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Original Research Article

Post-Harvest Nitrogen Dynamics of Knolkhol (*Brassica oleraceae* var. gongylodes) Under Varied Times of Planting, Spacing and Nitrogen Levels

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A B S T R A C T

A field experiment was conducted during two consecutive *rabi* seasons of 2014-15 and 2015-16 at College of Horticulture, Anantharajupeta to study post harvest nitrogen dynamics of knolkhol *(Brassica oleraceae var. gongylodes)* under varied times of planting, spacing and nitrogen levels. The experimental results revealed that the highest post harvest available nitrogen in soil was with the crop planted during I FN of November (T_1), which was significantly higher than that due to later planting times, during both the years while among three spacings tried, it was highest with 30 cm x 30 cm (S_2). Increase in nitrogen levels from 0 to 150 kg ha^{-1} increased the post harvest soil fertility status, significantly. The balance of soil available nitrogen followed similar trend during both the years, only with variation in magnitude. Net loss of soil available nitrogen is higher with late planting during I FN of December (T_3) and it was decreased with advancement in planting time of knolkhol. Irrespective of time of planting, the net gain of soil available nitrogen is more in widest spacing (S_2 - 30 x 30 cm) followed by other two closer spacings. Irrespective of time of planting and spacings, successive increase in nitrogen dose from 0 to 150 kg ha^{-1} increased the net gain of soil available nitrogen. The application of varying doses of nitrogen increased the total available nitrogen accordingly, when compared to control where a net loss was noticed. The actual soil nitrogen after harvest was found lower when compared to the expected nitrogen in soil during both the years of study.

Keywords

Brassica oleraceae, Post-Harvest Nitrogen Dynamics

Introduction

The assortment of vegetables cultivated in Andhra Pradesh is constantly widening. New vegetable species, not known earlier on a large scale, are introduced to the market offer. The knolkhol (*Brassica oleracea* var. *gongylodes* L.*)* is a cool season crop which is gaining popularity due to its antihyperglycemic and anticarcinogenic properties owing to higher antioxidant activity (530 micro moles g^{-1} fresh weight) because of rich antioxidant composition *i.e.* ascorbic acid (164 mg), carotenoids (54 mg) and total phenolic content (169 mg) per every 100 grams of fresh weight (Ahmed, 2009).

Knolkhol or kohlrabi is not a common crop in Southern Agroclimatic zone of Andhra Pradesh. When a non-traditional crop is introduced to the field cultivation in new regions, has to be evaluated for the response to local climatic factors. Optimum date of planting and plant density are important variables for achieving maximum yield and uniform vegetable maturity. Nitrogen is an important element for economic vegetable production that most frequently limits the production and is the key input in nutrient management. Knolkhol is one among the few vegetables which require heavier nutrition. Nitrogen being the primary element of plant nutrition has well established beneficial effects on vegetative growth and yield. Among cole crops, knolkhol responds favourably to nitrogen application (Saleh *et al.,* 2013). Moreover intensive agriculture demands full exploitation of the genetic potentiality of the varieties with available resources, especially fertilizers while being economic at the same time. Hence, the present investigation was planned to study post-harvest nitrogen dynamics of knolkhol *(Brassica oleraceae var. gongylodes L.)* under varied times of planting, spacing and nitrogen levels.

Materials and Methods

Field experiment was conducted during two consecutive *rabi* seasons of 2014-15 and 2015-16 at College of Horticulture, Anantharajupeta, which falls under Southern Agro-Climatic Zone of Andhra Pradesh. Experimental design was split-split, with three replications. The treatments comprised of three times of planting *viz.,* I FN of November (T_1), II FN of November (T_2) and I FN of December (T_3) assigned to main plots, three spacings *viz.,* 30 x 15 cm (S_1), 30 x 30 cm (S_2) and 45 x 15 cm (S_3) allotted to sub plots and five nitrogen doses *viz.,*0 kg N ha^{-1} (N_1), 75 kg N ha^{-1} (N_2), 100 kg N ha^{-1} (N_3), 125 kg N ha^{-1} (N_4) and 150 kg N ha^{-1} (N_5) assigned to sub-sub plots. The test variety was White Vienna. The nursery was raised 30 days prior to each transplanting date under shade nets. The crop was grown under open field condition by adopting the recommended cultural practices. Uniform dose of 60 kg P_2O_5 and 80 kg K_2O ha $^{-1}$ through single super phosphate and muriate of potash, respectively were applied as basal through band placement, 5 cm away from the crop row uniformly to all the treatments. Half the dose of nitrogen was applied as basal and the remaining dose is applied in two equal splits *viz.,* at 3 weeks after planting and at 6 weeks after planting as per the treatments. Oven dried plant samples of knolkhol at harvest were finely powdered and used for chemical analysis.

Nitrogen content in plants was analyzed by the standard procedure outlined by Jackson (1973). The uptake of nitrogen at harvest was calculated and expressed in kg ha^{-1} by multiplying the nutrient content with the corresponding dry matter production. Soil samples were taken after harvest of crop, treatment wise. The shade dried soil sample was analyzed for available nitrogen (Subbiah and Asija, 1956) during both the years of investigation.

Results and Discussion

Post-harvest nitrogen status of soil after knolkhol significantly varied due to planting time, spacing and nitrogen doses with unaltered trend, during both the years of investigation. Collective effect of time of planting and nitrogen doses and spacing and nitrogen doses were only statistically measurable, while all other interaction effects were non-significant.

Higher post-harvest soil available nitrogen (Table 1) was with the crop planted during I FN of November (T_1), which was distinctly superior to that of II FN of November planting (T_2). The latter in turn was significantly higher than that with I FN of December (T_3). Lower residual soil nitrogen after the harvest of late planted knolkhol crop was due to efficient use of soil and applied nitrogen for optimum growth and final knob yield due to its longer duration compared with the earlier plantings.

Table.1 Post-harvest soil available nitrogen (kg ha^{-1}) at harvest of knolkhol as influenced by varied time of planting, spacing and nitrogen doses

		2014-15							2015-16						
		N_1	N_2	N_3	N_4	N_5	Mean for T	Mean for S	N_1	N_2	N_3	N_4	N_5	Mean for T	Mean for S
T_1	S_1	186	219	225	235	248	**235**	**212**	218	255	254	267	279	**259**	**246**
	S_2	190	240	249	260	287			219	270	256	268	282		
	S_3	188	241	240	254	270			219	263	266	276	288		
T_2	S_1	182	215	217	219	230	**223**	**235**	217	245	248	252	265	**248**	**248**
	S_2	187	199	238	249	275			219	247	250	254	266		
	S_3	185	231	227	240	255			218	247	259	262	275		
T_3	S_1	180	204	204	207	216	**218**	**229**	217	235	243	243	251	**240**	**253**
	S_2	186	227	232	241	267			214	237	244	243	254		
	S_3	187	226	219	231	245			214	242	255	249	260		
Mean for N		**186**	**222**	**228**	**237**	**255**	-	-	**217**	**249**	**253**	**257**	**269**	-	-

	2014-15		2015-16	
	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
T	1.3	5	0.3	12
S	1.9	6	1.7	5
N	1.8	5	0.8	2
TxS	3.2	NS	3.0	NS
TxN	3.1	9	1.3	4
SxN	3.1	9	1.3	4
TxSxN	5.4	NS	2.3	NS

Table.2 Interaction effect of time of planting and nitrogen doses on post-harvest soil available nitrogen (kg ha^{-1}) of knolkhol

2014-15							2015-16						
	N_1	**N_2**	**N_3**	**N_4**	**N_5**	**Mean of T**		**N_1**	**N_2**	**N_3**	**N_4**	**N_5**	**Mean of T**
T_1	188	233	238	250	269	**235**	**T_1**	219	263	259	270	283	**259**
$5T_2$	185	215	228	236	253	**223**	**T_2**	218	247	252	256	269	**248**
T_3	184	219	218	226	243	**218**	**T_3**	215	238	247	245	255	**240**
Mean of N	**186**	**222**	**228**	**237**	**255**	-	**Mean of N**	**217**	**249**	**253**	**257**	**269**	-

Table.3 Interaction effect of spacing and nitrogen doses on post-harvest soil available nitrogen (kg ha^{-1}) of knolkhol

2014-15							2015-16						
	N_1	**N_2**	**N_3**	**N_4**	**N_5**	**Mean of S**		**N_1**	**N_2**	**N_3**	**N_4**	**N_5**	**Mean of S**
S_1	183	213	215	220	232	**212.4**	S_1	218	245	248	254	265	**246**
S_2	188	222	240	250	276	**234.9**	S_2	217	251	250	255	268	**248**
S_3	187	232	229	242	257	**229.3**	S_3	217	251	260	262	274	**253**
Mean of N	**186**	**222**	**228**	**237**	**255**	-	**Mean of N**	**217**	**249**	**253**	**257**	**269**	-

	2014-15		**2015-16**	
	SEm ±	**CD (P = 0.05)**	**SEm ±**	**CD (P = 0.05)**
TxN	3.1	9	1.3	4
SxN	3.1	9	1.3	4

Table.4 Balance sheet of soil available N (kg ha^{-1}) as influenced by varied time of planting, spacing and nitrogen doses (2014-15)

Treatments	Initial soil available nitrogen	Nitrogen applied through urea to knokhol	Total Available nitrogen	Nitrogen uptake by knolkhol	Expected balance	Soil available nitrogen at harvest of knolkhol (Actual balance)	Change in soil available nitrogen
$T_1S_1N_1$	204.3	0	204.3	12.1	192.2	185.9	-18.4
$T_1S_1N_2$	204.3	75	279.3	46.6	232.7	218.9	14.6
$T_1S_1N_3$	204.3	100	304.3	70.9	233.4	225.1	20.8
$T_1S_1N_4$	204.3	125	329.3	85.0	244.3	234.5	30.2
$T_1S_1N_5$	204.3	150	354.3	94.0	260.3	248.3	44.0
$T_1S_2N_1$	204.3	0	204.3	7.8	196.5	189.7	-14.6
$T_1S_2N_2$	204.3	75	279.3	31.7	247.6	239.8	35.5
$T_1S_2N_3$	204.3	100	304.3	49.9	254.4	249.0	44.7
$T_1S_2N_4$	204.3	125	329.3	60.8	268.5	260.0	55.7
$T_1S_2N_5$	204.3	150	354.3	63.3	291.0	286.7	82.4
$T_1S_3N_1$	204.3	0	204.3	9.5	194.8	188.3	-16.0
$T_1S_3N_2$	204.3	75	279.3	34.0	245.3	240.6	36.3
$T_1S_3N_3$	204.3	100	304.3	55.8	248.5	239.7	35.4
$T_1S_3N_4$	204.3	125	329.3	71.0	258.3	254.3	50.0
$T_1S_3N_5$	204.3	150	354.3	76.4	277.9	270.4	66.1
$T_2S_1N_1$	204.3	0	204.3	16.2	188.1	182.0	-22.3
$T_2S_1N_2$	204.3	75	279.3	59.8	219.5	215.1	10.8
$T_2S_1N_3$	204.3	100	304.3	86.6	217.7	216.7	12.4
$T_2S_1N_4$	204.3	125	329.3	104.6	224.7	219.3	15.0
$T_2S_1N_5$	204.3	150	354.3	115.3	239.0	230.1	25.8
$T_2S_2N_1$	204.3	0	204.3	10.6	193.7	187.1	-17.2
$T_2S_2N_2$	204.3	75	279.3	39.8	239.5	198.5	-5.8
$T_2S_2N_3$	204.3	100	304.3	60.8	243.5	238.4	34.1
$T_2S_2N_4$	204.3	125	329.3	73.2	256.1	248.6	44.3
$T_2S_2N_5$	204.3	150	354.3	75.9	278.4	274.5	70.2
$T_2S_3N_1$	204.3	0	204.3	12.7	191.6	185.4	-18.9
$T_2S_3N_2$	204.3	75	279.3	44.1	235.2	231.0	26.7
$T_2S_3N_3$	204.3	100	304.3	68.7	235.6	227.1	22.8
$T_2S_3N_4$	204.3	125	329.3	85.8	243.5	240.1	35.8
$T_2S_3N_5$	204.3	150	354.3	92.2	262.1	255.0	50.7
$T_3S_1N_1$	204.3	0	204.3	18.7	185.6	179.8	-24.5
$T_3S_1N_2$	204.3	75	279.3	67.9	211.4	203.7	-0.6
$T_3S_1N_3$	204.3	100	304.3	97.7	206.6	203.5	-0.8
$T_3S_1N_4$	204.3	125	329.3	117.1	212.2	207.2	2.9
$T_3S_1N_5$	204.3	150	354.3	129.2	225.1	216.3	12.0
$T_3S_2N_1$	204.3	0	204.3	12.2	192.1	185.7	-18.6
$T_3S_2N_2$	204.3	75	279.3	44.9	234.4	226.9	22.6
$T_3S_2N_3$	204.3	100	304.3	67.9	236.4	231.7	27.4
$T_3S_2N_4$	204.3	125	329.3	81.4	247.9	240.7	36.4
$T_3S_2N_5$	204.3	150	354.3	84.3	270.0	266.6	62.3
$T_3S_3N_1$	204.3	0	204.3	14.7	189.6	187.1	-17.2
$T_3S_3N_2$	204.3	75	279.3	49.9	229.4	225.5	21.2
$T_3S_3N_3$	204.3	100	304.3	77.1	227.2	219.3	15.0
$T_3S_3N_4$	204.3	125	329.3	95.6	233.7	230.8	26.5
$T_3S_3N_5$	204.3	150	354.3	102.8	251.5	244.9	40.6

Table.5 Balance sheet of soil available N (kg ha^{-1}) as influenced by varied time of planting, spacing and nitrogen doses (2015-16)

Treatments	Initial soil available nitrogen	Nitrogen applied through urea to knokhol	Total Available nitrogen	Nitrogen uptake by knolkhol	Expected balance	Soil available nitrogen at harvest of knolkhol (Actual balance)	Change in soil available nitrogen
$T_1S_1N_1$	220	0	220	11.3	208.8	218.5	-1.5
$T_1S_1N_2$	220	75	295	43.3	251.7	255.1	35.1
$T_1S_1N_3$	220	100	320	66.1	253.9	253.6	33.6
$T_1S_1N_4$	220	125	345	78.5	266.5	267.4	47.4
$T_1S_1N_5$	220	150	370	87.6	282.4	279.2	59.2
$T_1S_2N_1$	220	0	220	7.1	212.9	219.5	-0.5
$T_1S_2N_2$	220	75	295	29.7	265.5	270.0	50.0
$T_1S_2N_3$	220	100	320	46.1	273.9	256.4	36.4
$T_1S_2N_4$	220	125	345	56.7	288.3	268.0	48.0
$T_1S_2N_5$	220	150	370	58.6	311.4	281.9	61.9
$T_1S_3N_1$	220	0	220	8.9	211.1	219.3	-0.7
$T_1S_3N_2$	220	75	295	31.3	263.7	262.4	42.4
$T_1S_3N_3$	220	100	320	52.1	268.0	266.0	46.0
$T_1S_3N_4$	220	125	345	65.9	279.1	276.0	56.0
$T_1S_3N_5$	220	150	370	71.2	298.8	288.4	68.4
$T_2S_1N_1$	220	0	220	15.4	204.6	217.2	-2.8
$T_2S_1N_2$	220	75	295	58.2	236.8	245.0	25.0
$T_2S_1N_3$	220	100	320	83.8	236.2	248.0	28.0
$T_2S_1N_4$	220	125	345	101.9	243.1	252.2	32.2
$T_2S_1N_5$	220	150	370	111.9	258.1	264.7	44.7
$T_2S_2N_1$	220	0	220	10.3	209.7	218.7	-1.3
$T_2S_2N_2$	220	75	295	38.4	256.6	247.0	27.0
$T_2S_2N_3$	220	100	320	58.8	261.2	250.0	30.0
$T_2S_2N_4$	220	125	345	71.3	273.7	254.3	34.3
$T_2S_2N_5$	220	150	370	73.7	296.3	266.4	46.4
$T_2S_3N_1$	220	0	220	12.4	207.7	218.0	-2.0
$T_2S_3N_2$	220	75	295	42.6	252.4	247.0	27.0
$T_2S_3N_3$	220	100	320	66.9	253.1	259.0	39.0
$T_2S_3N_4$	220	125	345	83.3	261.7	262.4	42.4
$T_2S_3N_5$	220	150	370	89.5	280.5	274.6	54.6
$T_3S_1N_1$	220	0	220	18.6	201.4	217.1	-2.9
$T_3S_1N_2$	220	75	295	67.2	227.8	235.0	15.0
$T_3S_1N_3$	220	100	320	97.2	222.8	242.8	22.8
$T_3S_1N_4$	220	125	345	115.8	229.2	242.9	22.9
$T_3S_1N_5$	220	150	370	127.7	242.3	251.2	31.2
$T_3S_2N_1$	220	0	220	12.1	207.9	214.0	-6.0
$T_3S_2N_2$	220	75	295	44.4	250.6	236.5	16.5
$T_3S_2N_3$	220	100	320	67.5	252.5	244.0	24.0
$T_3S_2N_4$	220	125	345	80.5	264.5	243.4	23.4
$T_3S_2N_5$	220	150	370	83.6	286.1	254.3	34.3
$T_3S_3N_1$	220	0	220	20.4	199.6	214.2	-5.8
$T_3S_3N_2$	220	75	295	49.6	245.3	242.0	22.0
$T_3S_3N_3$	220	100	320	76.1	243.9	255.0	35.0
$T_3S_3N_4$	220	125	345	95.1	249.9	248.9	28.9
$T_3S_3N_5$	220	150	370	101.8	268.2	260.3	40.3

During first year of study, the highest post-harvest soil available nitrogen was recorded with the planting pattern of 30 x 30 cm (S_2), which was comparable with that planting pattern of 45 x 15 cm (S_3), which in turn were significantly superior to 30 x 15 cm (S_1). While during second year of experimentation, planting pattern of 45 x 15 cm (S_3) registered the highest post-harvest soil available nitrogen followed by 30 x 30 cm (S_2), which stood at par with each other. The lowest post-harvest soil available nitrogen was recorded with the planting pattern of 30 x 15 cm (S_1), which in turn maintained parity with that of 30 x 30 cm (S_2). Lower residual soil nitrogen with closer spacings might be due to efficient use of soil and applied nitrogen leading to enhanced depletion of nitrogen at higher plant population.

Increase in nitrogen levels from 0 to 150 kg ha^{-1} increased the soil available nitrogen significantly. Relatively higher soil available nitrogen status with higher nitrogen supply might be due to unutilized nitrogen tapped in the soil. The results are in conformity with that of Brahma *et al.*, (2000).

Interaction between times of planting and nitrogen doses (Table 2) indicated that the higher soil available nitrogen was registered with the combination of earliest planting during I FN of November along with highest level of nitrogen tried at 150 kg N ha^{-1}. The lower soil available nitrogen was recorded with late planting during I FN of December along with 0 kg N ha^{-1}.

Regarding collective effect of spacing and nitrogen doses tested (Table 3) on soil available nitrogen status of knolkhol, the higher values were registered with wider spacing of 45 x 15 cm coupled with the maximum level of nitrogen at 150 kg N ha^{-1} relative to all other combinations. Irrespective of the planting patterns tried, the lower soil available nitrogen was recorded at 0 kg N ha^{-1}.

Balance Sheet for Soil Available Nitrogen

The balance sheet of soil available nitrogen was worked out for both the years of study (Table 4 and 5) duly considering the quantities of nitrogen applied to different treatments and uptake by crop to examine the change in the status of soil available nitrogen after completion of the cropping period in comparison with the initial status. The balance of soil available nitrogen followed similar trend during both the years, only with variation in magnitude. Net loss of soil available nitrogen is higher with late planting during I FN of December (T_3) and it was decreased with advancement in planting time of knolkhol, which might be due to lesser growth and yields in earlier planting times tried. Irrespective of time of planting, the net gain of soil available nitrogen is more in widest spacing (S_2 - 30 x 30 cm) followed by other two closer spacings *i.e.*, S_3 - 45 x 15 cm and S_1 - 30 x 15 cm respectively in the order of descent, due to lesser uptake of nitrogen under widest spacing by sparse population which accommodated only 1,11,111 plants ha^{-1} in contrast to denser populations of 1,48,148 and 2,22,222 plants ha^{-1} in other closer spacings. Irrespective of time of planting and spacings, successive increase in nitrogen dose from 0 to 150 kg ha^{-1} increased the net gain of soil available nitrogen, due to better growth of the crop leading to higher addition of leaves to soil. The application of varying doses of nitrogen increased the total available nitrogen accordingly, when compared to control where a net loss was noticed. The actual soil nitrogen after harvest was found lower when compared to the expected nitrogen in soil during both the years of study.

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