Meta-Analysis Assessing Potential of Drone Remote Sensing in Estimating Plant Traits Related to Nitrogen Use Efficiency

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Category

Table S1. Regression models without moderator (Null) and with one moderator (Sensor Type, Crop, Signal Processing Technique, Growth Stage, R^2 Type, respectively) for Plant Height. Esti.: Estimated Coefficient; SE: Standard Error; Pr(>|t|): p-value; F: F-statistic; df: degrees of freedom; num: Numerator Degrees of Freedom; den: Denominator Degrees of Freedom; p: p-value; ICC: Intra-class Correlation Coefficient; $R^2_{(2)}$: proportion of the variance at the study level; $R^2_{(3)}$: proportion of the variance at the data set level; MS: Multispectral sensor; HSI: Hyperspectral sensor. Significance levels: ***p<0.001, **p<0.01, *p<0.05

Moderator	Regression Model Statistics			Anova Test			Variance of Effect		Heterogeneity Measures		
Null	Fixed Effects			F	df	p	Level 2	Level 3	ICC	$R^2_{(2)}$	$R^2_{(3)}$
	Esti.	SE	Pr(>|t|)		(num; den)		0.123	0.314	0.281		
	1.378	0.311	0.159								
Sensor Type				32.927	2; 6	0.001	0.104	0.314	0.248	0	0
RGB	1.74	0.456	0.005**								
RGB, MS	1.112	0.385	0.020*								
Crop				-	-	-	0.104	0.314	0.248	0	0
Rice	1.112	0.385	0.020*								
Winter Wheat	1.74	0.456	0.005**								
Signal Processing Technique				12.061	1; 6	0.013	0.574	0.073	0.887	0	0.502
Multivariate Non-linear	2.256	0.567	0.129								
Univariate	1.191	0.546	0.274								
Growth Stage				0.355	1; 6	0.573	0.559	0.08	0.874	0	0.452
All	2.247	0.564	0.126								
Late	1.148	0.544	0.276								
Medium	1.295	0.566	0.227								
R^2 Type				-	-	-	0	0.064	0	1	0.564
Calibration	0.648	0.126	0.000***								
Validation	1.735	0.103	0.000***								
Number of obs: 10		Number of studies: 2									

Table S2. Regression models without moderator (Null) and with one moderator (Sensor Type, Crop, Signal Processing Technique, Growth Stage, R^2 Type, respectively) for Grain Yield. Esti.: Estimated Coefficient; SE: Standard Error; Pr(>|t|): p-value; F: F-statistic; df: degrees of freedom; num: Numerator Degrees of Freedom; den: Denominator Degrees of Freedom; p: p-value; ICC: Intra-class Correlation Coefficient; $R^2_{(2)}$: proportion of the variance at the study level; $R^2_{(3)}$: proportion of the variance at the data set level; MS: Multispectral sensor; HSI: Hyperspectral sensor. Significance levels: ***p<0.001, **p<0.01, *p<0.05

Moderator	Regression Model Statistics			Anova Test			Variance of Effect		Heterogeneity Measures		
Null	Fixed Effects			F	df	p	Level 2	Level 3	ICC	$R^2_{(2)}$	$R^2_{(3)}$
	Esti.	SE	Pr(>|t|)		(num; den)		0.099	0.154	0.391		
	1.269	0.149	0.001***								
Sensor Type				59.187	8; 90	0	0.074	0.047	0.608	0	0.676
HSI	1.363	0.282	0.041*								
HSI, LiDAR	1.352	0. 2766	0.047*								
HSI,LiDAR,Thermal	1.342	0.282	0.042*								
LiDAR	0.509	0.277	0.218								
MS	1.201	0.165	0.017*								
RGB	1.267	0.183	0.005**								
RGB, MS	1.708	0.276	0.031*								
Thermal	0.415	0.282	0. 280								
Crop				0.474	1; 90	0.493	0.261	0.154	0.629	0	0
Barley	1.156	0.526	0.258								
Camelina	0.979	0.535	0.292								
Maize	1.339	0.365	0.170								
Winter Wheat	1.504	0.523	0.203								
Signal Processing Technique				3.606	1; 90	0.061	0.141	0.154	0.478	0	0
Multivariate Linear	1.504	0.392	0.054								
Multivariate Non-linear	1.336	0.271	0.040*								
Physically Based	1.117	0.133	0.000***								
Univariate	1.070	0.284	0.048*								
Growth Stage				6.962	1; 90	0.01	0.113	0.152	0.426	0	0
All	1.071	0.258	0.046*								
Early	1.043	0.297	0.028*								
Late	1.289	0.251	0.039*								
Medium	1.708	0.348	0.047*								
R^2 Type				5.376	1; 90	0.023	0.103	0.153	0.403	0	0
Calibration	1.356	0.169	0.000 ***								
Validation	1.246	0.153	0.000 ***								
Number of obs: 102		Number of studies: 5									

Table S3. Regression models without moderator (Null) and with one moderator (Sensor Type, Crop, Signal Processing Technique, Growth Stage, R^2 Type, respectively) for Leaf Area Index. Esti.: Estimated Coefficient; SE: Standard Error; Pr(>|t|): p-value; F: F-statistic; df: degrees of freedom; num: Numerator Degrees of Freedom; den: Denominator Degrees of Freedom; p: p-value; ICC: Intra-class Correlation Coefficient; $R^2_{(2)}$: proportion of the variance at the study level; $R^2_{(3)}$: proportion of the variance at the data set level; MS: Multispectral sensor; HSI: Hyperspectral sensor. Significance levels: ***p<0.001, **p<0.01, *p<0.05

| Moderator	Regression Model Statistics			Anova Test			Variance of Effect		Heterogeneity Measures		
Null	Fixed Effects			F	df	p	Level 2	Level 3	ICC	$R^2_{(2)}$	$R^2_{(3)}$
	Esti.	SE	Pr(>|t|)		(num; den)		0.111	0.069	0.617		
	1.448	0.175	0.006**								
Sensor Type				116.97	4; 43	0	0.098	0.069	0.586	0	0.528
HSI	1.398	0.334	0.000***								
MS	1.314	0.315	0.000***								
RGB	2.039	0.347	0.000***								
RGB, MS	1.226	0.328	0.000***								
Crop				1.221	3; 43	0.314	0.204	0.071	0.742	0	0.515
Canola	1.714	0.408	0.004**								
Canola, Soybean, and Winter Wheat	1.785	0.362	0.005**								
Rice	1.226	0.463	0.144								
Soybean	1.800	0.408	0. 003**								
Winter Wheat	1.500	0.279	0.037*								
Signal Processing Technique				79.45	1; 43	0	0.424	0.041	0.912	0	0.721
Multivariate Non-linear	2.056	0.342	0.007**								
Univariate	1.178	0.333	0.040*								
Growth Stage				2.071	2; 43	0.14	0.131	0.068	0.658	0	0.534
All	1.538	0.194	0.005**								
Late	1.459	0.196	0.005**								
Medium	1.392	0.200	0.004**								
R^2 Type				30.101	1; 43	0	0.127	0.068	0.651	0	0.534
Calibration	1.540	0.193	0.004**								
Validation	1.452	0.188	0.006**								
Number of obs: 54		Number of studies: 4									
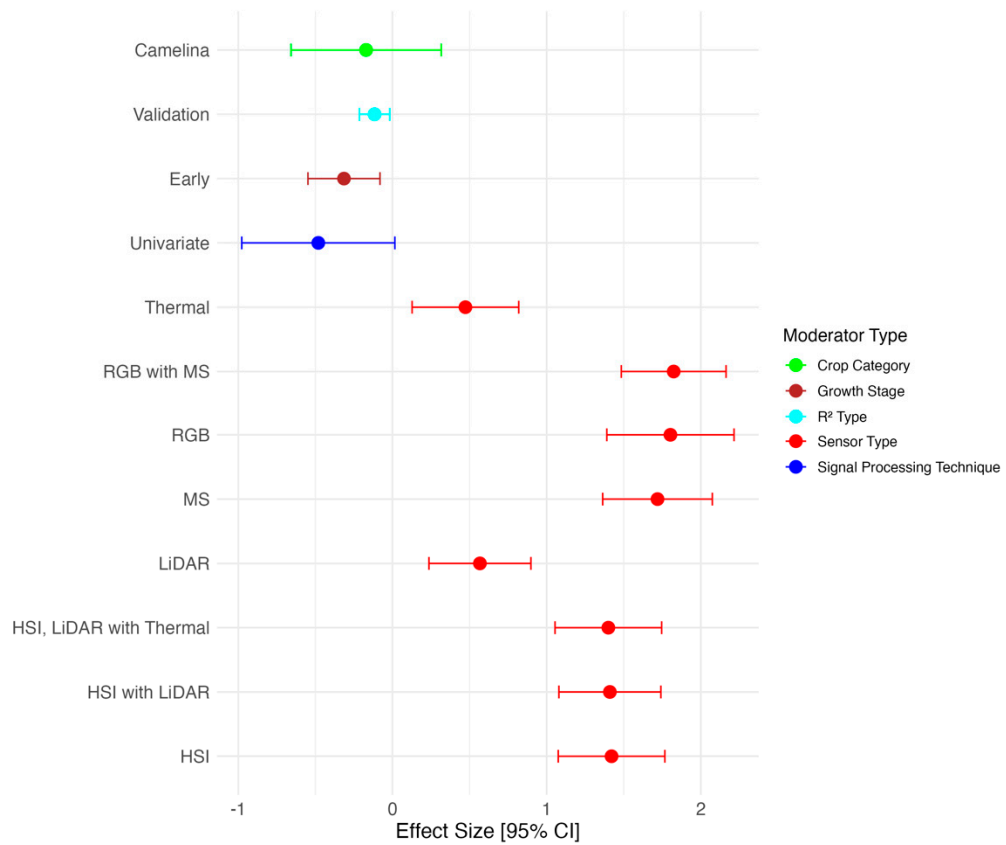
Figure S1. Observed Fisher's Z effect sizes with their 95% confidence interval for Grain Yield. HSI: Hyperspectral sensors; MS: Multispectral sensor; LiDAR: Light Detection and Ranging.
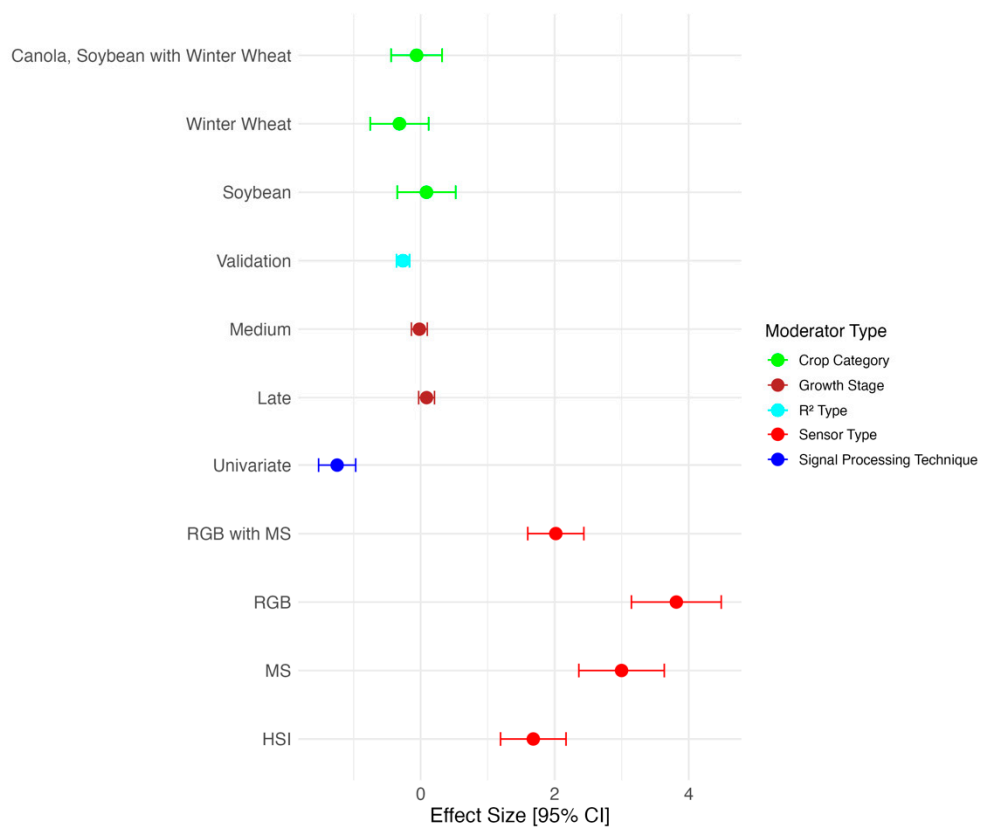
Figure S2. Observed Fisher's Z effect sizes with their 95% confidence interval for Leaf Area Index. HSI: Hyperspectral sensors; MS: Multispectral sensors. LiDAR: Light Detection and Ranging.
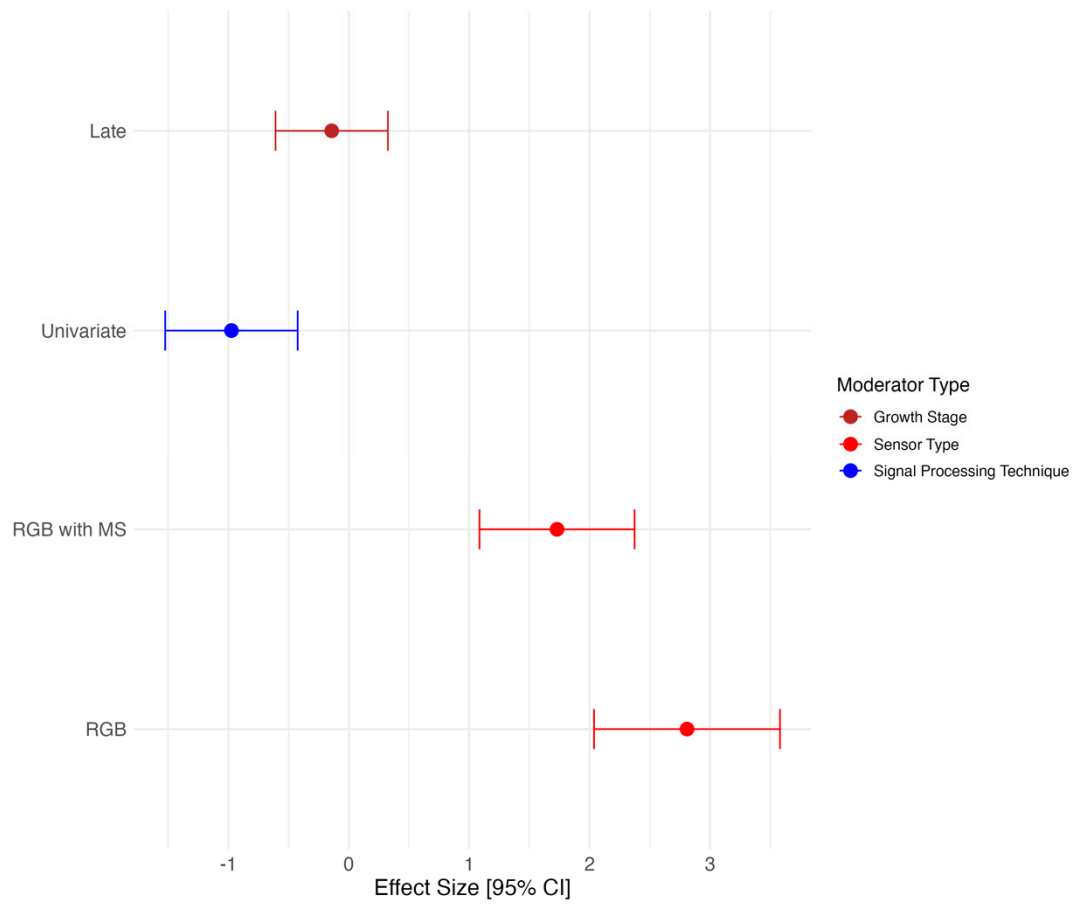
Figure S3. Observed Fisher's Z effect sizes with their 95% confidence interval for Plant Height.
HSI: Hyperspectral sensors; MS: Multispectral sensors; LiDAR: Light Detection and Ranging.