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Yield, Quality and Nutrient Uptake of Niger *(Guizotia abyssinica* Cass.*)* as Influenced by Plant Geometry, Fertilizer Level and Cycocel

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A B S T R A C T

A field experiment was conducted to study the effects of varying levels of plant geometry, fertilizer and cycocel on yield, quality and nutrient uptake of niger (*Guizotia abyssinica* Cass.) under rainfed conditions 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 10cm, 45 x 10cm and 60 x 10cm), 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). The results showed that the treatment combination of planting geometry of 45 x 10cm with 125% RDF and 1000 ppm cycocel spray recorded significantly higher total dry matter production (57 g plant^{-1}), N uptake (37.3 kg ha^{-1}), P uptake (9.2 kg ha^{-1}), K uptake (10.8 kg ha^{-1}), seed yield (726 kg ha^{-1}) and stalk yield (2606 kg ha^{-1}) as compared to other treatment combinations. There was 20.3% increase in grain yield, 19.0 % increase in stalk yield, 11.5% increase in N uptake, 8.0% increase in P uptake and 9.8% increase in K uptake by niger over control.

Introduction

Niger (*Guuizotia 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 0.58 m t and 388 kg ha^{-1} respectively (Anon., 2017). India is considered to be the chief niger producing country in the world grown over an area of about 3.9 lakh ha with respect to area, production and productivity of 0.99 lakh tonnes and 333 kg/ha and it ranks first with respect to area, production and productivity. In India, it contributes to about 2% of total edible oil production (Hansons *et al*., 2002). In Karnataka, niger is cultivated over an area of about 14000 ha with a production and productivity of 5000 tonnes and 357 kg/ha, respectively (Anon., 2017). Generally niger is being cultivated under rainfed situations both as sole and inter crop. Being a minor *Kharif* oil seed 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 *kharif* rains 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 10cm appears to be less which restricts production of branched 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) 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 meagre, the present investigation was undertaken to study the response of niger to planting geometries, fertilizer levels and cycocel spray under rainfed condition.

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 consists of 18 treatment combinations with single control (Recommended package of practice-RPP) and three replications. The treatment consisted three planting geometries (30 x 10cm, 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 experiment site had 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 fertilizers was 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 plant population. Thinning was carried out at twenty days after sowing retaining one healthy seedling per hill. Cycocel @ 500 ppm and 1000 ppm 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 growth and yield observations were recorded as per the established norms. Plant samples of niger collected at harvest were used for estimation of nutrient content. The dried sample were ground and passed through 40 mesh sieve. The ground material was collected in butter paper bag and used for chemical analysis. The soil samples (0-15 cm) so collected were air dried, ground with the help of wooden pastle and mortar, sieved through 2 mm sieve and analysed for available nitrogen (Alkaline Permanganate Method, Subbiah and Asija, 1956), available phosphorus (Olsen *et al.*, 1954) and available potassium (A.O.A.C., 1988). The protein and oil content of niger was determined by Modified Lowry's method and Soxhlet apparatus using petroleum ether

(60-80^{o} C) as an extractant (A.O.A.C.,1960) respectively. The data collected on different parameters were subjected to statistical analysis as described by Gomez and Gomez (1984) for better interpretation of results.

Results and Discussion

Total dry matter production, yield and quality

The data on total dry matter production, yield, oil content and protein content of niger differed significantly due to planting geometries, fertilizer levels and cycocel (Table 1). The crop sown at 45 x 10cm planting geometry recorded significantly higher total dry matter production (52.8 g plant^{-1}), seed yield (531 kg ha^{-1}), stalk yield (2038 kg ha^{-1}), oil content (39.0%) and protein content (23.4%) as compared to other planting geometries. The yield increase at 45 x 10cm planting geometry was 19.2, 14.5 and 20.3% higher over 60 x 10cm, 30 x 10cm and control (RPP) respectively. These higher values were mainly due to better resource availability and reduced interplant competition in the population. Thus resulted in better performance of individual plants as indicated by more number of branches plant^{-1} and yield parameters. Saren *et al*., (2008) observed the similar response of niger to planting geometries. The higher oil and protein content can be related to congenial micro climate as well as increase in light penetration within plant canopy which increased the assimilation rate as reported by Tenebe *et al.*, (2008).

Table.1 Total dry matter production, yield and quality of niger as influenced by planting geometry, fertilizer level and cycocel

Treatments	Total dry matter production at harvest DAS (g plant^{-1})	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Oil content (%)	Protein content (%)
Plant geometry					
30 cm x 10 cm	50.2	454	1657	38.5	22.1
45 cm x 10 cm	52.8	531	2038	39.0	23.4
60 cm x 10 cm	52.3	429	1590	38.1	22.8
S. Em.±	0.28	3	14	0.13	0.2
CD @ 5%	0.79	9	40	0.37	0.6
Fertilizer levels					
75% RDF	50.8	431	1652	38.2	22.3
100% RDF	52.1	475	1755	38.2	22.5
125% RDF	52.4	508	1879	39.1	23.5
S. Em.±	0.28	3	14	0.13	0.2
CD @ 5%	0.79	9	40	0.37	0.6
Cycocel					
500 ppm	51.1	456	1711	38.5	22.3
1000 ppm	52.4	486	1813	38.6	22.3
S. Em.±	0.22	3	12	0.10	0.2
CD @ 5%	0.65	7	33	NS	NS

Table.2 Nutrient uptake and availability of niger as influenced by planting geometries, fertilizer levels and cycocel spray

9.5	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})	Available nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potassium (kg/ha)
Plant geometry						
30 cm x 10 cm	31.8	8.3	9.8	174.4	37.3	376.1
45 cm x 10 cm	33.1	8.7	10.2	173.9	36.9	375.9
60 cm x 10 cm	27.9	7.6	9.0	178.6	37.8	377.1
S. Em.±	0.3	0.04	0.05	0.3	0.2	0.08
CD @ 5%	0.8	0.12	0.14	0.8	0.5	0.22
Fertilizer levels						
75% RDF	30.4	8.0	9.5	171.1	29.8	371.5
100% RDF	30.5	8.1	9.5	176.2	37.9	376.5
125% RDF	31.8	8.4	9.9	179.7	44.3	381.1
S. Em.±	0.3	0.04	0.05	0.3	0.2	0.08
CD @ 5%	0.8	0.12	0.14	0.8	0.5	0.22
Cycocel						
500 ppm	30.3	8.1	9.5	176.2	37.6	376.5
1000 ppm	31.5	8.3	9.8	175.1	37.1	376.3
S. Em.±	0.2	0.03	0.04	0.2	0.2	0.06
CD @ 5%	0.6	0.10	0.11	0.6	0.4	0.18

Table.3 Interaction effects of planting geometry, fertilizer level and cycocel

Treatment combinations	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Oil content (%)	Protein content (%)	Total dry matter produ ction (g plant^{-1})	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})	N availa bility (kgha^{-1})	P availa bility (kg ha^{-1})	K availa bility (kgha^{-1})
$P_1F_1C_1$	437	1629	37.6	21.2	48.8	30.6	8.0	9.5	168.8	31.2	371.0
$P_1F_1C_2$	450	1663	38.5	22.5	51.0	31.5	8.1	9.9	168.8	35.4	370.8
$P_1F_2C_1$	438	1630	38.5	22.3	51.0	32.0	8.0	9.7	176.0	38.7	376.8
$P_1F_2C_2$	469	1683	38.3	21.9	50.3	32.0	8.3	9.9	175.0	36.9	376.2
$P_1F_3C_1$	430	1383	39.0	22.4	49.1	32.3	8.3	9.8	178.9	43.5	381.4
$P_1F_3C_2$	498	1953	39.3	22.2	51.2	32.3	8.5	9.9	179.3	43.0	380.7
$P_2F_1C_1$	449	1845	38.9	22.8	49.4	31.5	8.5	10.0	170.6	33.8	371.3
$P_2F_1C_2$	399	1551	38.1	23.0	51.1	32.2	8.6	10.0	169.7	35.2	371.3
$P_2F_2C_1$	519	2031	38.8	22.7	52.2	31.3	8.3	10.0	175.3	37.9	375.9
$P_2F_2C_2$	562	2155	38.4	23.3	54.2	32.7	8.6	10.1	174.3	37.6	375.9
$P_2F_3C_1$	529	2041	39.6	23.1	52.9	33.7	8.8	10.2	178.6	41.1	380.6
$P_2F_3C_2$	726	2606	40.1	25.5	57.0	37.3	9.2	10.8	174.8	40.9	380.3
$P_3F_1C_1$	412	1660	38.2	22.5	52.2	27.0	7.2	8.6	174.7	35.9	372.4
$P_3F_1C_2$	420	1392	37.4	22.1	52.2	27.8	7.4	9.0	173.9	37.8	372.2
$P_3F_2C_1$	432	1574	37.7	20.8	52.4	27.8	7.4	8.8	178.5	37.7	377.2
$P_3F_2C_2$	430	1628	38.5	24.1	52.7	28.3	7.8	8.9	178.1	38.1	377.2
$P_3F_3C_1$	457	1601	38.4	22.5	52.1	26.9	7.8	9.0	184.4	41.1	382.0
$P_3F_3C_2$	424	1687	38.6	24.9	52.4	29.2	8.0	9.6	182.0	41.3	381.7
Control	423	1650	38.0	20.4	48.5	29.3	8.0	9.2	177.0	38.3	376.8
S. Em.±	8	35	0.31	0.5	0.67	0.6	0.10	0.12	0.7	0.7	0.19
CD @ 5%	22	99	NS	1.5	NS	NS	NS	NS	NS	NS	NS
Control (RPP)vs Treatment											
S. Em.±	7	34	0.30	0.5	0.67	0.7	0.10	0.12	0.7	0.7	0.21
CD @ 5%	21	97	0.87	1.5	1.91	1.9	0.30	0.33	2.0	1.9	0.60

There was linear increase both in seed and stalk yield with increase in RDF from 75% to 125%. Among the fertilizer levels, application of 125% RDF recorded significantly higher total dry matter production (52.4 g plant^{-1}), seed yield (508 kg ha^{-1}), stalk yield (1879 kg ha^{-1}), oil content (39.1%) and protein content (23.5%) over 100% RDF and 75% RDF. The increase in yield with 125% RDF was to the tune of 6.5, 15.2 and 16.7% higher compared to 100% RDF, 75% RDF and control (RPP) respectively. The higher yield can be related to better performance of growth and yield parameters at higher fertilizer level which was due to better availability of nutrients to the crop. This has favoured the growth and development of better root system and helped in better uptake of applied nutrients. Thus resulted in increased leaf area, dry matter production and its accumulation in reproductive parts as reported by Jadhav and Deshmukh (2008). The higher protein content at 125% RDF might be due to higher nitrogen uptake and also phosphorus which is a major constituent of fatty acids and thus resulted into higher oil content and protein content as reported by Amare *et al.,* (2015).

Application of cycocel @ 1000 ppm at 30 DAS recorded significantly higher total dry matter production (52.4 g plant^{-1}), seed yield (486 kg ha^{-1}), stalk yield (1813 kg ha^{-1}), oil content (38.6%) and protein content (22.3%) as compared to 500 ppm cycocel spray. The increase in seed yield was to an extent of 6.2 and 12.9% over 500 ppm and control (RPP) respectively. The higher yield at 1000 ppm cycocel spray can be attributed to its reduced plant height which was found to be useful in increasing the efficiency of translocation of photosynthates from source to sink as observed by Vasanth Kumar (2012). Thus resulted in improvement in growth and yield parameters (Kubsad *et al.,* 2004). There was no effect of cycocel on oil content and protein content of niger.

Uptake of nutrients and their availability in soil

The results revealed the significant effect of different treatments on nutrient uptake and their availability in soil after crop harvest (Table 2). The crop sown at 45 x 10 cm planting geometry recorded significantly higher N uptake (33.1 kg ha^{-1}), P uptake (8.7 kg ha^{-1}) and K uptake (10.2 kg ha^{-1}) as compared to 30 x 10 cm and 60 x 10 cm planting geometries. The N uptake was 3.9 and 15.7% higher, P uptake was 4.6 and 12.6% higher, K uptake was 3.9 and 11.7% higher over 30 x 10 cm and 60 x 10 cm planting geometries respectively. The wider plant geometry of 60 x 10 cm recorded the lowest nutrient uptake due to lowest seed and stalk yield. The higher nutrients uptake was mainly due to higher seed and stalk yield as reported by Dharma-Oraoan *et al.,* (2010). The available N (173.9 kg ha^{-1}), P (36.9 kg ha^{-1}) and K (375.9 kg ha^{-1}) content in soil after crop harvest at 45 x 10 cm was lowest as compared to other plant geometries due to higher nutrient uptake by the crop (Table 2).

There was linear increase both in nutrients uptake and also in their availability in soil after crop harvest with increase in fertilizer doze from 75 to 125% RDF. Crop supplied with 125% RDF recorded significantly higher nutrient uptake (31.8 kg N, 8.4 kg P, 9.9 kg K ha^{-1}) as compared to rest of the fertilizer dozes. The increased uptake was attributed to increased availability of nutrients in the soil which resulted in the higher dry matter production which lead to higher seed and stalk yield of niger. The results of the present investigation were in accordance with the findings of Patil *et al.,* (2010).

The available nutrients content in soil was increased with increase in fertilizer levels from 75% to 125% RDF. The available nitrogen, phosphorous and potassium

increased from 171.1 to 179.7, 29.8 to 44.3 and 371.5 to 381.1 kg ha^{-1} respectively in the soil after crop harvest which might be due to the supply of nitrogen, phosphorous and potassium through fertilizers. The lower value of available nutrient with 100% RDF and 75% RDF at harvest might be attributed to poor utilization of available soil nutrient resources due to lower efficiency of above ground canopy/ source-sink relation by the crop. Similar results were also reported by Prasanna Kumara *et al.*, (2014).

Uptake of nitrogen, phosphorus and potassium by niger at harvest was significantly higher with the application of cycocel @ 1000 ppm (31.5, 8.3 and 9.8 kg ha^{-1} respectively) compared to cycocel @ 500 ppm (30.3, 8.1 and 9.5 kg ha^{-1} respectively). The higher uptake of nutrients may be attributed to higher seed and stalk yield due to the better performance of the crop as reflected in higher values of yield parameters. These results were in accordance with the findings of Khashid *et al*., (2010).

Interaction effects

Interaction effect of planting geometries, fertilizer levels and cycocel had significant effect on seed yield, stalk yield and protein content of niger, while their effect on control treatment (RPP) was significant on all parameters (Table 3). A treatment combination of 45 cm x 10 cm plant geometry with the fertilizer level of 125% RDF and application of cycocel @ 1000 @ ppm at 30 DAS recorded significantly higher seed yield (726 kg ha^{-1}), stalk yield (2606 kg ha^{-1}) and protein content (25.5%) over other treatment combinations. The higher seed yield and stalk yield was mainly attributed to higher uptake of nitrogen, phosphorus and potassium (37.3, 9.2 and 10.8 kg ha^{-1} respectively) as reported by Jadhav and Deshmukh (2008). The N is essential for plant growth and also it is a constituent of all proteins and nucleic acids. Whereas P is essential for the production and transfer of energy in plants which might have resulted in the higher protein content of niger compared to other treatment combinations. Similar results were also reported by Vasanth Kumar (2012) in niger.

Based on the results obtained, it may be concluded that sowing of niger at a plant geometry of 45 cm x 10 cm with a fertilizer level of 125% RDF and application of cycocel @ 1000 ppm at 30 DAS found optimum to get maximum seed yield, stalk yield and protein content under rainfed conditions as compared to recommended package of practice.

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