Effect of Site Specific Nutrient Management Approach In Productivity Of Spring Rice In Kanchanpur, Nepal

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Abstract:
A field experiment was carried out in sub-tropical climate of Bhimdattanagar, Kanchanpur to assess the effect of site specific nutrient management approach in productivity of spring rice. The experiment was carried in single factor randomized completely block design with four replication, in four different farmer's field, each farmers' field as single replication. The seedlings were grown in the mat nursery bed and transplanted in the experimental plots with different nutrient management practices. Nutrient management practices were Site Specific Nutrient Management with Nutrient Expert dose (SSNM-NE)(109:28:38 kg NPK/ha), Government recommendation dose (100:30:30kg NPK/ha +6 ton FYM), Farmer's field practice (FFP)(different among farmers) with three omission plots viz. omission of Nitrogen (0:28:38 kg NPK/ha), Omission of Phosphorus (109:0:38 kg NPK/ha) and Omission of Potassium (109:28:0 kg NPK/ha). SSNM-NE dose was obtained by household survey in the respective area and using nutrient expert model. The growth parameters, yield, yield attributing traits and total cost of production were recorded. Data were analyzed using Duncan's Multiple Range Test (DMRT) in Genstat. Result indicates that the highest grain yield (5.81 t/ha) was obtained from SSNM-NE which was statistically at par with government recommendation (5.54 t/ha). Similarly, thousand grains weight, straw yield in the experiment 23.20g, 6.90t/ha were significantly higher in SSNM-NE respectively. Straw yield, grain yield and thousand grain weight of SSNM-NE were found to be statistically at par with government recommendation. The economic analysis revealed that higher B: C ratio (1.91), net return and gross return were higher in SSNM-NE.

Keywords: Hardinath-1; Productivity; Nutrient Management; Phenology; Nutrient Expert

1.0. Introduction:

Rice (Oryza sativa L.) or Dhan in Nepali is an annual, self-pollinated and semi-aquatic plant of Poaceae Family. Rice occupies a significant position among the world's food crops. It accounts for 50% of total edible cereal production and about 20.75% to Agricultural Gross Domestic Product (AGDP) on the country and provides more than 40% of the total calories required to the Nepalese people [1,2]. In Nepal it is the most important cereal crop in terms of the total cultivated area, the food habits of the people, and the impact it has on the economy. In the fiscal year 2016/17, the rice was cultivated in the area of 1469423 ha with production of 5151925mt and productivity 3.50t/ha [3]. The average productivity of rice in kanchanpur is 3.45t/ha which is far less than the potential yield 9.08t/ha of Nepal [4]. Productivity is affected by amount, time, source and method of fertilizer application [5]. Blanket application of the fertilizer result in the over fertilize in some areas and under fertilize in others, or apply an improper balance of nutrient for their soil and also undesirable environmental effects such as nutrient mining or pollution of surface and ground water due to the variable indigenous nutrient supply NPK in different areas [6]. Further, the fertilizer use efficiency is also lower which ultimately reduces the production [7]. The fertilizer use efficiency of nitrogen is only 20-30% in Asia; similarly potassium and phosphorous use efficiency are only 45% and 20-30% in world respectively. 75-80% of potential yield can be obtained by proper nutrient management [8]. Nutrient management helps to reduce loss of fertilizer and increase the production and profitability in rice farming [9]. Identification of proper nutrient management practice is the foremost need to improve the production of rice and increase farm profitability in case of rice farmers [10]. Therefore, a new concept SSNM in rice based systems is being developed [11]. In SSNM approach, scientists quantify crop nutrient requirement based on an economically efficient yield target; measure the potential indigenous supply of N, P and K; estimate the P and K balance for sustaining soil P and K reserves without depletion; monitor plant N status during critical period of rice growth to optimized fertilizer N efficiency and apply diagnostic criteria for identifying micronutrient disorders [11]. The purpose of this study is to access the indigenous nutrient supplying capacity of the soil, the proper amount of the nutrient to be applied in the field to get proper yield and to change the attitude the farmer about the blanket application of fertilizer.

1.1. Objectives
1.1.1. General Objective
To assess the effect of site specific nutrient management approaches for enhancing productivity in spring rice in kanchanpur.

1.1.2. Specific Objectives
• To analyze the effect of different nutrient management on phenology of spring rice
• To analyze the effect of different nutrient management on yield and yield attributes of spring rice
• To analyze the effect of different nutrient management on economics of spring rice production

2.0. Materials and methods
2.1. Experimental site

The experiment was conducted in the farmers' plot of the Baghphanta and Ultakham village (represents terai) of Rice zone implementation site of PMAMP, Kanchanpur during the spring season of 2019. Its coordinates are 28º50'13" N latitude and Longitude 80º19'16" E.

2.2. Field layout and Treatments

The experiment was conducted in the 4 farmer's field. Each farmer's field was considered as one Replication. The plot size of the field was of 2*4m2. The experiment had the following treatments viz.

T1-Omission of N (0:28:38 kg NPK/ha)

T2-Omission of P (109:0:3838 kg NPK/ha)

T3-Omission of K (109:28:0 kg NPK/ha)

T4-Government recommendation (100:30:30 kg NPK/ha)

T5-Farmers practice (Different among farmers)

T6-Nutrient expert dose (109:28:38 kg NPK/ha)

2.3. Physico-chemical properties of experimental soil

Composite soil sample were randomly taken from different using screw auger to record the initial soil physico-chemical properties of the experimental site. Soil pH that affects the availability of mineral nutrients varied from 6.0 to 7.3 with the average of 7.06. The total carbon and nitrogen ranged from to 0.65% to 2.41% and 0.03% to 0.12% respectively with the average of 0.70 and 0.086 percent. Available P and K also varied greatly among the farmers' field. Soil texture varied among the field from sandy loam to Silt clay loam.

2.4. Climatic condition during experimentation

The monthly average rainfall of 1.08mm/day was received during the entire period of experimentation. The highest rainfall was recorded during June (3.64 mm/day) and minimum rainfall in a month of April (0.16 mm/day) of crop growth period. The mean maximum temperature during the experimental period ranged from 34.060C to 44.380C during experimentation period. It was the highest during May and the lowest during February. Similarly, the mean minimum temperature during cropping period ranges from 16.770C to 29.210C.

2.5. Cultivation practices

Mat nursery bed were prepared and Seed was treated with Salt water in the ratio 1:5(4kg common salt in 20 liters if water). Then the salt treated seed was cleaned with fresh water 2-3 times and the seed was dried. Seed was sown with seed rates of100gm/m2. The seedling was transplanted at the age of 25-30 days with the spacing of 20cm*20cm row to row and plant to plant distance at a depth of 2-3cm with 2-3 seedlings per hill. The doses of fertilizers were applied as accordance to treatments. The pre-emergence herbicide Butachlor was applied by spray immediately after transplanting @2 kg a.i. in 400 lit of water for one hactare and two hand weeding were done in the plots to reduce the competition between the crops and weeds at 20 DAT and 45 DAT.

2.6. Observation and measurement

2.6.1. Morphological observations
Random sampling was followed for sampling plants on parameters like number of tillers and plant height in cm. For sampling on further parameters, ten plants were randomly selected and tagged and data collections were made on the basis of morphological observation.

2.6.1.1. Plant Height (Cm)
The height of the main shoot of randomly selected sample plants was measured from the base of the plant to the tip of the longest leaf. After panicle emergence, height was measured from the base of the plant to the tip of the panicle or leaf, which ever was longest. The observations were recorded at 30, 45, 60 and 75 DAT and at harvest.

2.6.1.2. Number of tillers/m²
The counting of tillers/m2 was taken at each plot at 30, 45, 60 and 75 DAT then, average was worked out.

2.6.2. Yield attributing characters

2.6.2.1. Number of grains per panicle
Total number of grains from five randomly selected panicles was counted. Thereafter, mean number of grains per panicle was computed.

2.6.2.2. Sterility percentage
Total number of grains from five randomly selected panicles were separated and counted. Later filled and unfilled grains were counted manually. Thereafter mean filled and unfilled grains per panicle were computed and used to calculate sterility percentage.

2.6.2.3. Test weight of grains (1000-grain weight)
Grain samples were drawn randomly from the total produce of each net plot at the time of weighing and 1000 grains were counted manually. Thereafter, the weight of these grains was recorded on electronic balance and mean test weight was computed by dividing the total weight of 5000 grains with 10.

2.6.3. Yields
2.6.3.1. Grain yield t/ha
After winnowing and cleaning, the grain yield obtained from each plot, were weighed on double pan balance. Later it was converted into grain yield t/ha by multiplying with appropriate factor.

2.7. Statistical analysis
All the data from the experimentation were subjected to analysis of variance and Duncan's Multiple Range Test (DMRT) for mean separations. The software program, Microsoft word 2007 was used for word processing, Genstat program for running statistical analysis. The LSD values were calculated at 5% level of significance.

3.0. Result

3.1. Biometric observation

3.1.1. Plant height

Plant height was significantly influenced by different Nutrient management practices. The mean plant height in the experiment varied from 36.05 cm at (30 DAT) to 89.77 cm at (75 DAT) (table-1). The nutrient levels were non-significant in 30 and 45 days after transplanting. Plant height was significantly influenced by nutrient levels at 60 and 75 days after transplanting. There At both the observation dates plant height of nutrient expert dose was significantly higher than nitrogen omitted plots. At 60 DAT, plant height of SSNM-NE dose was of rice was statistically similar (65.13cm) with other nutrient level except nitrogen omitted plots (55.93cm) whereas at 75 DAT, plant height of SSNM-NE plots (89.77 cm) were at par with farmer practice (85.97 cm) and significantly higher than government recommended dose (83.15 cm) and other nutrient omitted plots.

Table 1. Effect of different Nutrient doses on Plant height of rice in Kanchanpur, Nepal, 2019

Treatment	Plant height (cm)			
	30DAT(cm)	45DAT(cm)	60DAT(cm)	75DAT(cm)
Omission of Nitrogen	36.05	46.82	55.93[b]	77.72[c]

Omission of Phosphorus	37.63	50.25	60.70[ab]	80.30[bc]
Omission of Potassium	36.95	50.05	60.50[ab]	82.70[bc]
Nutrient Expert Dose	38.73	52.90	65.13[a]	89.77[a]
Government Recommendation	38.83	50.47	60.65[ab]	83.15[bc]
Farmers Practice	37.23	52.10	61.55[ab]	85.97[ab]
SEM($\pm$)	3.51	4.36	4.22	3.84
Mean	37.49	50.43	60.74	83.27
LSD	Ns	Ns	6.36	5.79
CV (%)	9.40	8.70	7.00	4.60

Note: The treatment mean followed by common letters are not significantly differ from each other based on DMRT at 5 % level of significance.

3.1.2. Number of Tillers per square meter

Numbers of Tillers per square meter was also influenced by Nutrient management practices (table: 2). The mean number of tillers per square meter varies from 226.3 (30 DAT) to 457.5 (75 DAT). The influence of different Nutrient management practice was not found to be significant in 30 DAT and 75 DAT and found to be significant at 45 DAT and 60 DAT. The numbers of tillers per meter square were found to be significant at 45 DAT and 60 DAT with highest value of 662.50 and 622.50 respectively.

Table 2. Effect of nutrient doses on number of tillers per square meter in kanchanpur, Nepal, 2019

Treatment	No. of Tillers per Sq. meter			
	30 DAT	45 DAT	60 DAT	75DAT
Omission of Nitrogen	226.20	386.20[c]	400[b]	320
Omission of Phosphorus	221.20	662.50[a]	622.50[a]	457.50
Omission of Potassium	258.80	493.80[abc]	472.50[ab]	331.20
Nutrient Expert Dose	278.80	598.80[ab]	545.50[ab]	442.50
Government Recommendation	297.50	507.50[abc]	486.20[ab]	386.20
Farmers Practice	216.20	463.80[bc]	443.70[b]	320.00
SEm	40.40	53.10	51.30	44.40
LSD(0.05)	ns	160.10*	154.60*	ns
CV%	17.90	20.50	20.70	23.60
P-value	0.78	0.03	0.09	0.14
Grand mean	249.80	519	495	376

Note: The treatment mean followed by common letters are not significantly differ from each other based on DMRT at 5 % level of significance.

3.2. Yield attributes and crop yield

3.2.1. Number of grains per panicle

Number of grains per panicle was influenced by nutrient management practices (table 6). Application of SSNM-NE had produced significantly higher grains per panicle (154.00) than other nutrient management practices but statistically at par with farmer's field practice (149.90) and government recommendation dose (148.40). The lowest number of grain per panicle was found in omission of nitrogen (128.10).

3.2.2. Sterility percentage

Nutrient management practices had also significant effect on sterility percentage. Omission of phosphorus had significantly higher sterility percentage (24.39%) but statistically at par with Omission of nitrogen (24.29%) and omission of potassium (21.94%). Lowest sterility percentage was found in SSNM-NE (18.62%).

3.2.3. Thousand Grain weight

Nutrient management practices had also significant effect on thousand grain weight (table 6). SSNM-NE plot had statistically higher thousand grain weight (23.20g) but statistically at par with government recommendation (23.00g). Lowest thousand grain weight was found in Omission of phosphorus (21.93g).

3.2.4. Grain yield

Nutrient management practices had also significant effect on grain yield (table 7). Application of SSNM-NE had produced significantly higher grain yield. The grain yield of SSNM-NE (6.9 t/ha) was found to be statistically at par with government recommendation (5.546t/ha) and lowest grain yield was obtained in omission of Nitrogen (4.41t/ha).

3.2.5. Straw yield

Nutrient management practices had also significant effect on straw yield (table 7). SSNM-NE had produced significantly higher straw yield. The straw yield of SSNM-NE (6.900 t/ha) was statistically at par with government recommendation (6.652 t/ha) and farmer's field practice (6.395 t/ha).

3.2.6. Harvest index

Harvest index was found to be non-significant among all nutrient management practices. However numerically higher harvest index was found in omission of nitrogen.

Table 3. Effect of nutrient doses on yield attributes and yields in kanchanpur, Nepal, 2019

Treatment	Yield and yield attributing traits					
	No. of grain per panicle	Sterility (%)	TGW (g)	HI (%)	Straw yield (t/ha)	Yield at 14% moisture(t/ha)
Omission of Nitrogen	128.10[b]	24.39[a]	22.16[c]	41.35	5.09[d]	4.61[e]
Omission of Phosphorus	152.70[a]	24.24[a]	22.07[c]	41.08	5.61[cd]	5.02[cd]
Omission of Potassium	142.30[ab]	21.94[ab]	21.93[c]	40.29	5.95[bc]	4.98[d]
Nutrient Expert Dose	154.40[a]	18.62[b]	23.20[a]	40.31	6.90[a]	5.81[a]
Government Recommendation	148.40[a]	20.51[b]	23.00[ab]	40.40 a	6.56[a]	5.54[ab]
Farmers Practice	149.90[a]	20.41[b]	22.65[b]	40.21	6.39[ab]	5.37[bc]
SEm	5.34	1.03	0.15	0.57	0.17	0.11
LSD(0.05)	16.08*	NS	0.45***	NS	0.52***	0.35***
CV%	7.3	9.6	1.4	2.8	5.7	4.5
P-value	0.033	0.007	<0.001	0.622	<0.001	<0.001
Grand mean	146.00	21.69	22.50	40.61	6.08	5.26

Note: The treatment mean followed by common letters are not significantly differ from each other based on DMRT at 5 % level of significance.

3.3. Economic analysis

3.3.1 Cost of production

The cost of production was calculated for one hectare from the cost involved in the experimental plots. Production cost included general cost and treatment wise variable cost. The treatment variables were Urea, DAP, MOP, SSP, FYM and compost were included in the variable cost. The cost for watching birds after sowing and at maturity stage of crop was not included here because it is not needed in the farmer's field. The average production cost was about NRs. 75560.   Among all the treatment, the highest production cost occurred in farmers field practice (NRs. 87060) followed by government recommendation (NRs. 84060), Nutrient expert dose (NRs. 73078.5), omission of phosphorus (NRs. 71075), omission of potassium (NRs. 70230) and omission of Nitrogen (NRs. 68023.5).

3.3.2 Gross return

Gross return was significantly influenced by nutrient management practice (Table 9). The average gross return in the experiment was NRs.125440/ha. Gross return for SSNM-NE was significantly higher than other management practices. Similarly, gross return in treatment 0 kg N/ha was significantly lowest (Rs. 11830) than other plots. SSNM-NE (NRs.139560) produced highest gross returns followed by government recommendation (NRs. 133110), FFP (NRs. 12880), 0 kg P/ha (NRs. 120510), 0 kg K/ha (NRs. 119730).

3.3.3 Net return

The average net return of the experiment was NRs.49850. and varied among the nutrient management practices. Net return for SSNM-NE was highest (NRs.

66480) and the net returns of other nutrient management practices were statistically at par with each other (table 5).

3.3.4 B: C ratio

The average benefit cost ratio of the experiment was 1.667 and influenced by nutrient management. Among nutrient management practices, B: C ratio was highest (1.910) for SSNM-NE and B: C ratio of 0 kg K/ha (1.705), 0 kg P/ha (1.696) and 0 kg K/ha (1.629) were statistically at par with each other. The B: C ratio of government recommendation (1.584) and FFP (1.480) were statistically similar with each other.

Table 2. Total cost of cultivation, gross return, net return and B: C ratio of spring rice as influenced by Nutrient management practices.

Treatment	Total cost of cultivation (NRs. '000/ha)	Gross return (NRs. '000/ha)	Net return (NRs. '000/ha)	B:C ratio
Omission of Nitrogen	68.02	110.83[e]	42.81[b]	1.62[b]
Omission of Phosphorus	71.07	120.51[cd]	49.43[b]	1.69[b]
Omission of Potassium	70.23	119.73[d]	49.50[b]	1.70[b]
Nutrient Expert Dose	73.78	139.56[a]	66.48[a]	1.91[a]
Government Recommendation	84.06	133.11[ab]	49.05[b]	1.58[bc]
Farmers Practice	87.06	128.88[bc]	41.82[b]	1.48[c]
SEm		2.80	2.80	0.04
LSD(0.05)		8.45	8.46	0.13
CV%		4.50	11.30	5.3
Grand mean	7.556	125.44	49.85	1.66

4.0. Discussion

4.1. Plant height

In the Nutrient expert plot the dose of nitrogen was higher than the other treatment. Nitrogen being major constituent of chlorophyll influences the photosynthetic activity of leaf and vegetative growth including plant height of the crop. The plant height in Nutrient expert dose was due to the balance application of fertilizers. The Nitrogen expert dose was with higher amount of Nitrogen as it enhanced the vegetative growth. The SSNM-NE is the recently developed precision nutrient management technology which assumes great significance in improving crop yields, restoring soil–fertility and enhancing nutrient use efficiencies with minimal deleterious effects on environment.

In current study, it was concluded that this software based nutrient management strategy out-yielded over the recommended blanket nutrient prescription (100% RDF) [12]. Nitrogen is essential for rapid development in generative and vegetative growth and higher production which is controlled by all protein based metabolic processes [13]. Milkkelson mentioned that the leaves and stems contain a large portion of nitrogen taken up by the plant. Similar Result was obtained in the research carried out which reported that the balanced and high dose of NPK at specific site contribute to the plant height [14].

4.2. Number of tillers per square meter

The development of tiller primordia was found to be higher at high nitrogen levels [15]. Singh and Singh reported that increasing levels of nitrogen significantly increased total tillers per square meter up to a certain stage [16]. The nitrogen content was higher in SSNM-NE, so results in higher number of tillers per square meter. Uddin, Sattarand, & Salam, reported that balanced and optimum use of fertilizer application increased the number of effective tiller. The application of N fertilizer may increase the number of productive tillers; however, not every tiller contributes similarly to high productivity [17,18]. The number of number of tillers per square meter of omission of Phosphorus but yield was not higher as the number and the size of panicles are closely related to the growth of tillers, although moderate tillering contributes greatly to rice yields, excessive tillering leads to high tiller abortion, poor grain setting, and small panicle size, and further reduces the grain yield [19]. The number of tillers increases upto 60 DAT and there after decreased till harvest. The decreased in number of tillers after flowering could be due to senescence of secondary tillers and tertiary tillers [20].

4.3. Yield and yield attributing characters

SSNM-NE and Government recommendation had produced significantly higher yield than Farmer's nutrient management practice implies the lack of nutrient input in farmer's practices. The lower yield in the farmer's management practice indicated that the farmer's yield can be increased by proper nutrient management. SSNM-NE works under the principle of SSNM and it is evident that nutrient dose provided by SSNM-NE fulfills the nutrient requirement of crop when required hence better grain yield, straw yield, thousand grain weight, effective tillers were [21,22].

4.3.1. Number of grains per panicle

The more number of grain per panicle in higher nitrogen rate(SSNM-NE) were probably due to better nitrogen status of plant during panicle growth period that was applied during second spilt dose of urea of NE recommendation. The availability of nitrogen in soil is essential for greater number of filled grains per panicle.

4.3.2. Sterility

The higher sterility percentage in was found on omission of phosphorus plot and minimum sterility percentage was found in SSNM-NE plot. It was found that necessary to know the optimum dose of phosphorus fertilizer to reduce spikelet sterility of rice, they reported that with increasing levels of soil fertility, the number of unfilled spikelet per panicle decreased with corresponding increase in filled spikelet.

4.3.3. Thousand grain weight

Higher thousand grain was observed in SSNM-NE plot. Test weight was higher if higher Nitrogen applied due to increase in chlorophyll content in leaves which lead to higher photosynthesis rate and ultimately plenty of photosynthesis available during grain development.

4.3.4. Grain Yield

The yield variability across sites was higher in the farmers' practices as compared to the NE treatment due to variable management of farmers. Other studies using NE for maize and wheat also showed significant yield advantage from the tool-based fertilizer recommendation as compared to existing practices [23]. A study also reported the same result that NE or SSNM practice showed the highest yield than the farmer practice [11]. There is significant increase in yield attributes with the increase in nitrogen levels [24]. A group researcher also confirmed similar result [9]. The SSNM-NE leads to enhancement in the growth attributes lead to photosynthates partitioning and better source-sink relationship, which enhance yield attributes. The leaf nitrogen content is directly related to chlorophyll content and depends on nitrogen uptake [24]. The nutrient management practices resulted significant differences in grain as well as in straw yields. On the other hand, imbalance nutrient applications in FFP probably the main reason for lower grain yield [25].

4.3.5. Straw weight

Straw yield is a function of vegetative growth. Balanced and optimum used of fertilizer (SSNM-NE) increased plant higher, green leaves/hill, tillers/hill and dry matter production which finally resulted in higher straw yield. Application of nitrogen enhances both photosynthetic activity and total above ground dry matter production [26-30].

4.4. Economic analysis

4.4.1. Cost of production

Farmer's field practice attributed to higher cost of production as compost manure was also used. Similarly, Government recommendation also results in higher cost of production due to the use of Farmyard manure.

4.4.2. Gross return

Gross return was higher in SSNM-NE due to higher grain and straw yield. The higher production of grains and straws results in higher gross returns.

4.4.3. Net returns

Net return was higher in SSNM-NE due to higher grain and straw yield (results higher gross return) and lower cost of production. Lower net return in FFP was due to lower grain and straw yield and higher cost of production.

4.4.4. B: C ratio

High gross return in SSNM-NE was due to higher gross return and lower cost of production as compared to Government recommendation and farmer's field practice.

5.0. Conclusion

The effect of different nutrient management in growth and yield of spring rice (Hardinath-1) was studied and the effect of crop establishment techniques on number of tillers/m2, plant height, panicle length, thousand grain yield, grain yield and sterility % was assessed. Three averaged data across different dates of 15 days' interval suggested that SSNM-NE nutrient management technique exhibited highest average number of tillers/m2 (442.5), highest average thousand grain weight (23.20 gm), highest number of grain per panicle (154.40), highest grain yield (5.81 t/ha) and low sterility percentage (18.62%) but was similar with government recommendation. Whereas, gross return, net return and B: C ratio was found higher in SSNM-NE. Although, yield and yield attributing characters were similar in both SSNM-NE and government recommendation, gross return, net return and B: C ratio was found higher in SSNM-NE, So, SSNM-NE is suitable among different nutrient management practices for higher productivity and profitability under transplanted spring rice in kanchanpur district, Nepal.

6.0. Acknowledgement

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