Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP1: 681-688

Pankaj Prashad Joshi
Assistant project manager, Nepal public health foundation, Chitwan, Nepal

Santosh Marahatta
Assistant professor, Department of agronomy, Agriculture and forestry university, Rampur, Chitwan, Nepal

Shrawan Kumar Sah
Professor, Department of agronomy, Agriculture and forestry university, Rampur, Chitwan, Nepal

Lal Prasad Amgain
Associate professor, Department of agronomy, Institute of Agriculture and animal Sciences, Lamjung, Nepal

Correspondence
Pankaj Prashad Joshi
Assistant project manager, Nepal public health foundation, Chitwan, Nepal

Simulation of growth and yield of rice varieties under varied agronomic management and changing climatic scenario in Chitwan, Nepal

Pankaj Prashad Joshi, Santosh Marahatta, Shrawan Kumar Sah and Lal Prasad Amgain

Abstract
A field experiment and simulation modeling study in combination for different rice cultivars in different establishment methods applied with different levels of nitrogen was done in sub-tropical climate in Rampur, Chitwan during rainy season of 2015 to assess the impact of climate change scenarios by using CSM-CERES-rice model. Three factors Strip-split plot experimental design using establishment methods (conservation and conventional agriculture) in vertical plots; varieties (hybrid Gorakhnath 509 and high yielding Sabitri) in horizontal plots and four nitrogen levels (0, 60, 120 and 180 kg N ha^{-1}) in sub-sub plots was laid out with three replications. Data regarding phenology, biometrical observations and yield attributes were recorded during the experiment. In comparison between establishment methods, yield of rice was higher in conservation agriculture (4766 kg ha^{-1}) as compared to conventional agriculture (4106 kg ha^{-1}). The sensitivity for various climate change parameter indicated that there was severely decreased trend in simulated yield of varieties in different establishment method with increase in maximum and minimum temperature, carbon dioxide concentration and solar radiation. Even 2^0C rise in temperature can decrease around 71.36 % yield of rice cultivars and this effect was even more pronounced in hybrid than improved cultivars. Reduction of temperature by 2^0C resulted in increased yield by 51.51 and 17.37% for Gorakhnath 509 and Sabitri under CA respectively but Sabitri and Gorakhnath 509 in conventional agriculture were not influenced due to reduction of temperature. Increase in CO_2 concentration by 20ppm increased yield did not influenced the yield of varieties whereas change in solar radiation showed positive response to yield but the variation due to solar radiation was small. Solar radiation mainly influenced the Gorakhnath 509 in conventional agriculture which showed up to 18% variation in yield. Therefore crop production under conservation agriculture was more productive and profitable and beneficial for sustainable rice production. Further evaluating the climatic parameters showed that yield will increase as the temperature and CO_2 concentration will decrease in conservation agriculture and conventional agriculture will be less affected by increase or decrease in temperature.

Keywords: CSM-CERES-rice model, parameters, sensitivity, simulation

Introduction

Rice is the world's third crop on the basis of volume of supply (501.9 million tons in 2017) after wheat and maize (FAO, 2018) but it is the most important staple crops in Asia, and it is estimated that more than 90% rice is grown and consumed in Asia region (Pathak, Tiwari, Sankhyan, Dubey, Mina, Singh, Jain and Bhatia, 2011). In Nepal, rice is cultivated in 56.42% of cultivated land with the productivity of 3.30 t $ha^{-1}$and constitutes 13.85 % of agricultural gross domestic product (MOF Economic Survey, 2016; MOAD ABPSD, 2015).

Rice cultivation is commonly done by transplanting in puddled field in as conventional method while the modern method of direct seeding is gaining popularity in recent days. In puddled transplanting, puddling is main field operation which benefits rice by reducing water percolation losses, controlling weeds, facilitate transplanting and easy seedling establishment and creates anaerobic conditions that enhance nutrient availability. At the same time it encounters several problems such as high labor and water requirement, deteriorate soil physical, chemical and microbial properties, increase the cost of cultivation, development of hardpan in the subsoil below the puddled layer (Giri, 1996), high methane emission (Kumar & Ladha, 2011).

Conservation agriculture (CA) can be defined as "resource-conserving agricultural crop production system to achieve acceptable profits together with high and sustained production levels while at the same time conserving natural resources and environment" by following no or minimum tillage, optimum residue retention and proper crop rotation (Sayre & Hobbs, 2004) that may prove advantageous for upland crops (Derpsch& Friedrich, 2009).

CA practices can have advantages over conventional practices as they increase water storage, reduce water loss and erosion, improve crop yield and water productivity and labor use (Wang, 2006), increase soil organic matter (Rasmussen, 1999), increase carbon sequestration (Uri, Atwood & Sanabria, 1999), and produce yield equivalent to or higher than those under conventional farming (Karunatilake, Vanes & Schindelbeck, 2000) and reduce the production cost. Mulching with crop residue in CA increases infiltration (Huang, Xia, Zou, Jiang, Feng, Cheng & Mo, 2012) and decreases evaporation loss of water (Bezborodov, Shadmanov, Mirhashimov, Yuldashev, Qureshi, Noble & Qadir, 2010) hence improve water use efficiency.

Apart from these merits, CAon rice and rice based system has some short comings as high weed infestation, poor seed germination and reduced early seedling growth (Qi, Nie, Liu, Peng, Shah, Huang, Cui & Sun, 2012; Joshi, Kumar, Lal, Nepalia, Gautam& Vyas, 2013). In comparison with transplanted rice, nitrogen loss through denitrification, volatilization, leaching and runoff is also higher in CA (Kumar & Ladha, 2011; Davidson, 1991).

Nitrogen is a prime component governinggrowth and development. Low nitrogen use efficiency due to ineffective splitting of N application including the unbalance use of nitrogen is one of the various factors responsible for lower rice production (Adhikari, 2006). Low nitrogen recovery (20-40%) is reported from Asia (De Datta, Obcemea, Chen, Calabio & Evangelista, 1987). Only a part of applied nitrogen is used by plant and remaining residual is accumulated in soil and mostly lost as runoff (Khan & Mohammad, 2014). The synchronization between crop demand and nitrogen supply is the most important aspect of increasing nitrogen use efficiency, high yields and reduced nitrogen losses. Nitrogen demand differ with inbred and hybrid variety. Use of hybrid allows farmers to obtain 15-30% more rice than inbred (Siddiq, 1993; Virmani, Mao & Hardy, 2003). Viramani (1996) reported that hybrid rice had bigger panicles and more spikeletsper panicle but filled spikelet percentage was less probably due to higher nutrient demand during reproductive growth stage and hybrid rice required different strategies for N management to maximize expression of their yield advantage.

Rapid change in climate may lead to impact on growth of rice. Temperature, solar radiation, rainfall, relative humidity and wind velocity independently or in combination, can influence crop growth and productivity. It was reported that by increasing maximum and minimum temperature, irrespective of whether the CO_2 concentration increased or not, seemed to have adverse effect on rice yield (Amgain, 2004).

The decision support system for agro technology transfer (DSSAT) was originally developed by an international network of scientists, cooperating in the International Benchmark Sites Network for Agro technology Transfer project (Tsuji, 1998; Uehara, 1998; Jones, Tsuji, Hoogenboom, Hunt, Thornton, Wilkens, Imamura, Bowen & Singh, 1998). CERES-Rice is a process-based, management-oriented model that can simulate the growth and development of rice as affected by varying levels of water and nitrogen (Ritchie, Singh, Godwin & Bowen, 1998).

Although versions of the DSSAT model (v. 3.5) have been evaluated across rice growing environments of Asia and Australia and their performance has found to be satisfactory, but variation exists. It will be high valued scientific work in Nepal to simulate agronomic and climate change parameter on the growth and yield of the rice. Thus, an experiment was conducted with an objective of evaluating the effect of change in climatic parameters as well as the agronomic practices on the performance of rice cultivars at different establishment methods.

Materials and Methods

A field experimentation consisting of the combination of the two establishment method (conservation and conventional agriculture), two varieties (hybrid Gorakhnath 509 and inbred Sabitri) and four nitrogen levels (0, 60, 120 and 180 kg N ha^{-1}) was accomplished at the agronomy farm of Agriculture and Forestry University, Rampur, Chitwan during rainy season of 2015 representing the sub-tropical climate of terai and inner terai. The experiment was carried out in three factor strip split design with three replication. The soil of the experimental research site was sandy loam and slightly acidic (5.93). Total nitrogen and soil available potassium was found to be lower (0.15% and 116.85 kg ha^{-1}) in surface soil profile but soil available phosphorous was found to be of medium (27.45 kg ha^{-1}) and most of all parameters were found decreasing with increasing profile depth up to 1m. In TPR the spacing between the hills was 20 cm between row to row and plant to plant whereas in DSR 20 cm and continuous was kept. The maximum and minimum temperatures, sunshine hours and rainfall data during the cropping periods and historical weather records were collected from the National Climatic observatory of National Maize research Program. Urea, DAP, MOP, zinc sulphate and SSP were used as the fertilizer. The phenology and yield data obtained from field experiment was analyzed with the MSTAT-C package software and mean data was further subjected to model evaluation byDSSAT v. 4.6.

Model evaluation and application

The data were taken in consideration to make appropriate input files (file X, file A, file T, soil file and weather file) required for CSM-CERES-Rice v 4.6. Model evaluation was done by standard model procedures on various climate change factors to simulate the growth and yield performance of diverse rice genotypes. At first model calibration was done by using the best performing treatment (180 kg N ha^{-1} for both varieties in conservation agriculture) while validation was done for second best treatment (120 kg N ha^{-1} for both establishment method and varieties) over the days to heading, days to physiological maturity and grain yield. Simulation to different scenarios of climatic parameters was accomplished by comparing the yield performance of rice genotypes. The climatic scenarios are altered in the range of 2^0C for minimum and maximum temperature, CO_2 concentration by 20ppm and solar radiation by 1 MJ m^{-2} day $^{-1}$.

Result and Discussion

Yield attributing characters: Effective tillers per meter square was found significantly higher in conservation agriculture (261.10 m^{-2}) than conventional agriculture (201.30 m^{-2}). Increase in nitrogen levels increased the effective tillers per meter square (Table 1). Zhang and Zhu (1999) and Gathala, Kumar, Sharma, Saharawat, Jat, Singh, Kumar, Jat, Humphreys, Sharma, Sharma and Ladha (2013) also recorded more number of effective tillers per square meter under no till DSR compared with TPR. This was due to the close spacing causing higher plant population (Patil, Aladakatti, Channagoudar, Hanamaratti, Gupta & Ladha, 2007) which increases the number of mother plant causing less effect on tiller mortality. There wassignificantly more number of effective tillers per meter square in 180 kg N ha^{-1}(251.80) than 0 and 60 kg N ha^{-1} but at par with 120 kg N ha^{-1} (243.50). Lowest effective tillers was observed in control plot (205.90).Saxena& Yadav (1998) recorded significantly higher growth of rice with increase in nitrogen level up to 150 kg N ha^{-1}. Nitrogen as a prime element in growth and development of plant, with increase in its dose provide higher availability of photosynthate reducing the tiller mortality. Thakur & Singh (1987) also reported significantly higher effective tillers per square meter square with higher nitrogen levels.

Number of grains per panicle was found higher in conventional agriculture (137.70). Hobbs, Singh, Giri, Lauren and Duxbury (2002) recorded 150% higher number of panicles per unit area in DSR than TPR. In general, DSR had more panicles per unit area but fewer spikelets per panicle, eventually, fewer number of grains per panicle (Schnier, Dingkuhn, De Datta, Mengel & Faronilo, 1990; Dingkuhn, Schnier, Datta, Wijangco & Dorffling 1992). It is due to the higher plant population causing intra plant completion for assimilates causing fewer number of grains formation per panicle. Gorakhnath-509 had statistically higher number of spikelet and grains per panicle (158.90) than Sabitri (101.60). This shows that the hybrid have higher number of grains per panicle as compared to improved varieties. Similar result was also obtained by Manzoor, Awan, Zahid and Faiz, (2006).Number of grains per panicle was found highest in 120 kg N ha^{-1} (136.10)which was at par with 180 (135.00) and 60 kg N ha^{-1} (129.60).This might be due to the better nitrogen status of plant during panicle growth period. Swain and Jagpat (2010) reported that nitrogen contributes in grains during the grain filling stage.

Thousand grain weight was found significantly higher in conventional agriculture (17.80) than conservation agriculture (17.67 gm) (Table 1). Akhgari & Kaviani (2011) also observed significantly higher thousand grain weight in DSR as compared to TPR in their experiment. Similarly, thousand grain weight of Gorakhnath-509 significantly lower (14.82 gm) than Sabitri (20.65 gm). The grains of Gorkhnath 509 was finer than the Sabitri which cause the lower thousand grain weight.

Table 1: Influence of establishment methods, varieties and nitrogen levels on Yield attributes of rice during monsoon season at Rampur, Chitwan, Nepal, 2015

Treatment	Effective tillers per square meter	Grains per Panicle	Thousand grain weight (gm)
Establishment method			
CA	261.10^{a}	122.80^{b}	17.67^{b}
Con A	201.30^{b}	137.70^{a}	17.80^{a}
SEm (±)	9.27	1.58	0.02
LSD (=0.05)	56.40	9.62	0.102
Varieties			
Gorakhnath-509	219.40	158.90^{a}	14.82^{b}
Sabitri	242.90	101.60^{b}	20.65^{a}
SEm (±)	8.85	5.82	0.26
LSD (=0.05)	Ns	35.44	1.592
Nitrogen levels (kg Nha^{-1})			
0	205.90^{c}	120.10^{b}	17.98
60	223.50^{bc}	129.60^{ab}	17.77
120	243.40^{a}	136.10^{a}	17.64
180	251.80^{ab}	135.00^{a}	17.55
SEm (±)	7.24	4.14	0.23
LSD (=0.05)	21.13	12.08	Ns
CV, %	10.80	11.00	4.40
Grand mean	231.20	130.20	17.74

Note: CA, Conservation agriculture; ConA, conventional agriculture; ns, non-significance; DAS, days after sowing. Treatments means followed by common letter (s) are not significantly different among each other based on DMRT at 5% level of significance

Yield

The average grain yield was 4436 kg ha^{-1}. The grain yields was significantly influenced by crop establishment methods and nitrogen levels but not by the varieties (Table 2). The grain yield under conservation agriculture (4766 kg ha^{-1}) was significantly higher than conventional agriculture (4106 kg ha^{-1}). Reddy (2004) and Singh, Kumar and Kang (2014) also reported the significantly higher grain yield of rice in no- till DSR than TPR. The higher LAI and greater biomass in DSR was attributed to increased number of tillers per square meter (Murthy & Murthy, 1984) which along with residue retention increased the yield in conservation agriculture. Similarly, Zheng, Jiang, Chen, Sun, Feng, Deng & Zhang (2014) (2014) reported that rice yield increases in conservation agriculture by 4.1%.

Table 2: Influence of establishment methods, varieties and nitrogen levels on grain and straw yield of rice during monsoon season at Rampur, Chitwan, Nepal, 2015

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Establishment methods		
CA	4766.00^{a}	5648.00^{a}
Con A	4106.00^{b}	4487.00^{b}
SEm (±)	35.60	62.7
LSD (=0.05)	216.50	381.5
Varieties		
Gorakhnath 509	4438.00	4451.00^{b}

Sabitri	4433.00	5683.00[a]
SEm (±)	172.80	183.70
LSD (=0.05)	Ns	1117.50
Nitrogen levels (kg ha^{-1})		
0	3686.00[c]	4041.00[b]
60	4308.00[b]	4540.00[b]
120	4769.00[a]	5792.00[a]
180	4980.00[a]	5896.00[a]
SEm (±)	91.00	268.40
LSD (=0.05)	265.70	783.30
CV, %	7.10	18.30
Grand mean	4436.00	5067.00

Note: CA, Conservation agriculture; ConA, conventional agriculture; ns, non-significance; DAS, days after sowing. Treatments means followed by common letter (s) in colums are not significantly different among each other based on DMRT at 5% level of significance

The grain yield at 180 kg N ha^{-1}was statistically similar with 120 kg N ha^{-1} (4769 kg ha^{-1})which was significantly higher than grain yield at 60 kg N ha^{-1} (4308kg ha^{-1}) and 0 kg N ha^{-1} (3686 kg ha^{-1}). Manzoor, Awan, ZahidandFaiz (2006)also reported that 175 kg N per hectare produced maximum grain yield which was statistically similar with 150, 200 and 225 kg N ha^{-1} with lowest paddy yield in control plots. Increased nitrogen content of plant is closely associated with numbers of tillers, spikelets (Matsushima, 1976) and leaf area index which in turn increases the yield.

In response to establishment methods straw yield was significantly higher under conservation agriculture (5648 kg ha^{-1}) than conventional agriculture (4487 kg ha^{-1}), whereas in case of variety the straw yield of Sabitri was significantly higher (5683 kg ha^{-1}) compared toGorakhnath-509 (4451 kg ha^{-1}). Straw yield at 180 kg N ha^{-1} (5896 kg ha^{-1}) was at par with 120 kg N ha^{-1} (5792 kg ha^{-1}) and statistically higher than 60 kg N ha^{-1} (5540 kg ha^{-1})and0 kg N ha^{-1}(4041 kg ha^{-1}) application. Straw yield is the total outcome of weight of stem and leaves. Total dry weight was observed higher in conservation agriculture due to the higher plant population per meter square resulting higher straw yield. Belder, Spiertz, Boumanb, Lu andTuong (2004) reported that biomass production was significantly higher for 180 Kg N ha^{-1} than nitrogen omitted plots.Togari, Okamoto and Kumura (1954) and Fageria (2014) stated that higher N application helps in protein metabolism and ultimately carbohydrate metabolism in the latter stages of growth which might be the cause of higher straw yield.

Nutrient uptake

Comparatively higher nitrogen uptake was observed under conservation agriculture. Straw nitrogen uptake, grain nitrogen uptake and total nitrogen uptake showed similar trend to nitrogen levels. Grain nitrogen uptake and total nitrogen uptake in 180 and 120 kg per ha^{-1} was significantly at par whereas significantly higher than 0 and 60 kg N ha^{-1}. Grain and total nitrogen uptake in 0 and 60 kg ha^{-1} were significantly at par. Similarly in case of straw nitrogen uptake 180 and 120 kg per ha^{-1} was significantly at par. Application 120 kg per ha^{-1} was also similar with 60 kg ha^{-1} but was statistically higher than 0 kg per ha^{-1}.The relationship between grain nitrogen uptake, straw nitrogen uptake and total nitrogen uptake was quadratic in nature and significant (r = 0.81**, 0.47** and 0.77** respectively).

CSM-CERES-Rice model

Model calibration

The adjustment of parameters so that simulated values were similar with observed values is known as calibration. Using the data obtained from field experiment, genetic coefficients of both Gorakhnath 509 and Sabitri variety of rice under study were adjusted using CSM-CERES-Rice model embodied under DSSAT v 4.6. The meanings of the various genetic coefficients of rice cultivars along with their values are presented below:

Table 3: Estimated genetic coefficients of rice genotypes under different establishment method in Chitwan, 2015

Genetic Coefficients	Gorakhnath 509	Sabitri
Time period (in ^{0}C above a base temperature of 9 ^{0}C) from seedling emergence (P1)	667.6	780.4
Critical photoperiod or the longest day length (in hours) at which the development occurs at a maximum rate (P2O).	11.53	11.43
Extent to which phasic development leading to panicle initiation is delayed (in ^{0}C) for each hour increase in photoperiod above P_2O (P2R).	120.6	250.3
Time period in (GDD ^{0}C) from beginning of grain filling to physiological maturity with a base temperature of 9^{0}C (P5).	345.2	459.2
Potential spikelet number coefficient (G1).	76.09	100.5
Single grain weight (g) under ideal growing conditions (G2)	0.026	0.047
Tillering coefficient relative to IR64 cultivar under ideal conditions (G3).	0.938	0.524
Temperature tolerance coefficient (G4)	1.048	0.971
Interval between successive leaf tip appearances (^{0}C.d) (PHINT)	83	83.0

Model Validation

Model validation was done by using the second best nitrogen levels of both establishment methods and varieties for phenological characters anthesis, physiological maturity and grain yield shown in Figure 2.

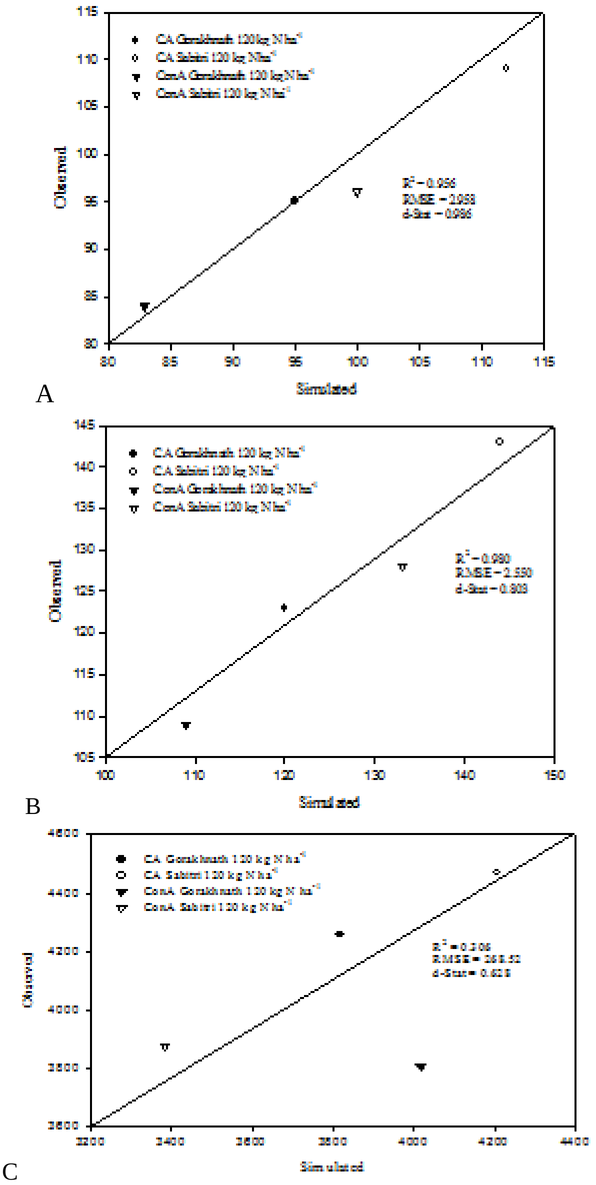

Fig 1: Model validation by plotting simulated and observed days to anthesis (figure A), physiological maturity (B) and yield (C) for rice cultivars at Rampur, Chitwan

Sensitivity analysis
Climate change scenarios

Sensitivity analysis showed that increasing minimum and maximum temperature results in drastic reduction of yield whereas decreasing minimum and maximum temperature increase in yield except for conventional Sabitri which was vice-versa. Increase in temperature by 2^{0}C resulted in 71.36, 51.40, 46.91 and 121.67% yield of CA Gorakhnath, CA Sabitri, conventional Gorakhnath and conventional Sabitri respectively as compared to actual (Table 4). Whereas decrease in temperature increase in yield of all cultivars except for conventional Sabitri. Decrease in temperature by 2^{0}C resulted in 151.51, 117.37, 100.72 and 98.17% yield of CA Gorakhnath, CA Sabitri and conventional Gorakhnath and conventional Sabitri respectively as compared to actual. Gorakhnath 509 showed highest yield in CA whereas no difference in conventional agriculture whereas in Sabitri yield was higher in conventional agriculture compared to conservation agriculture. Similar result was reported by Lamshal, Amgain and Giri (2013). Increase in yield due to decrease in minimum and maximum temperature by 2^{0}C is due to reduction of respiration and increase in photosynthesis rate causing increase in net accumulation rate which was also reported by Schlenker and Roberts (2009). Welch, Vincent, Auffhammer, Moya, Dobermann and Dawe (2010) reported that higher minimum temperatures reduced final grain yield in rice. Grain yield declined by 10% for each 1^{0}C increase in growing-season minimum temperature (Peng, Huang, Sheehy, Laza, Visperas, Zhong, Centeno, Khush, Kenneth and Cassman, 2004).

Change in CO_2 level by 20ppm with similar change in temperature slightly influenced the yield of rice cultivars. Further, increase or decrease in solar radiation by 1MJ m^{-2} day^{-1} with increase in temperature and CO_2 concentration did not drastically affect the grain yield. Similar was observed in case of decrease in temperature. Decrease in solar radiation increased the yield and vice versa but the change in yield was at slower rate. Similar effect was observed as temperature was decreased by 2^{0}C with increased CO_2 concentration and change in solar radiation.

Table 4: Sensitivity analysis of rice cultivars with change in maximum and minimum temperature, CO_2 concentration and solar radiation in different establishment methods and varieties at 120 kg N ha^{-1} in Rampur, Chitwan

Minimum temperature	Maximum temperature	CO_2 concentration	Solar radiation	V	An	M	Y	% yield change
+0[a]	+0	+0	+0	A	95	120	3817	100.00
				B	112	144	4208	100.00
				C	83	109	4016	100.00
				D	100	133	3383	100.00
+2	+2	+0	+0	A	95	121	2724	71.36
				B	109	139	2163	51.40
				C	83	109	1884	46.91
				D	97	127	4116	121.67
-2	-2	+0	+0	A	96	123	5783	151.51
				B	117	154	4939	117.37
				C	86	114	4045	100.72
				D	107	147	3321	98.17
+2	+2	+20	+0	A	95	121	2753	72.12
				B	109	139	2227	52.92
				C	83	109	1936	48.21
				D	97	127	4179	123.53
-2	-2	+20	+0	A	96	123	5869	153.76
				B	117	154	5005	118.94
				C	86	114	4152	103.39

				D	107	147	3447	101.89
+2	+2	+20	+1	A	95	121	2651	69.45
				B	109	139	2110	50.14
				C	83	109	1648	41.04
				D	97	127	4095	121.05
+2	+2	+20	-1	A	95	121	2845	74.53
				B	109	139	2365	56.20
				C	83	109	2384	59.36
				D	97	127	4235	125.18
-2	-2	+20	+1	A	96	123	5618	147.18
				B	117	154	4791	113.85
				C	86	114	3396	84.56
				D	107	147	3237	95.68
-2	-2	+20	-1	A	96	123	5865	153.65
				B	119	156	5099	121.17
				C	86	114	4712	117.33
				D	107	147	3657	108.10

[a] = Standard base,V= variety, An= anthesis date, M= Physiological maturity,Y= yield (kg ha^{-1})
A = Conservation Agriculture Gorakhnath 509 with 120 kg N ha^{-1}
B = Conservation Agriculture - Sabitri with 120 kg N ha^{-1}
C = Conventional Agriculture -Gorakhnath 509 with 120 kg N ha^{-1}
D = Conventional Agriculture -Sabitri with 120 kg N ha^{-1}

The anthesis and maturity days were found influenced by change in temperature. Change in temperature increased the anthesis and maturity days but increase in temperature showed lower increase in anthesis and maturity days as compared to decrease in temperature.Increased CO_2 levels increased rice yields and reduction of rice yields due to high temperature in all season was observed by Karim, Ahmed, Hussain and Rashid (1994). Singh and Padila (1995) reported that the increased CO_2 concentration would reduce transpiration and N losses and increase water, N and radiation use efficiencies. Hendry and Kimball (1994) reported that higher CO_2 concentration increase growth and yield, mainly through their effect on the photosynthetic processes of crop. Takuya, Kumi& Yuji (1999) reported that insufficient grain filling of hybrid rice was due to shortage of solar radiation which led to the abnormal physio-chemical properties. Vijayalakshmi, Radhakrishnan, Nagarajan and Rajendran (1991) reported that the reduction in the ultimate grain yield was due to increased number of ill-filled spikelets which was due to deficit of solar radiation.

Conclusions
Yield was higher under conservation agriculture than conventional agriculture. Increase in the minimum and maximum temperature would decrease the yield of both varieties in conservation agriculture whereas decreased minimum and maximum temperature would increase the yield of both varieties in conservation agriculture but shows negligible effect on conventional agriculture.

References

1. Akhgari H, Kaviani B. Assessment of direct seeded and transplanting methods of rice cultivars in the northern part of Iran. African Journal of Agricultural Research. 2011; 6(31):6492-6499.
2. Amgain LP. Simulation of growth and yield of rice and wheat under different levels of nitrogen and irrigation, and effects of climate change on their yield in Punjab, India, using CSM-CERES- Rice and Wheat Model. Technical report. 2004, 36-67.
3. Belder P, Spiertz JHJ, Boumanb BAM, Lu G, Tuong TP. Nitrogen economy and water productivity of lowland rice under water-saving irrigation. Field Crops Research. 2004; 93:169-185.
4. Bezborodov GA, Shadmanov DK, Mirhashimov RT, Yuldashev T, Qureshi AS, Noble AD. *Et al*. Mulching and water quality effects on soil salinity and sodicity dynamics and cotton productivity in Central Asia. Agriculture, Ecosystems and Environment. 2010; 138:95-102.
5. Chandrakar BL, Khan RA. Optimum spacing for early, medium and late duration tall indica rice cultivars. Short Communication. Oryza, 1981; 18:108-109
6. Davidson EA. Fluxes of nitrous oxide and nitric oxide from terrestrial ecosystems. *In*: J. E. Rogers and W. B. Whitman. (Eds), Microbial Production And Consumption Of Greenhouse Gases: Methane, Nitrogen Oxides and Halomethane. Washington, the American Society of Microbiology, 1991.
7. De Datta SK, Obcemea WN, Chen RY, Calabio JC, Evangelista RC. Effect of water depth on nitrogen use efficiency and nitrogen-15 balance in lowland rice. Agron. J. 1987; 79:210-216.
8. Derpsch R, Friedrich T. Global overview of conservation agriculture no-till adoption. In 4th World Congress on Conservation Agriculture New Delhi, India. 2009, 4-7.
9. Dingkuhn M, Schnier H, Datta S, Wijangco E, Dorffling, K. Diurnal and developmental changes in canopy gas exchange in relation to growth in transplanted and direct-seeded flooded 284 rice. Australian Journal of Plant Physiology, 1990; 17:119-134.
10. Fageria NK. Nitrogen management in crop production. CRC press. 2014, 24-25.
11. Gathala MK, Kumar V, Sharma PC, Saharawat YS, Jat HS, Singh M, *et al*. Optimizing intensive cereal-based cropping systems addressing current and future drivers of agricultural change in the northwestern Indo-Gangetic Plains of India. Agric. Ecosyst. Environ. 2013; 177:85-97.
12. Giri GS. Effects of rice and wheat establishment techniques on wheat grain yield. *In:* Hobbs, P. R; Bhandari, R. (Eds.). Proceedings of Rice-wheat Research End of Project Workshop, India. 1988, 65-68.
13. Hendrey GR, Kimball BA. The FACE program. Agric. Forest Meteorol. 1994; 70:3-14.
14. Hobbs PR, Singh Y, Giri GS, Lauren JG, Duxbury JM. Direct seeding and reduced tillage option in the rice-wheat systems of Indo-Gangetic Plains of South Asia. In:

S. Pandey, M. Mortimer, L. Wade, T. P. Tuong, K. Lopez and B. Hardy (Eds.), Direct seeding: research issues and opportunities. Philippines, International Rice Research Institute, 2002, 201-218.

15. Huang M, Xia B, Zou Y, Jiang P, Feng Y, Cheng Z, *et al*. No till direct seeding for energy saving rice production in China. *In*: Lichtfouse, E. (ed.) Farming for food and water security. Springer Dordrecht Heidelberg New York London. 2012, 111-126.
16. Jones DB, Snyder GH. Seeding rate and row spacing effects on yield and yield components of drill-seeded rice. Agronomy Journal. 1987; 79(4):623-626.
17. Jones JW, Tsuji GY, Hoogenboom G, Hunt LA, Thornton PK, Wilkens PW, *et al*. Decision support system for agrotechnology transfer; DSSAT v3. *In:* G.Y. Tsuji, G. Hoogenboom, P.K. Thornton (eds.). and Understanding Options for Agricultural Production. Kluwer Academic Publishers, Dordrecht, the Netherlands. 1998, 157-177.
18. Joshi E, Kumar D, Lal B, Nepalia V, Gautam P, Vyas AK. Management of direct seeded rice for enhanced resource - use efficiency. Plant Knowledge Journal. 2013; 2(3):119-134.
19. Karim Z, Ahmed M, Hussain S, Rashid KB. Impact of climate change on the production of modern rice in bangladesh. Implications of Climate Change for International Agriculture Crop Modeling Study. 1994, 1-11.
20. Karunatilake U, Van Es HM, Schindelbeck RR. Soil and maize response to plow and no-tillage after alfalfa-to-maize conversion on a clay loam soil in New York. Soil Till. Res. 2000; 55:31-42.
21. Khan MN, Mohammad F. *Eutrophication: Challenges and Solutions*. In: Ansari, A. A., Gill, S. S. (Eds.), Eutrophication: Causes, Consequences and Control, Springer Science, Business Media Dordrecht, 2014. doi:10.1007/978-94-007-7814-6_5
22. Kumar V, Ladha JK. Direct Seeding of Rice: Recent Developments and Future Research Needs. *Advances in* Agronomy. 2011; 11:297-413.
23. Manzoor Z, Awan TH, Zahid MA, Faiz FA. Response of rice crop (super basmati) to different nitrogen levels. Journal of Animal & Plant Sciences. 2006; 16(1-2):52-55.
24. Matsushima S. High yielding rice cultivation. University of Tokyo Press, Japan. 1976, 340-356.
25. MoAD. Statistical information on Nepalese Agriculture 2015/16. Ministry of Agriculture and Development, Agribusiness Promotion and Statistics Division, Kathmandu, Nepal, 2016.
26. MOF. Economic survey 2016/17. Ministry of Finance, Kathmandu, Nepal, 2016.
27. Murthy PPS, Murthy KS. Amelioration of spikelets sterility in rice (*Oryza sativa* L.) by the exogenous application of growth regulators. J Res. Assam Agric. Univ. 1984; 5:114-116.
28. Naresh RK, Singh SP, Kumar V. Crop establishment, tillage and water management technologies on crop and water productivity in rice-wheat cropping system of North West India. Int. J Life Sci. Bt. Pharm. Res. 2013; 2(3):237-248.
29. Pathak H, Tewari AN, Sankhyan S, Dubey DS, Mina U, Singh VK, *et al*. Direct-seeded rice: Potential, performance and problems – A review. Current Advances in Agricultural Sciences. 2011; 3(2):77-88.
30. Patil SG, Aladakatti YR, Channagoudar RF, Hanamaratti NG, Gupta RK, Ladha JK. (2007). Zero-tillage: an effective resource conserving technology for sustainable direct seeded rice production in Karnataka. *In*: International Conference on 21st Century Challenges to Sustainable Agri-Food system, Chengappa, P. G., N. Nagaraj and R. Kanwa (eds.). I. K. international Publishing House Pvt. Ltd. 2011, 88-99.
31. Qi X, Nie L, Liu H, Peng S, Shah F, Huang J, Sun L. Grain yield and apparent N recovery efficiency of dry direct-seeded rice under different N treatments aimed to reduce soil ammonia volatilization. Field Crops Research. 2012; 134:138-143.
32. Rasmussen KJ. Impact of ploughless soil tillage on yield and soil quality: a Scandinavian review. Soil and Tillage Research, 1999; 53(1):3-14.
33. Reddy CV. Crop establishment techniques in rice under different environments in Haryana. Ph.D. Thesis, CCSHAU, Hisar, India. 2004, 160.
34. Retrieved from: http://www.fao.org/worldfoodsituation/csdb/en/
35. Ritchie JT, Singh U, Godwin DC, Bowen WT. Cereal growth, development and yield. *In:* Tsuji, G.Y., G. Hoogenboom, P.K. Thornton, (Eds.), Understanding options for agricultural production. Kluwer Academic Publishers, Dordrecht, the Netherlands. 1998, 79-98.
36. Saxena A, Yadav DS. Effect of summer green manure (*Phaseolus radiates*) on rice (*Oryza sativa*)-wheat (*Triticumaestivum*) system. Indian J Agric. Sci. 1998; 68(9):583-586.
37. Sayre KD, Hobbs PR. The raised-bed system of cultivation for irrigated production conditions. Sustainable Agriculture and the Rice-Wheat System. 2004, 337355.
38. Schnier HF, Dingkuhn M, De Datta SK, Mengel K, Faronilo JE. Nitrogen Fertilization of Direct-Seeded Flooded vs. Transplanted Rice: I. Nitrogen Uptake, Photosynthesis, Growth, and Yield. Crop Science. 1990; 30:1276-1284.
39. Sharma P, Tripathi RP, Singh S. Tillage effects on soil physical properties and performance of rice—wheat cropping system under shallow water table conditions of Tarai, Northern India. European Journal of Agronomy. 2005; 23:327-335.
40. Siddiq S. Rice production strategy for the 21st century. Oryza, 1993; 30:186-196.
41. Singh A, Kumar R, Kang JS. Tillage system, crop residues and nitrogen to improve the productivity of direct seeded rice and transplanted rice. Current Agriculture Research Journal. 2014; 2(1):14-29.
42. Singh U, Padila JL. Simulating rice response to climate change. In: climate Change and Agriculture: Analysis of potential International Impacts. ASA Special Publication Number 59. ASA Madison, Wisconsin. 1995, 99-122.
43. Swain DK, Jagtap S. Development of spad values of medium-and long duration rice variety for site-specific nitrogen management. Journal of Agronomy. 2010; 9(2):38-44.
44. Takuya W, Kumi FO, Yuji H. Effect of high air temperature and insufficient solar radiation during ripening period on the palatability and physiochemical properties of rice in 199 in kyushu region. Japanese J of Crop Sci. 1999; 71.346-354.
45. Thakur KS, Singh CM. Effect of organic wastes and N levels on transplanted rice. Indian J Agron. 1987; 32(2):161-164.

46. Timsina J, Humphreys E. Application of CERES –Rice and CERES- Wheat ion research, policy and climate change studies in Asia: A review. CSIRO Land and Water Technical Reports 13/03. CSIRO Land and water Griffith, NSW 2680, Australia, 2006.
47. Togari Y, Okamoto Y, Kumura A. Studies on the production and behavior of carbohydrates in rice plant. 1. Proc. Crop Sci. Soc. Japan. 1954; 22:95-97.
48. Tsuji GY. (1998). Network management and information dissemination for agro-technology transfer. *In:* G.Y. Tsuji, G. Hoogenboom, P.K. Thornton (eds.), Understanding Options for Agricultural Production. Kluwer Academic Publishers, Dordrecht, the Netherlands. pp. 367-381.
49. Uehara G, Tsuji GY. Overview of IBSNAT. *In:* G.Y. Tsuji, G. Hoogenboom, P.K. Thornton (eds.), Understanding Options for Agricultural Production. Kluwer Academic Publishers, Dordrecht, the Netherlands. 1998, 1-7.
50. Uri ND, Atwood JD, Sanabria J. The environmental benefits and costs of conservation tillage. Environmental Geology. 1999; 38(2):111-125.
51. Vijayalakshmi C, Radhakrishnan R, Nagarajan M, Rajendran C. Effect of solar radiation deficit on rice productivity. J of Agron. and Crop Sci. 1991; 167.184-187.
52. Virmani SS. Hybrid rice. Adv. Agronomy. 1996; 57:377-462.
53. Virmani SS, Mao CX, Hardy B. Hybrid rice for food security, poverty alleviation and environmental protection. *In*: Misra *et al.,* Proceedings of the 4th International Symposium on Hybrid Rice, Hanoi, Vietnam, 14-17 May 2002. Los Banos (Philippines): Int Rice Res Inst. 2003, 265-286.
54. Zheng C, Jiang Y, Chen C, Sun Y, Feng J, Deng A, *et al*. The impacts of conservation agriculture on crop yield in China depend on specific practices, crops and cropping regions. The Crop Journal. 2014; 2(5):289-296.