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BUI VAN QUANG

APPLICATION OF CHLOROPHYLL AND RATIO VEGETATION INDEXES TO CALCULATE NITROGEN RATES AT 10 DAYS BEFORE TASSEL EMERGENCE PERIOD FOR TWO HYBRID MAIZE VARIETIES LVN99 AND LVN14

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PREAMBLE

1. Research Rationale

Maize (*Zeamays* L.) is an important plant to the livestock feed and an food for many people in the world.

Fertilization timing has been significant in enhancing the effect of nitrogen (N) and increasing productivity. At present, N is usually applied to 3 stages: 4-5 leaves, 8-9 leaves and especially 10 days before tassel emergence, in which N content in stem and leaves has correlated with the performance of productivity.

Currently, fertilizer application in Vietnam still remains in a predefined rate and timing for each specific region or productivity goals, according to topography, climate, soil, crops etc... that less based on the nutritional status of the plant. Therefore, we conducted a study ***"Application of chlorophyll and ratio vegetation indexes to calculate nitrogen rates at 10 days before tassel emergence period for two hybrid maize varieties LVN99 and LVN14 ".***

2. Objectives of the study

2.1. Overall objectives

Determination of N rates applied to 2 maize varieties LVN14 and LVN99 based on using the method of rapid assessment of N status at 10 days before tassel emergence period in order to achieve target yield, increase N fertilization efficiency and contribute to the increase in economic efficiency and reduction in environmental pollution.

2.2. Specific objectives

- To determine the effect of N rates applied to maize at 8-9 leaves and 10 days before tassel emergence periods on the growth, yield and N absorption efficiency of two hybrids maize varieties through Spring and Winter crops of 2011 and 2012; The identification of the relationships between chlorophyll index (SPAD), ratio vegetation index (RVI), plant N concentration at 10 days before tassel emergence period and their effects on yield of two hybrids maize varieties.

- To develop the methods for determining the rates of N fertilization to 2 hybrids maize varieties at 10 days before tassel emergence period based on CI and RVI.

- To assess the applicability of the N rate prescription methods to determine top-dressing N rates for maize at 10 days before tassel emergence period based on SPAD and RVI in Quang Ninh, Thai Nguyen and Tuyen Quang provinces.

3. Scientific and practical significance of the study

3.1. Scientific significance of the study

The findings of the study were:

- To find the close correlation between plant N concentration of maize with SPAD and RVI and propose the use of two indexes for topdressing N rate prescription for maize.

- To propose new solutions in prescribing top-dressing N rates for maize based on SPAD and RVI in order to improve maize productivity, N fertilization efficiency and reduce environmental pollution caused by applying N excess.

3.2. Practical significance of the study

- To improve N fertilization and economic efficiency in maize production through N fertilization rate prescription methods at 10 days before tassel emergence period based on SPAD and RVI.

- To help maize growers to achieve maximum economic efficiency when N was applied in Northern midlands and mountainous provinces.

3.3. The new findings of the study:

- The identification of SPAD and RVI was reliable indexes in the assessment of N status of maize at 10 days before tassel emergence period (significant correlation with N concentration in the stem).

- To propose new solutions in prescribing top-dressing N rates for maize based on SPAD and RVI rates achieve yield goals for 2 maize varieties LVN14 and LVN99.

CHAPTER 1
LITERATURE REVIEW

1.1. The scientific basis of the study

1.2. Maize production in the world and Vietnam

1.3. Fertilizer studies for maize

1.4. Fertilizer studies based on soil and plant growth status

1.5. Conclusions from the overview

CHAPTER 2
MATERIALS AND METHODS

2.1. Materials

Subjects of the study was 2 maize varieties LVN99, LVN14

Fertilizers applied: - Nitrogen: urea (46%); Phosphate: Superphosphate (16% P_2O_5); Potassium: Chloride (60% K_2O) and Gianh organic fertilizer.

2.2. Locations and study periods

The study was conducted in Spring and Winter crops during 2 years 2011 and 2012 at the upland crop areas - Thai Nguyen University of Agriculture and Forestry.

Demonstration models were carried out in 2013 in three provinces: Quang Ninh, Thai Nguyen and Tuyen Quang.

2.3. Research contents

- *Content 1*. The effect of N fertilization rates at 8-9 leaves stage, 10 days before tassel emergence period on N fertilization efficiency and the relationships between N content, SPAD and RVI and productivity of some hybrid maize varieties.

- *Content 2*. Calculation of N fertilization rates for maize at 10 days before tassel emergence period based on SPAD and RVI.

- *Content 3*. Assessing the applicability of the Calculating N rate methods at top-dressing of maize at 10 days before tassel emergence period based on SPAD and RVI in Quang Ninh, Thai Nguyen and Tuyen Quang provinces.

2.4. Research methods

2.4.1. Experimental design and management

* Experiment title: ***"Application of chlorophyll and ratio vegetation indexes to calculate nitrogen rates for two hybrids maize varieties LVN99 and LVN14 at 10 days before tassel emergence period".***

* Duration of the experiment: Spring and Winter crops in 2011-2012.

* Experimental design: The experiment was conducted as Split Plot Design with 17 N treatments x 2 varieties (LVN14 and LVN99) x 3 replications. The rates of N fertilization were set into subplots, varieties were set into main plots. The subplot size was 34.3 m^2 (7 x 4.9 m), main plot size was 68.6 m^2, planted in 7 rows/plot. The distance between replications was 1m.

Table 2.1. Treatments of N fertilization rates

Treatment	N rates *(kg N/ha)*			Treatment	N rates*(kg N/ha)*		
	4 – 5 leaves	8 – 9 leaves	10 days before tassel emergence		4 – 5 leaves	8 – 9 leaves	10 days before tassel emergence
1	0	0	0	10	50	50	0
2	50	0	0	11	50	50	25
3	50	0	25	12	50	50	50
4	50	0	50	13	50	50	75
5	50	0	75	14	50	75	0
6	50	25	0	15	50	75	25
7	50	25	25	16	50	75	50
8	50	25	50	17	50	75	75
9	50	25	75				

Technical processes applied to experiments (National technical regulation on testing cultivation value and use of maize variety QCVN 01-56: 2011/BNNPTNT; Process of National Maize Research Institute).

- Sowing date

+ Spring crops: 20/02/2011 and 02/20/2012.

+ Winter crops: 15/9/2011 and 20/9/2012

- Fertilizers: 90 K_2O + P_2O_5 + 90 K_2O + 2 tons organic/ha

+ Banded fertilizers: 100% organic fertilizers + 100% P_2O_5

+ Top-dressing: 3 times

1st time when maize was at 4-5 leaves stage: N (according to treatments) + 1/2 K_2O.

2nd time when maize was at 8-9 leaves stage: N (according to treatments) + 1/2 K_2O

3rd time (at 10 days before tassel emergence period). N was applied following each treatment combined with turning up soil.

* Indexes and observation methods

These were conducted in accordance with National technical standards for testing and cultivation value and use of maize variety (NTR 01-56: 2011 / BNNPTNT; Process of National Maize Research Institute)

+ Analysis of soil before conducting experiments (pH, humus, total and digestible of N, P, K, CEC). Sampling methods and analysis

were in accordance with the current standards of Institute of Life Science, Thai Nguyen University;

- Determination of the ratio vegetation index (RVI)

+ Digital photos were taken with the automatic adjustable focus camera - white and time balance to improve the process of colors reflection identification. On the other hand, it could be done with different lighting conditions to minimize the weather effects.

+ Collecting and calculating image processes: In order to ensure the lighting angle and intensity, all the photos were taken at the same time (11 - 15h on a clear day) and at the same height above the soil surface and the angle of 60^o, then each image was transferred to a computer and processed by specialized software to show information on the reflections of foliage determining the growth and N status of maize when it was taken (taken 1 day before fertilization with KONIKA camera).

+ The methods of calculating RVI: RVI = R/G

R is the reflectance value of the red waveband, G is the reflectance value of the green waveband.

- Determination of SPAD

+ SPAD was measured by a machine (SPAD 512 Minota) when it was not rain, at 1 day before fertilizing, 4-5 leaves, 8-9 leaves and twisted whorl period; measured the first fully-expended leaf from up to down (measured 3 points with the spaces of 3 - 5 cm between points and the average calculation of 3 measurements) and measured in between the leaf sheath to the tip of the leaf and the middle section measured from the leaf blade to the leaf midrib.

2.4.2. Calculating methods

- Fertilizer rates for maximum yield and economic optimum yield were calculated following the methods described in the textbook "Soil and plant nutrition" published by Nguyen The Dang et al. (2011)

- Comparative analysis

+ Performing the correlation between yield and SPAD or RVI by Excel.

+ The data were analyzed for comparing between the treatments using analysis of variance (ANOVA), correlation, regression on IRRISTAT software 5.0

- Calculating equation establishment for N rates in maize:

+ Determining the effects of N at top-dressing at 10 days before tassel emergence period and the growth and N status in maize before fertilization (determined by RVI and SPAD) established by multiple regression.

2.5. Establishment for the experimental models of N fertilization rates at 10 days before tassel emergence period based on the growth and N status in maize before fertilizing to achieve productivity goals.

- The experiments were carried out in the fields of 2 households in each province (each household was a replication), a total area of 0.3 hectares per province. At each research site, the maize fields of each household were designed randomly for three treatments: 1, 2 and 3.

+ Treatment 1: Applied as following the current recommendations of local community, applied 50 N/ha at 10 days before tassel emergence period.

+ Treatment 2: at 10 days before tassel emergence period, the rates of N were applied following the calculation methods based on SPAD.

+ Treatment 3: at 10 days before tassel emergence period, the rates of N were applied following the calculation methods based on RVI.

- The experiments were designed, monitored and evaluated by the author, local extension officers and farmers (using the methods of Farmer Participatory Research).

- The size of each plot: 0.05 ha

- Research materials:

+ Hybrid maize LVN99

+ Nitrogen: urea (46%);

+ Phosphate: superphosphate (16% P_2O_5);

+ Potassium: Chloride (60% K_2O)

+ Manure: cattle

- Fertilizer treatments:

+ Standard: 90 K_2O + 90 P_2O_5 + 10 tons manure/ha + 100 N

+ Banded fertilizers: 100% manure + 100% P_2O_5

+ Top-dressing: 3 times

1st when maize was at 4-5 leaves stage: 50kg N/ha + 1/2 K_2O

2nd when maize was at 8-9 leaves stage: 50kg N/ha + 1/2 K_2O

3rd when twisted whorl period (at 10 days before tassel emergence period): Applied N combining with turning up soil.

- Experimental design and management

+ Experimental title: Testing of calculating equation for the N fertilization rates prescription for maize in the some Northern provinces and comparing N fertilization efficiency as calculated with the current N fertilization treatments recommended.

Duration of the experiments: Winter crop in 2013.

+ Experimental design: Included 3 treatments and 2 replications.

Table 2.2. The treatments models in the provinces

Treatment	N rates (Kg N/Ha)		
	4-5 leaves	**8-9 leaves**	**10 days before tassel emergence**
1	50	50	50
2	50	50	Based on SPAD
3	50	50	Based on RVI

+ The indexes and monitoring methods, calculations

These were conducted in accordance with National technical standards for testing cultivation value and use of maize (QCVN 01-56: 2011/BNNPTNT; Process of National Maize Research Institute); indexes monitoring experiment: RVI, CI, yield and yield components.

Calculation methods (Presented in part 2.4.1)

CHAPTER 3
RESULTS AND DISCUSSION

3.1. The effects of N fertilization rates at the 8-9 leaves stage and at 10 days before tassel emergence period on the indexes of the 2 hybrids maize varieties in 2011-2012.

3.1.1. The effects of N fertilization rates at the 8-9 leaves stage and at 10 days before tassel emergence period on the indexes of the 2 hybrids maize varieties in Spring crops in 2011-2012.

3.1.1.1. Plant height

Plant height was influenced by the rates of N fertilization at the 8-9 leaves stage and at 10 days before tassel emergence period of the 2 maize varieties.

3.1.1.2. Height at ear establishment

- Height of LVN14 variety at ear establishment reached from 77.1 to 121.5 cm (2011); 72 to 118.5 cm (2012). The variety had lower height at the level of 0 N/ha in comparison to other rates and it had a significant difference in comparison to other treatments at the significant level of 95%.

3.1.1.3. Number of leaves/plant

$P \geq 0.05$ of the 2 varieties over 2 years means that there were no significant relationships between the rates of N fertilization and the number of leaves/plant.

3.1.1.4. Leaf size index

- Leaf size index of LVN14 variety ranged from 2.5 to 3.7 m^2 leaf/m^2 soil (2011); 2.5 to 3.6 m^2 leaf/m^2 soil (2012), leaf size index was lowest at the level of 0 kg N/ha.

- Leaf size index of LVN99 variety reached from 2.6 to 3.7 m^2 leaf/m^2 soil; 2.4 to 3.6 m^2 leaf/m^2 soil. The fluctuations between the rates of N fertilization in the two years research were similar as LVN14 varieties.

3.1.1.5. Pets and diseases resistance

- European corn borer (Ostrinia nubilalis); Rhizoctonia solani Kuhn.

These were prevented so there were negligible damages.

3.1.1.6. Yield and yield components

- Number of ears/plant: + The number of ears/plant of LVN14 variety ranged from 0.91 to 0.95 ear (2011); 0.93 to 0.98 ear (2012). Statistical analysis results showed that there were no significant relationships between the rates of N fertilization and the number of ears/plant in both 2 crops.

- Number of kernel rows/ear: There were no significant relationships between the rates of N fertilization and the number of kernel rows/ear in the 2 varieties.

+ The number of kernel rows/ear of LVN14 variety ranged from 13.07 to 13.93 rows (2011); 13.47 to 14.2 rows (2012).

+ The number of kernel rows/ear of LVN99 variety varied 13.5 to 14.03 rows (2011); 13.17 to 14.07 rows (2012).

- The number of kernels/row

+ The number of kernels/row of LVN14 variety varied from 27.5- 32.9 kernels (2011); 28.9 to 33.6 kernels (2012). The number of kernels/row at the level of 0 kg N/ha was lower compared to the other N rates in the confident level of 95%.

+ The number of kernels/row of LVN99 variety varied from 29.6 to 35.9 kernels (2011); 28.9 to 34.1 kernels (2012). The effects of N fertilization on the number of kernels/row was similar as LVN14 variety.

- 1000 grain weight

+ 1000 grain weight of LVN14 variety varied from 272.0 to 348.4 g (2011); 249.5 to 320.1 g (2012). 1000 grain weight at the level of 0 Kg/ha was lower in comparison to other rates at the confident level of 95%.

+ 1000 grain weight of LVN99 variety varied from 219.6 to 306.6 g (2011); 236.8 to 302.7 g (2012) and the effects of N fertilization on 1000 grain weight was similar as LVN14 variety.

- Yield

+ Yield of LVN14 variety ranged from 35.72 to 63.94 kg/ha (in 2011); 32.69 to 61.02 kg/ha (in 2012). Yield at the level of 0 Kg/ha was lower than other rates at the confident level of 95%.

+ Yield of LVN99 variety ranged from 34.84 to 62.27 kg/ha (in 2011); 31.84 to 59.17 kg/ha (2012). Although yield in Spring crop in 2012 was lower than that of LVN14 variety, the effects of N fertilization on yield in 2 crops was similar as LVN14 variety (there were no significant relationships between the rates of N fertilization and varieties).

3.1.2. The effects of N fertilization rates at 8-9 leaves period and 10 days before tassel emergence period in maize

The norm fluctuated as similar as Spring crops.

3.1.3. N fertilization efficiency during the growth period of some hybrids maize varieties in experiments in 2011 - 2012

3.1.3.1. N fertilization efficiency during the growth period of some hybrids maize varieties in Spring crops in 2011 - 2012

N fertilization efficiency was calculated through two indexes: N fertilization coefficient and N fertilization performance.

- N fertilization coefficient: As the percentage of N absorption compared to the rates of N applied.

+ N fertilization coefficient at 4 -5 leaves stage was 36.8% (LVN14) and 33.8% (LVN99).

+ N fertilization coefficient at 8-9 leaves stage reached from 52.9 to 61.2% (LVN14) and 54.5 to 63.2% (LVN99). N fertilization coefficient in both 2 varieties increased inversely proportional to the rates of N applied.

+ N fertilization coefficient at 10 days before tassel emergency period reached from 45.2 to 65.6% (LVN14) and 46.4 to 64.4% (LVN99).

- N fertilization performance: As the increase in the amount of kernels when 1 kg of N was applied.

+ N fertilization performance at 4-5 leaves stage reached 24.7 kg kernels/kg N applied (LVN14) and 22.2 kg kernels/kg N applied (LVN99).

+ N fertilization performance at 8-9 leaves stage increased inversely to the rates of N applied, reached from 14.8 to 25.5 kg kernels/kg N applied.

+ N fertilization performance at 10 days before tassel emergency period increased inversely to the rates of N applied at 8-9 leaves stage.

3.1.3.2. N fertilization efficiency during the growth period of some hybrids maize varieties in Winter crops in 2011 - 2012

The results were quite similar as Spring crops, N fertilization efficiency in maize in the periods was calculated through two indexes: N fertilization coefficient and N fertilization performance.

3.1.4. The relationships between N content in stem, CI, RVI at 10 days before tassel emergence period and yield at harvest

3.1.4.1. N content, CI, RVI and yields in Spring crops 2011 - 2012 in the different N level treatments

RVI, CI and N content in plants were measured, captured, analyzed and interpreted 1 day before applying at 10 days before tassel emergence period.

The results of N content in plants, CI, RVI and yields were the average results of Spring crops in 2011 and 2012, shown in Table 3.1

Table 3.1. N content, *CI, RVI* at 10 days before tassel emergence period and yields in Spring crops 2011-2012

T	RVI	CI	N conc. %	Yield quintal/ha	T	RVI	CI	N conc. %	Yield quintal/ha
1	0,614	31,300	1,13	33,77	10	0,720	37,810	1,84	55.01
2	0,638	34,767	1,44	45,48	11	0,721	37,942	1,88	59,56
3	0,640	35,517	1,45	51,89	12	0,713	38,400	1,83	61,28
4	0,645	36,150	1,44	54,58	13	0,712	38,975	1,86	58,17
5	0,637	35,685	1,45	56,11	14	0,745	38,905	2,04	56,62
6	0,676	36,858	1,66	51,35	15	0,730	39,350	2,01	59,68
7	0,681	36,908	1,65	56,71	16	0,740	39,783	2,01	58,14
8	0,681	37,317	1,65	59,33	17	0,727	39,933	1,84	53,97
9	0,686	37,365	1,68	60,89					

Table 3.1 showed that N content, CI and RVI increased directly proportional to the rates of N applied. The lowest yield, N content, CI and RVI were in treatment 1 in comparison to other N rates caused by no N fertilization for all stages.

3.1.4.2. N content in plants, CI and RVI and yields in the different fertilizer treatments in Winter crops in 2011 - 2012.

Similarly in Spring crops, N content, CI and RVI increased directly proportional to the rates of N applied;

The lowest yield, N content, CI and RVI were in treatment 1 in comparison to other N rates caused by no N fertilization for all stages.

3.1.4.3. The relationships between RVI and N content in plants at 10 days before tassel emergence period and the effects of RVI on yields in 2011-2012

- The relationships between N content in plants and CI in Spring and Winter crops in 2011-2012

The relationships between them were shown by 2 equations

Spring crops: N content = 2.2864 CI - 30 277 $R^2 = 0.5544$ (Equation 3.1)

Winter crops: N content = 1.8592 CI - 9842 R^2 = 0.5143 (Equation 3.2)

The correlations between N content and CI at 10 days before tassel emergence period were positive ($R^2 > 0.5$). Therefore, CI can be used as a basis to measure quickly in the field instead of using N content in plants to calculate the rates of N fertilization in maize.

The results of the effects of CI analysis on yield were shown through equation 3.3.

Yield = - 0,4351CI^2 + 3792 CI - 598.07 R^2 = 0.76 (Equation 3.3).

The results of the effects of CI analysis on yield in Winter crops were shown through equation 3.4.

Yield = - 0,4152CI^2 + 30 208 CI - 491.17 R^2 = 0.75 (Equation 3.4).

The relationships between RVI at 10 days before tassel emergence period and yields in Spring crops in 2011- 2012 (Equation 3.5).

Yield = - 2280.5RVI^2 + 3225.8 RVI - 1081.2 R^2 = 0.68 (Equation 3.5).

The relationships between RVI at 10 days before tassel emergence period and yields in Winter crops.

Yield = - 2916.9RVI^2 + 3980.6RVI - 1298.8 R^2 = 0.74 (Equation 3.6).

By analyzing the correlations between CI and RVI at 10 days before tassel emergence period and yields in maize in Spring, Winter crops in 2011-2012, we can determine that both RVI and CI can be used to project yield in maize early with high reliability.

3.2. Recommendation of calculating methods for N rates in maize at 10 days before tassel emergence period based on CI

3.2.1. The results of establishment of calculating models for N rates at top-dressing in maize at 10 days before tassel emergence period based on CI

3.2.1.1. Calculation of N rates at top-dressing in maize at 10 days before tassel emergence period based on CI

The results from multivariate regression analysis determined the effects CI before fertilizing and N content before tassel emergence period (N3) on yield in maize and they were shown in equation 3.7 in Spring crops and equation 3.8 in Winter crops.

$$Yield\ 1=-306.8834+17.2106*CI+1.268963*N3-0.2025572*CI^2-0.00175587*N3^2-0.028793*CI*N3 \quad \textit{(Equation 3.7)}$$

$$Yield\ 2=-288.1007+17.52617*CI+1.144589*N3-0.2218583*CI^2\ 0.001945353*N3^2-0.02703836*CI*N3 \quad \textit{(Equation 3.8)}$$

Note:

Yield 1 and Yield 2: Kernel yield in Spring and Winter crops (quintal/ha).

CI: chlorophyll index measured at 10 days before tassel emergence period.

N3: The rates of N applied before tassel emergence (kg/ha).

- Based on CI at 10 days before tassel emergence period to discover calculating methods for the maximum technique of N rates fertilization and economic optimum.

Based on equations 3.7 and 3.8, we established a table to recommend the rates of N fertilization for different crops. The results showed that when we knew CI in maize at 10 days before tassel emergence period, yield goals can be referred from the table to determine the rates of N required.

3.2.1.2. The methods referring the table to determine the maximum technique of N rates fertilization or economic optimum based on CI in maize at 10 days before tassel emergence period

+ Spring crops:

The rates of N fertilization reached maximum technique and economic optimum and N use efficiency were shown in table 3.2

The maximum technique of N fertilization or economic optimum can be calculated for each CI.

Table 3.2. Recommendation of the rates of N fertilization in maize at 10 days before tassel emergency period based on CI and yield goals (Spring crops)

Crop	CI	Yield with no N (quintal/ha)	N rates required and N fertilization performance with yields etc...					
			N applied to economic optimum			N applied to maximum technique		
			Yield (quintal /ha)	N required (kg/ha)	N fertilization performance (kg kernels /kg N)	Yield (quintal /ha)	N required (kg/ha)	N fertilization performance (kg kernels /kg N)
1	2	3	4	5	6	7	8	9
Spring	31,5	34,26	51,64	90	19,3	52,16	107	16,7
	32	36,44	53,29	85	19,8	53,64	99	17,4
	33	40,48	54,75	80	17,8	54,95	91	15,9
	34	44,12	55,82	70	16,7	56,09	83	14,4
	35	47,36	56,71	60	15,6	57,07	74	13,1
	36	50,18	57,42	50	14,4	57,87	66	11,6
	37	52,61	57,94	40	13,3	58,51	58	10,2
	38	54,63	58,59	35	11,3	58,98	50	8,7
	39	56,24	59,04	30	9,3	59,28	42	7,2
	40	57,45	59,09	20	8,2	59,40	33	5,9

+ Winter crops: conducted similar as Spring crops.

CI and yield when different rates of N applied were shown in Table 3.3

Table 3.3. Yields and different N rates when CI was known (Spring crops)

CI	Yields at different rates of N fertilization (quital/ha)									
	0	10	0	30	0	50	0	70	0	
(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	
31,5	34,26	31,5	34,26	31,5	34,26	31,5	34,26	31,5	34,26	
32	36,44	32	36,44	32	36,44	32	36,44	32	36,44	
33	40,48	33	40,48	33	40,48	33	40,48	33	40,48	
34	44,12	34	44,12	34	44,12	34	44,12	34	44,12	
35	47,36	35	47,36	35	47,36	35	47,36	35	47,36	
36	50,18	36	50,18	36	50,18	36	50,18	36	50,18	
37	52,61	37	52,61	37	52,61	37	52,61	37	52,61	
38	54,63	38	54,63	38	54,63	38	54,63	38	54,63	
39	56,24	39	56,24	39	56,24	39	56,24	39	56,24	
40	57,45	40	57,45	40	57,45	40	57,45	40	57,45	

3.2.2. Recommendation of calculating methods for the rates of N fertilization in maize at 10 days before tassel emergency period based on CRI

3.2.2.1. Calculating models for the rates of N fertilization in maize at 10 days before tassel emergency period based on RVI

The results of multivariate regression analysis determined the effect of RVI before fertilizing and the rates of N applied before tassel emergence period (N3) on yields in Spring and Winter crops and they were shown in Equation 3.9 and 3.10, respectively.

Yield 3=-679.5111+1993.34*RVI+1.552296*N3-134 9.169*RVI^2-0.002399247*$N3^2$-1.884318*RVI*N3 $R^2 = 0,93$ *(Equation 3.9)*

Yield 4=-928.4014+2805.622*RVI+1.426672*N3-1997.751*RVI^2-0.002191784*$N3^2$-1.802605*RVI*N3 $R^2 = 0,95$ *(Equation 3.10)*

Yield 3 and Yield 4: Kernel yield of in maize in Spring and Winter crop (quintal/ha)

RVI: Ratio vegetation index of maize at 10 days before tassel emergency period (RVI = R/G)

N3: The rates of N applied before tassel emergency period (quintal/ha)

- Methods based on RVI at 10 days before tassel emergency period to calculate the maximum technique of N rates fertilization and economic optimum.

Based on Equation 3.9 and 3:10, we established table 3.4 to recommend the rates of N fertilization in maize in Spring crops. The results showed that when we knew RVI at 10 days before tassel emergency period, yield goals can be referred to the table to determine the rates of N required.

3.2.2.2. The methods of referring the table to determine the rates of N fertilization at 10 days before tassel emergency period to achieve yield goals when RVI was known.

Spring crops: (Table 3.4):

Table 3.4. The recommendation of N fertilization in maize at 10 days before tassel emergence period based on CI and yield goals (Spring crops)

Crop	RVI	Yield with no N (quintal/ha)	N rates required and N fertilization performance with yields etc...					
			Optimal yield			Maximum yield		
			Yield (quintal /ha)	N rates required (kg/ha)	N fertilization performance (kg kernels /kg N)	Yield (quintal /ha)	N rates required (kg/ha)	N fertilization performance (kg kernels /kg N)
1	2	3	4	5	6	7	8	9
Spring crops	0,61	34,40	51,07	75	22,4	51,31	84	20,2
	0,64	43,61	55,74	60	20,3	56,11	72	17,4
	0,66	48,40	58,12	55	17,7	58,32	64	15.6
	0,68	52,10	59,46	45	16,3	59,75	56	13,7
	0,7	54,73	59,98	35	15,0	60,40	49	11,6
	0,72	56,28	60	30	12,3	60,27	41	9,7
	0,74	56,76	58,95	20	11,0	59,35	33	7,8

- Winter crops: Conducted similar as Spring crops

RVI and yields when different rates of N applied were shown in Table 3.5

Spring crops: (Table 3.5)

Table 3.5. Yields and different rates of N fertilization when RVI was known (Spring crops)

Index RVI (1)	Yields at different rates of N (quintal/ha)								
	0 (2)	10 (3)	20 (4)	30 (5)	40 (6)	50 (7)	60 (8)	70 (9)	75 (10)
0,61	34,28	38,19	41,50	44,33	46,68	48,55	49,93	50,84	51,12
0,64	43,55	46,83	49,57	51,84	53,62	54,93	55,75	56,09	56,09
0,66	48,37	51,24	53,61	55,50	56,90	57,83	58,28	58,24	58,05
0,68	52,10	54,57	56,56	58,07	59,10	59,65	59,72	59,32	58,93
0,7	54,74	56,83	58,44	59,57	60,23	60,40	60,09	59,31	58,73
0,72	56,30	58,00	59,24	59,99	60,27	60,07	59,38	58,22	57,46
0,74	56,76	58,09	58,95	59,33	59,23	58,65	57,59	56,05	55,10

Winter crops: Conducted similar as Spring crops

3.3. The results of 3 experimental models in Thai Nguyen, Quang Ninh and Tuyen Quang provinces

3.3.1. The results of experimental models for calculating process of N rates applied to top-dressing in maize at 10 days before tassel emergence period based on CI and RVI in Thai Nguyen

Fields in the two households were randomly assigned into 3 treatments (Treatment 1, treatment 2 and treatment 3; 500 m^2/each treatment).

Results were shown in Table 3.6

Table 3.6. The rates of N applied to experimental models in the fields in Thai Nguyen during Winter crops in 2013

Number of household	Treatment	CI	RVI	N rates during 10 days before tassel emergence *(Kg/ha)*	Difference compared to treatment 1 applied before tassel emergence period (%)
1	1	36,0	0,68	50	-
	2	36,0		30	- 40,0
	3		0,68	35	- 30,0
2	1	36,5	0,69	50	-
	2	36,3		28	- 44,0
	3		0,69	30	- 40,0
Mean of 2 householdes	1	36,25	0,685	50	-
	2	36,15		29	- 42,0
	3		0,685	32,5	- 35,0

According to economic accounting, N in treatment 2 and 3 were applied based on the N status of the plant added from 1125000-2014000 VND/ha.

3.3.2. The results of experimental models for calculating process of N rates applied to top-dressing in maize during 10 days before tassel emergence period based on CI and RVI in Quang Ninh

Results were shown in Table 3.7

Table 3.7. The rates of N applied to experimental models in the fields in Quang Ninh during Winter crops in 2013

Number of household	Treatment	CI	RVI	N rates during 10 days before tassel emergence *(Kg/ha)*	Difference compared to treatment 1 applied before tassel emergence period (%)
	1	36,5	0,69	50	-
1	2	36,0		**30**	- 40,0
	3		0,69	**30**	- 40,0
	1	35,0	0,68	50	-
2	2	35,0		**40**	- 20,0
	3		0,68	**35**	- 30,0
Mean of	1	35,75	0,685	*50*	-
2 households	2	35,5		***35***	- *30,0*
	3		0,685	***32,5***	- *35,0*

The results showed that, treatment 2 and 3 used less N than treatment 1 at the 3rd time of N applied to top-dressing (10 days before tassel emergence) ranged from 30.0 to 32.5% and yield increased from 1.2 - 3.0% and income increased from 870.000-1.706.000 VND/ha.

3.3.3. The results of experimental models for calculating process of N rates applied to top-dressing in maize during 10 days before tassel emergence period based on CI and RVI in Tuyen Quang

Results were shown in Table 3.8

Table 3.8. The rates of N applied to experimental models in the fields in Tuyen Quang during Winter crops in 2013

Number of household	Treatment	CI	RVI	N rates during 10 days before tassel emergence *(Kg/ha)*	Difference compared to treatment 1 applied before tassel emergence period (%)
1	1	35,0	0,68	50	-
	2	35,0		35	30,0
	3		0,68	35	30,0
2	1	35,5	0,69	50	-
	2	35,5		35	30,0
	3		0,69	30	40,0
Mean of 2 housholds	1	35,25	0,685	50	-
	2	35,25		35,0	30,0
	3		0,685	32,5	35,0

The results showed that, treatment 2 and 3 used less N than treatment 1 at the 3rd time of N applied to top-dressing (10 days before tassel emergence) ranged from 30.0 to 35.0% and yield increased from 0.6 - 2.4%.

CONCLUSIONS AND RECOMMENDATIONS

1. Conclusions

1.1. The effects of N rates applied to 8-9 leaves stage and 10 days before tassel emergence period to some research indexes of 2 maize varieties in Thai Nguyen

The different rates of N fertilization at 8-9 leave stage and 10 days before tassel emergence period significantly affected to the growth and yields of 2 hybrid maize in Thai Nguyen. The highest yield reached when the total rates of N applied to top-dressing in all 3 periods were 150 kg N/ha and the effects of N rates on 2 crops and 2 varieties were not significantly different.

N uptake efficiency and Agronomic N use Efficiency at 10 days before tassel emergence period in both 2 crops were high variation and depended on the rates of N applied to 8-9 leaves stage. N uptake efficiency and Agronomic N use Efficiency were highest when applied 25 kg N/ha in both Spring and Winter crops.

N concentration in stem was highly positive correlations with the CI (R^2> 0.5) and RVI (R^2> 0.87). SPAD and RVI measured at 10 days before tassel emergence period affected yield related to the 2nd degree curve. The equation forecasted yield of maize based on SPAD and RVI at 10 days before tassel emergence period had high regression (R^2> 0.68).

1.2. Calculation of N rates applied to maize at 10 days before tassel emergence period based on SPAD

The equations forecasted yield in maize relies on N rates at top-dressing at 10 days before tassel emergence period and SPAD before applying N with $R^2 = 0.88$ (significant relation at the confident level of 95%) in Spring crops and $R^2 = 0.92$ (significant relation at the confident level of 95%) in Winter crops. The highest yields reached when SPAD was 40 and the rates of N applied to 10 days before tassel emergence period were 33 kg/ha in Spring crops; SPAD was 37 and the rates of N applied were 37 kg N/ha in Winter crops.

The calculating equation of yield in maize relied on the rates of N applied to top-dressing at 10 days before tassel emergence period and RVI had $R^2 = 0.93$ (significant relation at the confident level of 95%) in Spring crops and $R^2 = 0.95$ (significant relation at the confident level of 95%) in Winter crops. The highest yield reached when RVI was 0.70 and the rates of N applied to top-dressing at 10 days before tassel emergence period were 49 kg/ha in Spring crops; and RVI was 0.68 and the rates of N required were 46 kg N/ha in Winter crops.

1.3. The results of experimental models in Thai Nguyen, Quang Ninh and Tuyen Quang provinces

Nitrogen fertilization according to N status of the plants at 10 days before tassel emergence period based on SPAD and RVI significantly reduced the rates of N applied in comparison to the current process (reduced about 30-42%) but yield has still increased compare to the controls. Hence, top-dressing N based on SPAD or RVI can increase income compared with application in process from 597 000 - 2.014 VND/ha.

2. Recommendations

The study results showed that RVI and SPAD were reliable indexes in determining the rates of N applied to top-dressing for 2 hybrid maize varieties LVN99 and LVN14 at 10 days before tassel emergence period. In order to recommend the widely use of RVI and SPAD, further research should use RVI and SPAD for other maize varieties and in different ecological zones to have more confident conclusions.

Recommending to continue testing on other plants.

DISCLOSURE OF WORKS RELATING TO TOPICS

1) Bui Van Quang, Nguyen The Hung, Nguyen Thi Lan, Tran Trung Kien, Tran Thi Mai Thao (2015), "The effect of nitrogen dosages at periods of 8-9 leaves and 10 days before flowering on the growth and development on hybrid maize varieties in spring crops (2011 and 2012) in Thai Nguyen", *Journal of Agriculture and Rural Development*, No. 16/2015, pp. 39-47.

2) Bui Van Quang, Nguyen The Hung, Nguyen Thi Lan, Tran Trung Kien (2015), "The effect of nitrogen dosages at periods of 8-9 leaves and 10 days before flowering on the growth and development on hybrid maize varieties LVN14, LVN99 in winter crops (2011 and 2012) in Thai Nguyen", Journal of Science and Technology, Thai Nguyen University, No. *138(8)*, pp. 35-43.

3) Bui Van Quang, Nguyen The Hung, Nguyen Thi Lan, Tran Trung Kien, Pham Quoc Toan (2015) "Calculation of the nitrogen dosages at 10 days before flowering based on ratio vegetation index to some corn varities in winter season in Thai Nguyen", *Journal of Agriculture and Rural Development*, No. 21/2015, pp. 25-31.

4). Bui Van Quang, Nguyen The Hung, Nguyen Thi Lan, Tran Trung Kien, Pham Quoc Toan (2016), " Calculation of the nitrogen dosages at 10 days before flowering based on ratio vegetation index to some corn varities in spring season in thai nguyen", *Journal of Agriculture and Rural Development*, No. 1/2016, pp. 42-48.