting geometries, fertilizer levels and cycocel.

Treatments	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Harvest index (%)	Gross returns (₹ ha^{-1})	Net returns (ha^{-1})	B:C Ratio
Planting geometry						
P_1 – 30 cm x 10 cm	454	1657	21.6	36419	19052	2.10
P_2 – 45 cm x 10 cm	531	2038	20.6	43083	25742	2.48
P_3 – 60 cm x 10 cm	429	1590	21.3	34550	17217	2.00
S.Em±	3	14	0.15	217	217	0.01
C.D. (P=0.05)	9	40	0.44	625	625	0.04
Fertilizer levels						
F_1 - 75 % RDF	431	1652	20.7	34986	17640	2.02
F_2 - 100 % RDF	475	1755	21.3	38202	21563	2.26
F_3 - 125 % RDF	508	1879	21.4	40865	22808	2.30
S.Em±	3	14	0.15	217	217	0.01
C.D. (P=0.05)	9	40	0.44	625	625	0.04
Cycocel						
C_1 - 500 ppm	456	1711	21.1	36811	19524	2.13
C_2 - 1000 ppm	486	1813	21.2	39224	21817	2.25
S.Em±	3	12	0.12	178	178	0.01
C.D. (P=0.05)	7	33	NS	510	510	0.03

F_1: (75 % RDF): 15:30:15 kg N, P_2O_5, K_2O ha^{-1}, F_2: (100 % RDF):- 20:40:20 kg N, P_2O_5, K_2O ha^{-1}

F_3 : (125 % RDF): 25:50:25 kg N, P_2O_5, K_2O ha^{-1}

wider plant geometry of 45 cm × 10 cm recorded significantly higher seed yield (615 kg ha^{-1}) as compared to 30 x 10 cm. The same planting geometry also recorded significantly higher stalk yield (2038 kg ha^{-1}), gross returns (₹ 43083 ha^{-1}), net returns (₹ 25742 ha^{-1}) and B:C ratio (2.48) as compared to other planting geometries (Table 2). There was linear increase in seed yield of niger form 75% RDF (431 kg ha^{-1}) to125% RDF (508 kg ha^{-1}). The increase in yield was to an extent of 6.5 and 15.16 per cent higher over 100% RDF and 75% RDF respectively. 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 yield of niger. Similar observations were reported by Amare *et al*. (2015) where in significantly higher number of capitula plant^{-1} (55.6), 1000-seed weight (3.39 g), seeds capitulum^{-1} (28), seed yield (1503.1 kg ha^{-1}), biomass yield (10072.0 kg ha^{-1}) and oil content (39.9%) were recorded with application of 41 kg N and 23 kg P_2O_5 ha^{-1} to niger as compared to 20.5 kg N and 23 kg P_2O_5 ha^{-1}. Application of 125% RDF recorded significantly higher stalk yield (1879 kg ha^{-1}), harvest index (21.4), gross returns (₹ 4086 ha^{-1}), net returns (₹ 22808 ha^{-1}) and BC ratio (2.30) as

Table 3. Interaction effects of planting geometries, fertilizer levels and cycocel.

Treatments	Plant height (cm)	No. of branches plant^{-1}	Leaf area (dm^{2})	LAI	No. of capitula plant^{-1}	No. of seeds capitulum^{-1}	Seed weight plant^{-1}(g)	Test weight (g)	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Harvest index (%)	Gross returns (ha^{-1})	Net returns (ha^{-1})	B:C ratio
$P_1F_1C_1$	127.8	9.2	2.233	0.744	50.3	20.2	2.50	3.233	437	1629	21.2	35259	15589	1.87
$P_1F_1C_2$	124.8	9.5	2.367	0.789	51.0	20.2	2.68	3.200	450	1663	21.3	36188	22499	2.24
$P_1F_2C_1$	127.0	9.5	2.367	0.789	51.7	20.1	2.59	3.167	438	1630	21.2	35306	18000	2.04
$P_1F_2C_2$	125.7	9.5	2.567	0.856	50.9	21.1	2.62	3.300	469	1683	21.8	37522	20095	2.15
$P_1F_3C_1$	125.5	9.8	2.400	0.800	52.3	19.7	2.63	3.367	430	1383	23.7	33605	18661	2.12
$P_1F_3C_2$	125.7	10.2	2.600	0.867	53.3	21.7	2.73	3.500	498	1953	20.3	40636	19470	2.16
$P_2F_1C_1$	124.0	10.0	2.827	0.628	50.2	20.6	2.60	3.740	449	1845	19.6	37036	19755	2.14
$P_2F_1C_2$	120.3	10.0	3.193	0.710	54.7	19.9	2.80	4.000	399	1551	20.5	32506	15105	1.87
$P_2F_2C_1$	124.3	10.3	3.340	0.742	51.7	20.2	2.63	3.933	519	2031	20.3	42303	25730	2.55
$P_2F_2C_2$	120.0	10.5	3.387	0.753	54.3	21.2	2.80	3.960	562	2155	20.7	45602	28909	2.73
$P_2F_3C_1$	115.3	10.2	3.247	0.721	56.6	22.4	2.78	4.040	529	2041	20.6	42993	25002	2.39
$P_2F_3C_2$	112.2	12.0	3.600	0.800	59.4	24.2	3.07	4.180	726	2606	21.8	58061	39950	3.21
$P_3F_1C_1$	122.0	9.7	3.173	0.550	50.5	18.8	2.79	3.900	412	1660	20.7	33384	16112	1.93
$P_3F_1C_2$	121.0	10.2	3.273	0.587	54.2	19.6	2.71	4.007	420	1392	20.5	34165	16772	1.94
$P_3F_2C_1$	125.5	9.8	3.407	0.529	55.3	19.8	2.79	4.000	432	1574	21.3	36619	16814	1.93
$P_3F_2C_2$	120.7	10.2	3.293	0.546	52.6	21.2	2.81	3.987	430	1628	20.3	33238	16996	1.96
$P_3F_3C_1$	125.3	10.5	3.300	0.568	55.4	20.8	2.81	4.007	457	1601	21.6	34797	20055	2.21
$P_3F_3C_2$	124.7	10.7	3.520	0.549	54.2	20.3	2.74	3.993	424	1687	23.4	35099	16553	1.99
Control	133.2	7.5	2.133	0.711	42.0	17.4	2.36	3.427	423	1650	20.4	34466	17280	2.01
S.Em±	1.2	0.4	0.116	0.027	1.0	0.8	0.07	0.081	8	35	0.37	533	533	0.03
C.D. (P=0.05)	NS	NS	NS	NS	2.9	NS	NS	NS	22	99	1.02	1531	1531	0.09

P_1 - 30 x 10 cm, P_2 - 45 x 10 cm, P_3 - 60 x 10 cm F_1: 75 % RDF- 15:30:15 kg N, P_2O_5, K_2O ha^{-1} ,
F_2 : 100 % RDF - 20:40:20 kg N, P_2O_5, K_2Oha^{-1} F_3 : 125 % RDF - 25:50:25 kg N, P_2O_5, K_2O ha^{-1}
C_1 - 500 ppm cycocel spray, C_2 - 1000 ppm cycocel spray
Market prices (q ha^{-1}): Seed- 6200 q^{-1}, Stalk – 500 q^{-1}, NS – Non significant

compared to 100% RDF and 75% RDF. It might be due to higher seed yield and stalk yield of niger at125% RDF. The seed yield of niger was significantly higher at 1000 ppm cycocel spray (486 kg ha^{-1}) as compared to 500 ppm. The increase in the seed yield was 6.2 per cent higher over cycocel @ 500 ppm respectively (453 kg ha^{-1}) (Table 2). 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) at Dharwad where in foliar spray of cycocel @ 1000 ppm at 30 days after sowing recorded significantly higher seed yield (600 kg ha^{-1}) over control. Application of 1000 ppm cycocel spray also resulted in significant incrase in the stalk yield (1813 kg ha^{-1}), harvest index (21.2%), gross returns (39224 ha^{-1}), net returns (21817 ha^{-1}) and B C ratio (2.25) as compared to 500 ppm.

Interaction effects

The seed yield (726 kg ha^{-1}) and stalk yield (2606 kg ha^{-1}) at 45 x 10 cm planting geometry with a fertilizer level of 125% RDF and 1000 ppm cycocel spray were significantly higher as compared to other treatment combinations. The increase in the seed yield was due to increase in growth and yield attributing characters such as branches plant^{-1} (12), leaf area (3.600 dm^{2}), LAI (0.800), number of capitula plant^{-1} (59.4), number of seeds capitulum^{-1} (24.2), seed weight plant^{-1} (3.07 g) and test weight (4.180 g) as compared to other treatment combinations (Table 3). The higher values of growth and yield attributing characters might be due to optimum spacing and adequate fertilizer availability along with growth retardant which helped in arresting excessive vegetative growth. Thus, there is an increased translocation of photosynthates to sink which inturn increased the number of capitulam per plant. Further, cycocel being a stable synthetic auxin inhibitor might have decreased the activity of meristematic tip and auxiliary buds and increased the translocation of photosynthates to sink results in higher capitula per plant and seed yield as reported by Thiruppathi *et al.* (2003). The same treatment realized significantly higher gross returns (₹ 58061 ha^{-1}), net returns (₹ 39950 ha^{-1}) and BC ratio (3.21) as compared to other treatment combinations. The increase in gross returns, net returns and BC ratio was due to increase in the seed yield and stalk yield of niger which closely related to a optimum planting geometry and higher nutrient availability as reported by Amare *et al.* (2015).

Based on the results obtained, it was concluded that sowing of niger at a planting geometry of 45 x 10 cm with a fertilizer level of 125% RDF (25:50:25 kg N, P_2O_5, K_2O ha^{-1}) and application of cycocel @ 1000 ppm at 30 DAS found optimum to get maximum seed yield and net returns under rainfed conditions.

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