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Assessment of chlorophyll meter and green seeker optical sensor in relation to yield in different methods of rice establishment and nitrogen levels

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Abstract: Rice is central to the lives of billions of people around the world. Possibly the oldest domesticated grain (10,000 years), rice is the staple food for 2.5 billion people and growing rice is the largest single use of land for producing food, covering 9% of the earth's arable land.The study was made to understand the chlorophyll content (SPAD) and normalized difference vegetation index (NDVI) values of direct seeded (DSR) and transplanted rice (TPR) cultivation.The SPAD meter was significantly superior in variety JKPH 3333 with 125% RDN (Recommended dose of nitrogen) in both direct seeded (30.4) and transplanted rice (30.7) system at harvest. The NDVI readings at panicle initiation recorded highest in JKPH 3333 under transplanted rice (0.63) compared to direct seeded rice (0.60). Among varieties BPT-5204 and Gangavathisona at 90 DAS had relatively lower NDVI values in DSR (0.59)as compared to TPR (0.62). The relative water content at panicle initiation was more in JKPH 3333 (89.43%) at 125% RND compared to other varieties and planting methods. Among methods of planting at 125% dose of nitrogen TPR (56.29 q^{-1}ha) recorded highest yield compared to DSR (42.97 q ha^{-1}). At 75% and 100% nitrogen, yields were significantly lower (38.90 q ha^{-1} and 44.25q ha^{-1}) under DSR compared to TPR. The study suggest that the maintenance of greenness of canopy over longer period and chlorophyll content after panicle initiation had greater influence on yields under transplanted rice cultivation to that of direct seeded rice.The study also reveals that, itis important to maintain the critical amount of plant nitrogen throughout the vegetative and reproductive phases for better yields in direct seeded rice.

Key words: Direct seeded rice, Transplanted rice, Normalized difference vegetation index and SPAD

Introduction

Paddy rice (*Oryza sativa* L.) agriculture is one of major cropping systems in Asia (Xiao *et al.*, 2002). Direct-seeding methods have also played a critical role in the intensification of Asian rice systems. Rising cost of labour, rice farmers of Asia will have to deal with an anticipated increasing scarcity of irrigation water as the demand for water from the urban and industrial sectors expands. Direct-seeding methods, especially dry seeding, may help in achieving higher water-use efficiency.To limit expansion of cultivation to marginal areas with attendant deforestation and soil degradation, the increase in grain supply must come from productivity growth in existing cultivated land. Time series of vegetation indexes (VIs) such as Simple Ratio (SR), Normalized Difference Vegetation Index (NDVI) is traditionally derived from multitemporal coarse spatial resolution satellite data. These time series are widely used to monitor spatial and temporal dynamics of vegetation biophysical variables such as Leaf Area Index (LAI), fraction of absorbed photosynthetically active radiation (fAPAR) and pigment content photosynthetically active radiation (fAPAR) and pigment content (Feng*et al*., 2006). Multitemporal maps of these biophysical variables can be effectively used for different purposes, such as phenology and vegetation status monitoring (Fensholt, 2004) or to drive environmental models such as biogeochemical and yield forecasting models (Matsushita and Tamura, 2002).

Ramesh *et al*. (2002) found that the SPAD meter values at 79 days after sowing (DAS) of wet direct seeded rice correlated well with the grain yield. Using LCC and SPAD meter for applying N to wet DSR resulted in reduced application of fertilizer N and increased the N-use efficiency vis-a-vis blanket fixed-time N management schedules in northwestern India (Bijay-Singh *et al*., 2006). The normalized difference vegetation index (NDVI) as measured by an optical sensor is based on the reflectance at red and near infrared (NIR) regions and has the ability to predict yield potential of rice (Harrell *et al*., 2011) and maize (Baez-Gonzalez *et al.*, 2002; Teal *et al*., 2006). The yield prediction is reported to be improved when NDVI values were adjusted using cumulative growing degree days (CGDD) in wheat and sorghum (Raun*et al*., 2001; Moges *et al*., 2007). Sembiring*et al.*1998 used reflectance spectrometry and found that indices using wavelengths between 705 and 735 nm and between 535 and 545 nm were good predictors of biomass but not suitable to predict nitrogen and phosphorus concentration in wheat (Blackburn, 1998). Crop growth stage is important form easuringa plant attribute. Raun*et al.* (2001) reported that relationship between NDVIand grain yield of winter wheat was the highest between Feekes 4 and 6. Bijay-Singh *et al*. (2011) observed robust relationshipsbetweenin-seasonsensor-basedestimates of yield at Feekes 5–6 and Feekes 7–8 stages of spring wheat. Teal *et al.* (2006) could achieve a strong relationship between NDVI measured at the V8 growth stage and grain yield of maize. The objectives include study of SPAD and NDVI at critical stages of plant growth and how these biophysical parameters contribute to grain yields with varied N doses. The aim of the experiment is to study the bio-physical parameters under different methods of rice cultivation.

Materials and Methods

A field experiment was conducted during the *Kharif* season of 2013 at Main Agricultural ResearchStation, Raichurstate, India at 16° 12' N latitude and 77° 20' E longitude with an altitude of 389 meters above the mean sea level. Soil of the experimental fieldwas deep black soil with pH of 7.53, Electrical conductivity (EC) 0.3 ds/m, low in organic C (0.6%), available N (140 kg/ha), medium in available P (24 kg/ha) and K (312 kg/ha). Treatments consisting of 2 water managementpractices (Transplanted rice -M_1 and direct seeded rice - M_2) in main plots and the combinations of 3 varieties ['BPT-5204', 'Gangavathisona' and 'JKPH 3333'] and 3 nitrogendoses [75%, 100% and 125% RDN were tested in a factorial RCBD designand replicated thrice. Under aerobic method, the plotswere dry-ploughed and harrowed but not puddled duringland preparation. Seeds were sown at a spacing 20 cm × 10 cm in favourable soil moisture condition for germination.Thinning and gap filling was done at 15 days after sowing. Flash irrigations of 5 cm depth were given startingfrom 10 days after sowing, when the soil moisture tension at 15 cm depth reached –20 kPa. At the time of flowering,the threshold for irrigation was reduced to –10 kPa to preventspikelet sterility. Weeds were controlled by pre-emergenceapplication of pendimethalin @ 0.75 kg a.i./ha followedby pyrazosulfuron ethyl @ 30 g a.i./ha at 30 DAS and hand-weeding at 40 days after sowing. In the transplanted field, land preparation consisted of wettillage and puddling in standing water. Twenty five days old seedlings was used for transplanting. The recommended dose of fertilizer 150:75:75 kg NPK per ha was applied in the form of Urea, Diammonium phosphate (DAP) and Muriate of potash (MoP), respectively. Entire P, K and 25% N was applied as basal dose and later, remaining 50% was applied in two splits at 30 and 60 days interval as top dress in the band form 5 cm away from the plant with the depth of 4-5 cm. In the field of transplanted method 2 cm depth of strading water was maintained till physiological maturity. The N content in leaf, stem and grain was determined as per procedure of Bremner and Mulvaney (1982). The data were analyzed byusing the 'Analysis of Variance Technique' as per the proceduresdescribed by Panse and Sukhatme (1985). Thetreatment means were compared at 5% level of significance.

Results and Discussions

SPAD and NDVI values: The data on leaf SPAD values recorded at various growth stages are represented in table 1. The leaf SPAD values of rice differed significantly at harvest. Among different planting methods, significantly higher leaf SPAD values (39.0) was recorded in direct seeded rice (M_2) compared to that of transplanted rice M_1(37.0) at panicle initiation stage. The variation in chlorophyll content due to growth factor may be attributed to decreased chlorophyll degradation in different environmental conditions. This indicates interrelationships between leaf-N, leaf-chlorophyll, and photosynthetic activity at different crop establishment methods. Among different varieties JKPH 3333 recorded significantly higher SPAD values (30.8) followed by Gangavathisona (29.7) and BPT-5204 (27.3) under transplanted condition at harvest. And least was recorded in BPT-5204. In direct seeded rice JKPH 3333 recorded higher SPAD values (30.5) as compared to other varieties. With respective to different nitrogen levels 125% RDN recorded significantly maximum SPAD values (30.7) followed by 100% RDN (29.3) and 75% RDN (27.0) under transplanted condition as compared to direct seeded rice at 90 DAS. Higher N metabolism resulted in maintaining the greenness and postponing the senescence during the peak reproductive phase. The data on NDVI valuesrecorded at various growth stages is shown in Table 2. The NDVI valuesof rice differed significantly at 90 DAS. Significantly higher NDVI values(0.62) were recorded in transplanted rice as compared to direct seeded rice (0.59). With respective to different nitrogen levels 125% RDN recorded significantly maximum NDVI values (0.63) followed by 100% RDN (0.62) and 75% RDN (0.61) under transplanted condition as compared to direct seeded rice at 90 DAS. In transplanted rice, significantly higher NDVI valueswere recorded in JKPH 3333 with 125% RDN (0.68) at 90 DAS.The experimental results indicated that JKPH 3333 recorded highest NDVI values as compared to other varieties with nitrogen combinations. This was mainly due maintenance of greenness as the variety produced large number of leaves throughout the growth period with better nitrogen utilization. Similar observations were reported by Bijaysingh *et al.* (2011) they reported that fertilizer N and irrigation exhibit a strong interaction that had a greater impact on yield. However, at 30 and 60 DAS it was on par with JKPH 3333 with 100% RDN grown under transplanted condition. Whereas, in direct seeded rice, significantly higher NDVI values(0.61) was recorded in JKPH 3333 with 125% RDN followed by JKPH 3333 with100% (0.60) RDN at 90 DAS.The interaction was found non significant in both the planting methods in all growth stages. Theseresultsare in agreement with Harrell *et al*. (2011) who found that late sensing timings beyond panicle initiation of transplanted rice were impractical and reduced yield potential estimation as opposed to panicle initiation. The NDVI readings were superior to SPAD meter readings. GreenSeeker optical sensor uses reflectance at 656 and 774nm while the SPAD meter measures transmittance at 650 and 940 nm. Moreover, the GreenSeeker optical sensor averages readings from the entire surface area but SPAD meter measures one spot on a leaf. The relative water content of rice differed significantssly at panicle initiation. Among different planting methods, significantly higher relative water content (88.30%) was recorded in transplanted rice as compared to direct seeded rice (81.5%).Among different varieties JKPH 3333 recorded significantly higher relative water content (89.43%) followed by Gangavathisona (88.36%) and BPT-5204 (87.02) under

Table-1: SPAD chlorophyll value of rice as influenced by methods of planting and varieties with nitrogen levels

Treatments	30 DAS		60 DAS		90 DAS		Harvest	
	M_1	M_2	M_1	M_2	M_1	M_2	M_1	M_2
Planting methods (M)								
Mean	33.0	35.4	36.1	36.9	37.2	39.0	29.2	29.4
S.Em±	1.21		1.76		1.26		0.90	
C.D. at 5%	3.37		5.13		3.87		2.70	
Varieties (V)								
BPT-5204	31.2	33.6	34.3	35.3	35.3	37.6	27.3	28.2
Gangavathisona	33.2	36.0	36.3	37.0	37.7	39.3	29.7	29.5
JKPH 3333	34.6	36.7	37.6	38.4	38.8	40.2	30.8	30.5
S.Em±	0.03	0.43	0.21	0.26	0.42	0.06	0.42	0.42
C.D. at 5%	0.09	1.28	0.63	0.78	1.25	0.19	1.25	1.26
Nitrogen levels (N)								
75% RDN	31.5	34.2	34.6	35.7	35.7	37.6	27.7	28.2
100% RDN	33.3	35.3	36.4	36.7	37.3	38.9	29.3	29.5
125% RDN	34.2	36.9	37.3	38.4	38.7	40.5	30.7	30.4
S.Em±	0.03	0.43	0.21	0.26	0.42	0.06	0.42	0.42
C.D. at 5%	0.09	1.28	0.63	0.78	1.25	0.19	1.25	1.26
Interactions (V x N)								
S.Em±	0.05	0.74	0.36	0.45	0.72	0.11	0.72	0.73
C.D. at 5%	0.2	NS	NS	NS	NS	0.3	NS	NS

Table-2: NDVI value and Relative Water Content (RWC %) of rice as influenced by methods of planting and varieties with nitrogen levels

Treatments	30 DAS		60 DAS		90 DAS		RWC (%)	
	M_1	M_2	M_1	M_2	M_1	M_2	M_1	M_2
Planting methods (M)								
Mean	0.20	0.26	0.43	0.43	0.62	0.59	88.30	81.5
S.Em±	0.001		0.008		0.007		0.79	
C.D. at 5%	0.005		NS		NS		2.39	
Varieties (V)								
BPT-5204	0.21	0.26	0.40	0.41	0.60	0.58	87.02	79.65
Gangavathisona	0.19	0.25	0.43	0.43	0.62	0.59	88.36	82.37
JKPH 3333	0.21	0.29	0.46	0.44	0.65	0.61	89.43	82.41
S.Em±	0.03	0.03	0.01	0.01	0.02	0.02	0.34	0.41
C.D. at 5%	NS	0.01	NS	NS	0.01	NS	1.01	1.24
Nitrogen levels (N)								
75% RDN	0.20	0.24	0.42	0.42	0.61	0.58	87.41	79.64
100% RDN	0.20	0.26	0.42	0.43	0.62	0.59	88.38	81.81
125% RDN	0.21	0.30	0.44	0.44	0.63	0.60	89.02	82.98
S.Em±	NS	0.03	0.01	0.02	0.02	0.03	0.34	0.41
C.D. at 5%	0.02	0.01	NS	NS	NS	0.01	1.01	1.24
Interactions (V x N)								
S.Em±	0.01	0.01	0.01	0.01	0.01	0.01	0.59	0.71
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS

transplanted condition at harvest. Similar trend was observed in case of earlier growth stages. In direct seeded rice JKPH 3333 recorded higher relative water content (82.41%) as compared to other varieties. With respective to different nitrogen levels 125% RDN recorded significantly maximum relative water content (89.02%) followed by 100% RDN (88.38%) and 75% RDN (87.41%) under transplanted condition as compared to direct seeded rice at panicle initiation stage.

Yield and yield components: There was a significant interaction between establishment method and graded nitrogen levels.Grain yield and harvest index were significantly lower in direct seeded rice (Fig. 1). The yieldof rice differed significantly with different planting methods; significantly higher yield (56.29 q ha^{-1}) was recorded in transplanted rice as compared to that of direct seeded rice(42.97 q ha^{-1}). Among different varieties JKPH 3333 recorded significantly higher yield (60.98 q ha^{-1}) followed by Gangavathisona (55.45 q ha^{-1}) under transplanted condition at harvest. And least was recorded in BPT-5204 (52.44 q ha^{-1}). Similar trend was observed in case of direct seeded rice cultivation. In direct seeded rice JKPH 3333 recorded more yield (52.21 q ha^{-1}) as compared to other varieties. With respective to different nitrogen levels 125% RDN recorded significantly maximum yield(45.75 q ha^{-1}) followed by 100% RDN (44.25 q ha^{-1}) and 75% RDN (38.90 q ha^{-1}) under transplanted condition as compared to direct seeded rice at harvest.Direct seeded rice also offer potential water savings at the field level due to reduced evaporation losses, since there is no continuous pounding in field condition as compared to transplanted rice. There was a difference in water balance between direct seeded and transplanted rice ecosystems. The results were in confirmative with the results of Lafitte *et al*., 2002; Bouman*et al*., 2005; Peng*et al*., 2006. They reported that aerobic rice tends to yield less than flooded rice and yield reductions are dramatic due to soil water deficit, lower photosynthesis and higher respiration. The present experimental results showed strong effect of nitrogen levels that contributed to the yield levels. The interaction effect in transplanted rice, significantly higher grain yieldwas recorded with JKPH 3333 with 125% RDN (62.72 q ha^{-1}) followed by JKPH 3333 with 100% RDN (60.75 q ha^{-1}) and Gangavathisona with 125% RDN (63.86 q ha^{-1}). Whereas, in direct seeded rice, significantly higher yield(51.81 q ha^{-1}) was recorded in JKPH 3333 with 125% RDN followed by JKPH 3333 with 100% RDN (50.52 q ha^{-1}).It is well established that the infrastructure of plant is decided by morphological parameters coupled with more photosynthetic activity which lead to higher biomass production and also efficient partitioning of dry matter in to reproductive parts. Thus it requires clear understanding of variety including nitrogen levels and its suitability to each method of cultivation and varieties differing growth habit and duration behave differently under different situations. Among the different treatment combination tested JKPH 3333 with 125% RDN recorded higher grain yield compared to other varieties. This was due to the varietal response to nitrogen and higher total biomass production at all the growth stages compared to other two varieties.

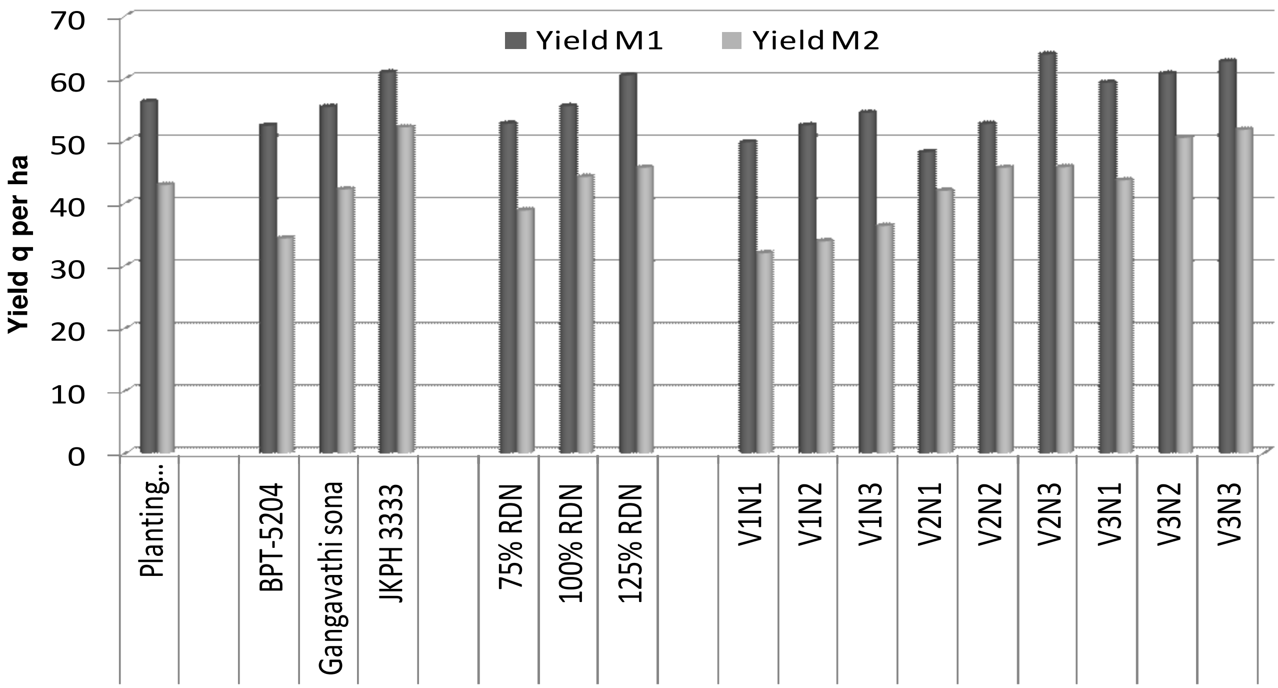

Fig. 1: Influence of different planting methods on yield q ha^{-1} with varieties and nitrogen levels

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References

Baez-Gonzalez, A.D., Chen, P., Tiscareno-Lopez, M. and Srinivasan, R., Using satellite and field data with crop growth modeling to monitor and estimate corn yield in Mexico. *Crop Sci*., **42:** 1943-1949 (2002).

Bijay-Singh, Gupta, R.K., Yadvinder Singh, Gupta, S.K., Jagmohan Singh, Bains, J.S. and Vashishta, M.: Need-based nitrogen management using leaf color chart in wet direct seed edrice in north western India. *J. New Seeds,* **8:** 35-47 (2006).

Bijay-Singh, Sharma, R.K., Jaspreet Kaur, Jat, M.L., Martin, K.L., Varinderpal Singh, Yadvinder Singh, Chandna, P., Choudhary, O.P., Gupta, R.K., Thind, H.S., Uppal, H.S., Jagmohan Singh, Khurana, H.S., Ajay Kumar, Uppal, R.K., Vashistha, M., Raun, W.R. and Gupta, R.K.: Assessmentofthenitrogenmanagementstrategy using anoptical sensor for irrigated wheat. *Agron. Sust. Dev*., **31:** 589-603 (2011).

Blackburn, G.A.: Spectral indices for estimating photosynthetic pigment concentrations: A test using senescence tree leaves. *Int. J. Remote Sens.,* **19:** 657-675 (1998).

Bouman, B.A.M., Peng, S., Castaneda, A.R. and Visperas, R.M.: Yield and water use of irrigated tropical aerobic rice systems. *Agricultural Water Management,* **74:** 87-105 (2005).

Bremner, J.M. and Mulvaney, C.S.: Methods of soil analysis. *ASA., Madison*, **2:** 595-624 (1982).

Fen sholt, R.: Earth observation of vegetation status in the Sahelian and Sudanian West Africa: Comparison of Terra MODIS and NOAA AVHRR satellite data. *International Journal of Remote Sensing*, **25:** 1641-1659 (2004).

Feng, D., Chen, J.M., Plummer, S., Mingzhen, C. and Pisek, J.: Algorithm for global leaf area index retrieval using satellite imagery. *IEEE Transactions on Geoscience and Remote Sensing*, **44:** 2219-2229 (2006).

Harrell, D.L., Tubana, B.S., Walker, T.S. and Phillips, S.B.: Estimating rice grain yield potential using normalized difference vegetation index. *Agron. J.,* **103:** 1717-1723 (2011).

Harrell, D.L.,Tubana, B.S., Walker, T.S. and Phillips, S.B.: Estimatingrice grain yield potential using normalized difference vegetation index. *Agron. J.,* **103:** 1717-1723 (2011).

Lafitte, H.R., Courtois, B. and Arraudeau, M.: Genetic improvement of rice in aerobic systems: progress from yield to genes. *Field Crops Res.,* **75:** 171-190 (2002).

Matsushita, B. and Tamura, M.: Integrating remotely sensed data with an ecosystem model to estimate net primary productivity in East Asia. Remote Sensing of Environment, **81:** 58-66 (2002).

Moges, S.M., Raun, W.R., Girma, K., Freman, K.W., Zhang, H., Arnall, D. B., Tubana, B., Teal, R., Holtz, S.L., Walsh, O. and Chung, B.: In season estimation of grain sorghum yield potential using a hand-held optical sensor. *Arch. Agron. Soil Sci.,* **53:** 617-628 (2007).

Panse, V.G. and Sukhatme, P.V.: Statistical Methods for Agricultural Workers, ICAR Publication, New Delhi, p. 167-174 (1985).

Peng, S., Bouman, B.M., Visperas, R.M., Castaneda, A., Nie, L. and Park, H.: Comparison between aerobic and flooded rice in the tropics: agronomic performance in an eight-season experiment. *Field Crops Res*., **96:** 252-259 (2006).

Ramesh, K., Chandrasekaran, B., Balasubramanian, T.N., Bangarusamy, U., Sivasamy, R. and Sankaran, N.: Chlorophyll dynamics in rice (*Oryza sativa*) before and after flowering based on SPAD (chlorophyll) meter monitoring and its relation with grain yield. *J. Agron. Crop Sci*., **188:** 102-105 (2002).

Raun, W.R., Solie, J.B., Johnson, G.V., Stone, M.L., Lukina, E.V., Thomason, E. and Schepers, J.S.: In-season prediction of potential grain yield in winter wheat using canopy reflectance. *Agron. J*., **93:** 131-138 (2001).

Sembiring, H., Raun, W.R., Johnson, G.V., Stone, M.L., Solie, J.B. and Phillips, S.B.: Detection of nitrogen and phosophorus nutrient status in winter wheat using spectral radiance. *J. Plant Nutr.,* **21:** 1207-1233 (1998).

Teal, R.K., Tubana, B.S., Girma, K., Fresseman, K.W., Arnall, D.B., Walsh, O. and Raun, W.R.: In-season prediction of corngrain yield potential using normalized difference vegetation index. *Agron. J.* **98:** 1488-1494 (2006).

Xiao, X.M., Boles, S., Frolking, S, Salas, W., Moore, B., Li C.S, He, L.H. and Zhao, R.: Observation of flooding and rice transplanting of paddy rice fields at the site to landscape scales in China using vegetation sensor data. *Int J. Remote. Sens,* **23:** 3009-3022 (2002).