Research Article

Nano Urea formulations for more wheat yield evaluated by AMMI and BLUP effects of treatments under irrigated conditions at North Western Plains Zone and Central Zone

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ABSTRACT

AMMI analysis of wheat yield for nano urea formulations treatments had observed highly significant variations due to treatments, locations, and TxL interactions with 44.6%, 33.5%, and 12.8% respectively. Thousands of grains weight of treatments observed that the first AMMI interaction component contributed for to 78.9% whereas AMMI2, AMMI3, AMMI4 accounted for 10.2%, 3.5%, 2.3% respectively. AMMI analysis analysis-based measures ASV & ASV1 has have utilized 73.4% of interaction sum of squares and T6, T8, T5 recommended by ASV1 whereas ASV pointed for T6, T8, T5 treatments for wheat yield. Measures MASV1 and MASV based on all significant IPCAs of the AMMI analysis for thousands grains weight and considered 94.9% of interactions sum of squares had recommended T6, T5, T11 and T6, T8, T7 treatments for stable performance respectively. Superiority index measures had considered 65% and 35% of ratios of average value and stable performance in weighted average observed suitability of T8, T3, T6 treatments for wheat yield. Analytic adaptability measures based on BLUP of treatments effects settled for T3, T4, T7 treatments as far as thousands of grains weight was considered in the present study. Biplot analysis observed a very tight positive relationship of ASV with ASV1, W1 , W2, W3, W4, W5, W6, WAASB , MASV with MASV1 values. Analytic measures PRVG , HMPRVG expressed strong bondage with BLUE and BLUP effects of treatments for wheat yield. Clustering The clustering pattern for thousands of grains weight had expressed first consisted of superiority indexes corresponding to mean, GAI, HM of treatments effects irrespective of BLUE and BLUP estimates joined hands in the first cluster and next cluster was of analytic measures PRVG, HMPRVG for treatments effects irrespective of BLUE and BLUP estimates with IPC1 measures in the present study. Recent analytic measures for adaptability and superior performance of treatments would be more suitable for large large-scale recommendations.

Keywords: *AMMI, Association analysis, BLUP, Superiority index, WAASB*

INTRODUCTION

Wheat (Triticumaestivum L.) has been established as one of the most important cereal crops at the world level [1]. Green The green revolution of the country had observed the a very good response of dwarf wheat genotypes towards the inorganic fertilizers [2]. Owing to the growing awareness of the harmful effects of fertilizers, the last decade has witnessed extensive research into biofertilizers, microbiomes, and soil health [3]. More over the applied fertilizers has have showed shown the reduced fertilizers use efficiency through the mechanism of leaching and dnitrificationetc [4]. In the last decade, nanotechnology as a novel technology has solved many problems in different fields of science and industry and it has found its position and functions in agriculture [5],[6]. Nano fertilizers are the most important part of nanotechnology in the production phase of agriculture to increase the efficiency of nitrogen fertilizers , reduce the amount of nitrogen fertilizer applied without affecting production, and reducing the risks of environmental pollution on soil and water [7],[8]. Foliar application of nano-fertilizers significantly increased the yield of the crop [9]. Application of nano fertilizers instead of common fertilizers, nutrients are provided to plants gradually and in a controlled manner [10]. The current study was carried out to find out the possible advantages of nano urea formulations treatments with conventional use of urea fertilizer on wheat yield by evaluation under multi multi-location trails trials during the last year.

METHODS AND MATERIALS

The thirteen treatments based on nano urea formulations were evaluated at fifteen major locations viz. Delhi, Gurdaspur, Gwalior, Hisar, Jammu, Karnal, Ludhiana, Pantnagar, Bilaspur, Durgapura, Indore, Jabalpur, Junagadh, Powarkheda, and Vijapur during 2021-22 cropping season to evaluate yield and thousands grains weight wheat genotype by optimizing the nitrogen dose and nano urea formulations under irrigated conditions. The recommended agronomical interventions were followed after thorough ploughing and field layering. One One-third of nitrogen along with full phosphorus and potash as basal dose as per treatments and the remaining 2/3rd nitrogen as 1/3rd at first irrigation and 1/3rd at second irrigation wherever required as per treatment. Well Well-labelled plots were of gross size of 1.80 m x 8 m = 14.40 sq. m. (9 rows at 20 cm spacing). Quantity The quantity of Nano urea will be 4 ml /litre

of water. Quantity The quantity to spray solution will be 400 litre of water/ha. Harvest of net plot size 1.40 m x 7 m = 9.80 sq. m. (7 inner rows x 7 m long) were analysed analyzed statistically by AMMI soft and SAS 9.3 version software's. A number of AMMI and BLUP measures [11] are mentioned below for ready reference and details about treatments and locations in table 1.

$$ASV = [(\frac{SSIPC\ 1}{SSIPC\ 2}PCI)^2 + (PC2)^2]^{1/2} \quad | \quad ASV1 = [\frac{SSIPC\ 1}{SSIPC\ 2}(PCI)^2 + (PC2)^2]^{1/2}$$

Modified AMMI stability
Value

$$MASV = \sqrt{\sum_{n=1}^{N-1} \frac{SSIPC_n}{SSIPC_{n+1}}(PC_n)^2 + (PC_{n+1})^2}$$

$$MASV1 = \sqrt{\sum_{n=1}^{N-1} (\frac{SSIPC_n}{SSIPC_{n+1}}PC_n)^2 + (PC_{n+1})^2}$$

$$HM = \text{Number of environments} / \sum_{j=1}^{k} \frac{1}{GV_{ij}}$$

GV_{ij} genetic value of ith genotype in jth environments

Relative performance of genotypic values across environments
Harmonic mean of Relative performance of genotypic values
Geometric Adaptability Index

$$RPGV_{ij} = \sum GV_{ij} / \sum GV_j$$

$$HMRPGV_{i.} = \text{Number of environments} / \sum_{j=1}^{k} \frac{1}{RPGV_{ij}}$$

$$GAI = \sqrt[n]{\prod_{k=1}^{n} \overline{X}_k}$$

The stability measure as a weighted Average of Absolute Scores has been defined [12] as

$$WAASB = \sum_{k=1}^{p} |IPCA_{ik} \times EP_k| / \sum_{k=1}^{p} EP_k$$

whereWAASBiwas the weighted average of absolute scores of the ith genotype; IPCAikwas the score of the ith genotype (or environment) in the kth IPCA, and EPkwas the amount of the variance explained by the kth IPCA. Superiority A superiority index has been devised that allowed weights between yield and WAASB as

$$\text{index SI} = \frac{(rG_i \times \theta_Y) + (rW_i \times \theta_S)}{(\theta_Y + \theta_S)}$$

where Giand Wiwere the rescaled values for yield and, respectively. The superiority index had weighted between yield and stable performance of treatments to be of 65% and 35% respectively.

Results and discussion

Analysis of Variance Yield

AMMI analysis observed highly significant variations due to treatments, locations, and TxL interactions with 44.6%, 33.5%, and 12.8% respectively (Table 2). First The first interaction component contributed for 46% whereas AMMI2, AMMI3, AMMI4 accounted for 27.4%, 12.8%, 5.2% respectively of TxL interactions effects [13]. The total contributions of significant components were 90.3% while the first two significant components accounted for 73.4% of significant interaction effects. The sums of squares for signal and noise were 74.4% and 25.6% of total T×L respectively. More over the sum of squares for the signal was 0.27 times and the noise was 0.07 times the treatments main effects.

Thousands grains weight

Highly significant variations due to locations, TxL interactions and treatments wereobservedby were observed by AMMI analysis, with 83.6%, 8.3% and 1.6% respectivecontributions (Table 2). AMMI1 contributed for 78.9% whereas AMMI2, AMMI3, AMMI4 accounted for 10.2%, 3.5%, 2.3% respectively of TxL interactions effects. The total contributions of significant components were 94.9% while the first two significant components accounted for 89.1% of significant interaction effects. About 70.5% and 29.5% of total T×L were accounted by signal and noise. More over the 3.77 and 1.58 times of treatments' main effects were expressed by signal and noisenoise in the current study.

Performance of treatments as per AMMI AMMI-based measures Yield

Minimum values of IPCA-1 pointed by T6, T5, T8as per IPCA-2, T2, T8, and T3 treatments would be of choice (Table 3). Values of IPCA-3 favored T10, T13, T2 treatments. As per IPCA-4, T7, T1, T8 would be of stable performance. Values of IPCA-5 settled for T13,T5,T3 while as per IPCA-6 treatments T4, T13,T2 and lastly IPCA-7 pointed for T10,T9,T13 [11]. First The first two IPCAs in ASV & ASV1 measures utilized 73.4% of T×L interaction sum of squares. ASV1 measures recommended (T6, T8, T5) and ASV pointed towards (T6, T8, T5) as of stable performance. Adaptability measures MASV and MASV1 considered all significant IPCAs of the AMMI analysis and used 90.3% of TxL interactions sum of squares. Values of MASV1 identified T8, T12, T5 treatments would express stable performance whereas T8, T12, T5 be of stable performance by MASV respectively. Higher mean values were found for T3 , T4, T2 treatments for more yield. More values of GAI showed by T3, T4, T2 along with higher values of HM measured by same treatments. T8,T3,T6 treatments pointed by superiority indexes SiMe, SiGe, SiHMe based on average value and stable performance in 65 and 35 ratios. Analytic measures PRVG and HMPRVG settled for T3, T4, T2 treatments.

Thousands grains weight

T6, T5, T11 pointed by IPCA-1 values and T2, T8, T3 treatments by as per IPCA-2 (Table 6). IPCA-3 favored T3, T2, T8 treatments while IPCA-4, T11, T2, T6would be of stable performance. Values of IPCA-5 settled for T9,T1,T5 while as per IPCA-6 treatments T8, T11,T4 and lastly IPCA-7 pointed for T2,T1,T9. First two IPCAs in ASV & ASV1 measures utilized 89.1% of T×L interaction sum of squares. ASV1 measures recommended (T6, T5, T11) and ASV pointed towards (T6, T5, T11) as of stable performance. Adaptability measures MASV and MASV1 considered all significant IPCAs of the AMMI analysis and used 94.9% of TxL interactions sum of squares. Values of MASV1 identified T6, T5, T11 treatments would express stable performance whereas T6, T8, T7 be of stable performance by MASV respectively. Higher mean values were found for T3 , T4, T8 treatments for more values. More values of GAI showed by T3, T4, T8 along with higher values of HM measured by same treatments. T8,T6,T7 treatments pointed by superiority indexes SiMe, SiGe, SiHMe based on average value and stable performance in 65 and 35 ratios. Analytic measures PRVG and HMPRVG settled for T3, T4, T8 treatments.

Superiority index measures: Weighted average of yield and stable performance Yield

Values of W1 based on first IPCA pointed for T6, T7, T8, and W2

pointed for T6, T8, T5 while as per W3 the T8, T6, T5 would be desirable while W3 pointed for T8,T6,T5 and W4 for T8,T6,T5 whereas by W5 and W6 treatments T8,T6,T5 would be desirable and lastly WAASB considered all IPCA found T8, T6, T5 for maximum yield among the treatments (Table 4). Average values based on BLUP of treatments observed higher values for T3, T4, T2 while large values of GAIu and HMu measures were expressed by T3, T4, T2 treatments [14]. SiMu Index found the utility of T8, T3, T6 considering the average value and stable performance in 65 and 35 ratios, while the index based on GAI and WAASB observed suitability of T8, T3, T6 whereas index considering HM and WAASB settled for T8, T3, T6 treatments. PRVGu and HMPRVGu settled for T3, T4, T2 treatments.

Thousands grains weight

Values of W1 pointed for T6, T5, T11 and W2 pointed for T6, T5, T11 while as per W3 the T6, T5, T11 would be desirable while W4, W5 and W6 pointed for T5,T6, T11 treatments and lastly WAASB found T6, T5, T11 treatments (Table 7). Average values based on BLUP of treatments observed higher values for T3, T4, T2 while Large values of GAIu and HMu measures were expressed by T3, T4, T2 treatments. SiMu Index found utility of T7, T3, T6 considering the average value and stable performance in 65 and 35 ratios, while index based on GAI and WAASB observed suitability of T7, T3, T6 whereas index considering HM and WAASB settled for T7, T3, T6 treatments. PRVGu and HMPRVGu settled for T3, T4, T7 treatments.

Cluster pattern of measures and treatments as per Biplot analysis Yield

The first two significant principal components among set of BLUE, BLUP and AMMI based measures had explained about 82.7% of the total variations considered for this study in biplot analysis (Table 5) with respective contributions of 68.0% & 14.6% by respective components. Measures SiMu ,SiHu, SiGuSiMe, SiGe, SiHe, HMPRVG, HMPRVGu, accounted for more of the share in first principal component whereas W1, ASV1, IPC4, IPC1, WAASB,W5, W6, were major contributors in PC2. In terms of treatment combinations T13, T8 , T6 and T3, T4, T2 were large contributors for the first and second principal components in biplot analysis.

Treatments that assembled together near to the biplot origin T10, T11, T7 indicated identical responses to all the tested locations as compared to the treatments that were positioned away i.e. T13, T3, T8. Moreover, treatments that were placed apart for biplot origin were more sensitive to environmental interaction related to closely positioned genotypes to biplot origin. Very tight positive relationship was observed for ASV with, ASV1, W1 , W2, W3, W4, W5, W6, WAASB measures as also of MASV with MASV1 values. Analytic measures PRVG , HMPRVG expressed strong bondage with BLUE and BLUP effects of treatments and lastly superiority indexes exhibited very tight association association-based mean, GAI, HM, values. IPC5 expressed straight line association with IPC6. Similar nature was expressed by IPC3 with MASV with MASV1 measures (Figure 1). Right angle of IPC6 observed with superiority indexes ASV, ASV1, and W1 measure exhibited ninety ninety-degree angles with values of IPC1.

Six clusters among the considered measures have been observed based on first two principal components cumulated cumulating about 82.7% of total variation (Figure 2). Measures IPC3 clubbed with IPC5 for form first cluster, while IPC2 formed a group with MASV, MASV1 measures besides cluster of W1, W2, W3, W4, W5, W6, WAASB, ASV, ASV1 values and next was of IPC4 with IPC6 measures. IPC1 measure along with analytic measures PRVG, HMPRVG for treatments effects irrespective of BLUE and BLUP estimates placed in fourth quadrant of biplot analysis .Superiority indexes corresponding to mean, GAI, HM of treatments effects irrespective of BLUE and BLUP estimates formed the last cluster on the considered measures in the present study.

Thousands grains weight

About 83.3% of the total variations among considered measures by first two significant principal components with respective contributions of 58.7% & 24.7% by respective components thousands grains weight in biplot analysis (Table 5). More of the share of SiMu ,SiHu, SiGuSiMe, SiGe, SiHe, MASV, HM Measures accounted in first principal component whereas W1, ASV1, ASV, WAASB, W2, W3, W4, W5, W6, were major contributors in PC2. In terms of treatment combinations T13, T9 , T6 and T3, T4, T11 were large contributors for the first and second principal components in biplot analysis.

Treatments observed near to the biplot origin T1, T2, T7 were supposed more or less the same response to all the tested locations as compared to the treatments T13, T3, T4 that were positioned away (Figure 4). Superiority indexes exhibited very tight association among themselves irrespective of BLUE and BLUP of treatments effects for thousands grains weight of the present study. Analytic measures PRVG , HMPRVG expressed strong bondage with BLUE and BLUP effects of treatments. Very tight positive relationship observed for ASV with, ASV1, W1 , W2, W3, W4, W5, W6, WAASB MASV, MASV1 values. IPC5 expressed straight line association with IPC5, IPC3 values. Right angles had expressed by AMMI based measures with Analytic measures PRVG , HMPRVG whereas superiority index measures for evaluated nano urea formulations treatments showed with IPC6 value.. Straight line angle expressed by MASV with IPC3 value while IPC6 with IPC4 measure. Latli IPC2 value had exhibited one hundred eighty angles with superiority index measures considered BLUE and BLUP of treatments effects.

Four clusters among the considered measures have been observed as first consisted of superiority indexes corresponding to mean, GAI, HM of treatments effects irrespective of BLUE and BLUP estimates and next cluster of analytic measures PRVG, HMPRVG for treatments effects irrespective of BLUE and BLUP estimates with IPC1 measures in the present study (Figure 5). Next quadrant observed MASV, MASV1 W1, W2, W3, W4, W5, W6, WAASB, ASV, ASV1 values. IPC3 measure along with IPC4, IPC5 placed in fourth quadrant of biplotanalysis biplot analysis.

Multivariate analysis as per BLUE and BLUP effects of treatments Yield

Treatment T13 had placed in separate and last place while treatments T1, T2,T3,T4,T9,T10, T11 were observed in the first cluster while the remaining T5,T6,T7,T8,T12 formed another group based on multivariate hierarchical clustering of treatment effects as per Ward's method in the current study (Figure 3). Studied measures had expressed different kind of relationship among themselves as four groups with respective memberships was were observed in 5,12, 6,11. Interaction principal components form a group of IPC3, IPC4, IPC5, IPC6, IPC7 and next group consisted of W1, W2, W3, W4, W5, W6, WAASB, ASV, ASV1, MASV, MASV1, IPC2 values.

Thousands grains weight

Figure 6 displayed the treatments T3 & T4 had placed in between of T9, T10, T13 on the left side T1, T2, T5, T6, T7, T8, T11, T12 on right right-hand side in multivariate hierarchical clustering of the treatment effects as per Ward's method. Studied measures had expressed four groups with respective memberships was observed in 12, 6, 6, 12 . MASV1 observed as point of separation off AMMI AMMI-based Interaction principal components form a group of W1, W2, W3, W4, W5, W6, WAASB, ASV, ASV1, MASV values while the other largest cluster consisted of IPC2, IPC3, IPC4, IPC5, IPC6, IPC7, Superiority index measures along with adaptability measures while considering BLUE effects. At the second node W1, ASV, MASV showed differentiation from ASV1, WAASB, W6 values.

Conclusions

AMMI analysis of wheat yield and thousands grains weight had observed highly significant variations due to treatments, locations and TxL interactions during the evaluation of nano urea formulations treatments. AMMI analysis analysis-based measures ASV1& ASV has recommended T6, T8, T5, and for T6, T8, T5 treatments for wheat yield. Measures MASV1 and MASV based on all significant IPCAs of the AMMI analysis for thousands of grains weight recommended T6, T5, T11 and T6, T8, T7 treatments for stable performance respectively. Superiority index measures had considered weighted average and stable performance observed suitability of T8, T3, T6 treatments for wheat yield. Analytic adaptability measures based on BLUP of treatments effects settled for T3, T4, T7 treatments as far as thousands of grains weight was considered in the present study. Biplot analysis observed very tight positive relationship of ASV with ASV1, W1 , W2, W3, W4, W5, W6, WAASB , MASV with MASV1 values. Analytic measures PRVG , HMPRVG expressed strong bondage with BLUE and BLUP effects of treatments for wheat yield. Clustering The clustering pattern for thousands of grains weight had expressed first consisted of superiority indexes corresponding to mean, GAI, HM of treatments effects irrespective of BLUE and BLUP estimates joined hands in the first cluster and the next cluster was of analytic measures PRVG, HMPRVG for treatments effects irrespective of BLUE and BLUP estimates with IPC1 measures in the present study.

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Table 1: Description of Nano urea formulations and location details of the study

Code	Treatment Details	Code	Locations	Code	Locations
T 1	Rec. N doses (1/3rd basal, 1/3rd CRI, 1/3rd tillering Rec. N) + water spray at tillering& jointing	L 1	Gwalior	L 14	Delhi
T 2	Rec. N + one spray of nano urea at tillering	L 2	Hisar	L 15	Gurdaspur
T 3	Rec. N + two spray of nano urea at tillering& jointing	L 3	Jammu		
T 4	Rec. N + two spray of urea (5%) at tillering& jointing	L 4	Karnal		
T 5	75% N + water spray at tillering& jointing	L 5	Ludhiana		
T 6	75% N + one spray of nano urea at tillering	L 6	Pantnagar		
T 7	75% N + two spray of nano urea at tillering& jointing	L 7	Bilaspur		
T 8	75% N + two spray of 5% urea at tillering& jointing	L 8	Durgapura		
T 9	50% N + water spray at tillering& jointing	L 9	Indore		
T 10	50% N + one spray of nano urea at tillering	L 10	Jabalpur		
T 11	50% N + two spray of nano urea at tillering& jointing	L 11	Junagadh		
T 12	50% N + Two spray of 5% urea at tillering& jointing	L 12	Powarkheda		
T 13	Control (without N only)	L 13	Vijapur		

Table2: AMMI analysis of Yield and thousands grains weight for Nano urea formulations treatments evaluated Multi location trials

Source of variations	Degree of freedom	Mean Sum of Squares		% share of factors		Tx L interaction Sum of Squares (%)		Cumulative Sum of Squares (%) by IPCA's	
		Yield	Thousands grains weight	Yield	Thousands grains weight	Yield	Thousands grains weight	Yield	Thousands grains weight
Treatments (T)	12	1621.50	28.82	44.63	1.56				
Locations (L)	14	1042.16	1325.52	33.46	83.61				
T x L interactions	168	33.25	11.00	12.81	8.33				
IPC1	25	102.77	58.38			46.00	78.99	46.00	78.99
IPC2	23	66.55	8.16			27.40	10.15	73.40	89.14
IPC3	21	31.26	3.08			11.75	3.50	85.15	92.64

IPC4	19	15.19	2.27			5.17	2.34	90.32	94.97
IPC5	17	9.87	1.79						
IPC6	15	9.71	1.79						
IPC7	13	8.03	1.38						
Residual	35	3.51	0.51						
Error	390	10.17	3.70						
Total	584	74.66	38.00						

Table 3: Adaptability and stability measures for Nano treatments formulations based on AMMI analysis

Code	IPC1	IPC2	IPC3	IPC4	IPC5	IPC6	IPC7	ASV1	ASV	MASV	MASV1	Mean	GAI	HM	SIMe	SIGe	SIHe
T 1	1.951	-0.156	-0.660	-0.092	-1.297	-0.488	0.920	3.28	2.53	4.37	3.60	49.00	48.60	48.19	78.70	78.90	79.11
T 2	2.080	0.700	0.233	-0.572	-0.828	0.046	-0.541	3.56	2.78	4.34	3.43	50.70	50.34	49.96	80.48	80.64	80.79
T 3	1.853	0.491	0.978	0.193	-0.223	1.177	-0.760	3.15	2.45	4.70	3.72	52.15	51.78	51.38	85.55	85.55	85.55
T 4	1.479	1.213	-1.345	1.925	1.135	-0.011	0.491	2.76	2.27	6.68	5.25	51.17	50.87	50.56	79.40	79.68	79.99
T 5	0.407	-0.503	-0.634	-1.287	0.186	0.206	0.895	0.85	0.73	3.48	2.81	45.96	45.56	45.13	80.34	80.79	81.20
T 6	0.072	-0.590	1.236	-0.680	0.436	-0.971	0.437	0.60	0.60	4.11	3.21	46.99	46.65	46.29	84.26	84.76	85.26
T 7	-0.183	-0.995	2.101	0.075	1.062	0.812	0.618	1.04	1.02	6.22	4.71	48.44	48.09	47.72	83.31	83.69	84.04
T 8	0.413	0.285	0.210	0.135	0.549	-1.020	-1.293	0.75	0.61	2.60	2.36	48.28	48.03	47.76	89.23	89.86	90.50
T 9	-1.040	-1.261	-2.174	-0.751	0.470	1.014	-0.350	2.15	1.85	6.95	5.21	41.69	41.24	40.78	55.52	56.19	56.85
T 10	-1.639	-1.594	0.146	1.295	-0.644	-0.680	0.257	3.18	2.65	5.75	4.43	43.20	42.77	42.31	57.64	58.21	58.78
T 11	-1.963	-0.714	0.267	0.856	-1.123	0.694	-0.359	3.37	2.64	4.69	3.79	44.55	44.11	43.65	63.18	63.64	64.08
T 12	-0.809	-0.579	-0.545	-0.637	0.442	-0.825	-0.673	1.48	1.20	3.22	2.61	44.95	44.66	44.37	74.29	75.12	75.97
T 13	-2.620	3.703	0.187	-0.458	-0.167	0.045	0.355	5.75	5.02	10.43	7.62	28.82	27.73	26.60	0.00	0.00	0.00

Table 4: Superiority Index measures for Nano treatments formulations based on BLUE and BLUP effects

Code	PRVG	HMPRVG	W 1	W 2	W 3	W 4	W 5	W 6	WAASB	Meanu	GAIu	Hmu	SIMu	SIGu	SIHu	PRVGu	HMPRVGu
T 1	1.069	1.065	1.95	1.25	1.15	1.08	1.09	1.06	1.06	48.82	48.43	48.02	78.75	78.96	79.16	1.065	1.061
T 2	1.107	1.103	2.08	1.54	1.33	1.28	1.26	1.21	1.22	50.39	50.04	49.67	80.49	80.66	80.82	1.101	1.097
T 3	1.139	1.135	1.85	1.32	1.26	1.19	1.15	1.15	1.16	51.74	51.38	50.99	85.55	85.55	85.55	1.130	1.126
T 4	1.120	1.114	1.48	1.37	1.37	1.41	1.40	1.34	1.34	50.84	50.56	50.26	79.45	79.75	80.10	1.113	1.107
T 5	1.001	0.999	0.41	0.44	0.47	0.53	0.52	0.50	0.53	45.96	45.57	45.14	80.32	80.78	81.19	1.001	1.000
T 6	1.025	1.023	0.07	0.28	0.43	0.44	0.44	0.46	0.47	46.89	46.55	46.20	84.13	84.66	85.18	1.023	1.021
T 7	1.058	1.054	0.18	0.50	0.75	0.70	0.72	0.72	0.74	48.25	47.92	47.56	83.22	83.63	84.00	1.053	1.051
T 8	1.055	1.054	0.41	0.36	0.34	0.32	0.33	0.36	0.40	48.10	47.85	47.58	89.12	89.77	90.43	1.051	1.050
T 9	0.908	0.903	1.04	1.13	1.29	1.25	1.22	1.21	1.21	41.97	41.54	41.08	55.49	56.19	56.85	0.914	0.910
T 10	0.942	0.936	1.64	1.62	1.39	1.38	1.35	1.32	1.32	43.36	42.93	42.49	57.52	58.11	58.71	0.945	0.940
T 11	0.971	0.966	1.96	1.47	1.28	1.25	1.25	1.23	1.22	44.60	44.18	43.73	63.03	63.52	63.97	0.972	0.967
T 12	0.981	0.980	0.81	0.72	0.69	0.69	0.68	0.68	0.70	44.98	44.70	44.41	74.17	75.03	75.89	0.982	0.981
T 13	0.625	0.590	2.62	3.05	2.60	2.45	2.35	2.25	2.24	29.98	28.93	27.83	0.00	0.00	0.00	0.650	0.618

Table 5: Loadings of measures and treatments for first two principal components

Measures	Principal Component 1	Principal Component 2	Principal Component 1	Principal Component 2
	Yield		Thousands grains weight	
IPC1	-0.140	0.234	-0.174	-0.184
IPC2	0.123	0.126	0.047	0.012
IPC3	-0.035	-0.025	-0.084	0.117
IPC4	-0.001	0.247	-0.015	0.136
IPC5	-0.046	-0.177	-0.010	0.056
IPC6	0.030	0.159	0.045	-0.157

IPC7	0.033	-0.013	-0.004	-0.019
MASV	0.177	0.074	0.174	-0.218
MASV1	0.176	0.090	0.184	-0.190
ASV1	0.163	0.262	0.168	-0.227
ASV	0.175	0.233	0.170	-0.224
W 1	0.131	0.313	0.168	-0.228
W 2	0.183	0.205	0.172	-0.220
W 3	0.184	0.207	0.173	-0.219
W 4	0.183	0.209	0.172	-0.219
W 5	0.181	0.215	0.173	-0.219
W 6	0.182	0.214	0.173	-0.219
WAASB	0.182	0.214	0.173	-0.218
Mean	-0.191	0.178	-0.178	-0.207
SIMe	-0.207	0.041	-0.221	-0.046
GAI	-0.191	0.173	-0.183	-0.193
SIGe	-0.207	0.038	-0.222	-0.032
HM	-0.192	0.169	-0.188	-0.179
SIHe	-0.207	0.034	-0.222	-0.019
PRVG	-0.190	0.179	-0.177	-0.205
HMPRVG	-0.193	0.168	-0.189	-0.180
Meanu	-0.190	0.179	-0.179	-0.202
SIMu	-0.207	0.042	-0.220	-0.051
GAIu	-0.191	0.174	-0.184	-0.192
SIGu	-0.207	0.038	-0.221	-0.041
Hmu	-0.192	0.170	-0.188	-0.182
SIHu	-0.207	0.035	-0.222	-0.032
PRVGu	-0.190	0.180	-0.178	-0.204
HMPRVGu	-0.192	0.168	-0.189	-0.180
% share of variation	68.03%	14.64%(82.67%)	58.66%	24.65% (83.31%)
T 1	-0.078	0.249	-0.051	0.025
T 2	-0.092	0.383	-0.110	-0.193
T 3	-0.150	0.421	-0.157	-0.573
T 4	-0.075	0.417	-0.036	-0.503
T 5	-0.151	-0.321	-0.133	0.351
T 6	-0.199	-0.347	-0.273	0.257
T 7	-0.161	-0.125	-0.245	0.009
T 8	-0.260	-0.258	-0.256	0.008
T 9	0.154	-0.172	0.450	-0.145
T 10	0.145	0.028	0.225	0.164
T 11	0.094	0.101	-0.118	0.278
T 12	-0.087	-0.297	0.014	0.247
T 13	0.860	-0.079	0.689	0.075

Table 6: Adaptability and stability measures for Nano treatments formulations based on AMMI analysis

Code	IPC1	IPC2	IPC3	IPC4	IPC5	IPC6	IPC7	MASV1	MASV	ASV1	ASV	Mean	GAI	HM	SIMe	SIGe	SIHe
T 1	0.927	-0.839	-0.568	1.179	0.066	-0.586	0.055	8.06	3.80	7.26	2.72	40.83	40.44	40.07	57.90	59.68	61.19
T 2	1.223	0.271	-0.066	0.200	-0.395	0.416	-0.009	9.61	3.58	9.52	3.42	41.31	40.86	40.43	66.33	66.28	66.08
T 3	1.789	-0.342	0.067	-0.607	-0.224	0.626	0.169	14.05	5.23	13.93	5.00	42.09	41.69	41.31	75.18	75.18	75.18
T 4	1.843	0.986	-0.754	-0.575	0.573	0.100	-0.242	14.78	5.76	14.37	5.23	41.58	41.10	40.63	61.41	60.52	59.32
T 5	-0.075	0.403	-0.533	-0.470	0.108	-1.134	-0.185	2.77	2.28	0.71	0.45	40.38	40.01	39.65	61.10	63.66	65.76
T 6	-0.017	-0.296	0.754	0.220	-0.173	-0.132	-0.175	1.73	1.42	0.32	0.30	41.08	40.71	40.35	77.79	79.56	81.06
T 7	0.626	0.090	0.675	0.250	-0.287	-0.279	0.122	5.09	2.18	4.87	1.75	41.36	40.97	40.59	75.81	76.85	77.67

T 8	0.477	-0.514	0.151	-0.242	-0.857	-0.026	0.261	4.27	2.15	3.75	1.43	41.46	41.09	40.74	79.48	80.82	82.00
T 9	-2.180	-1.700	-0.687	-0.661	0.047	0.187	-0.092	17.83	7.11	17.04	6.31	40.20	39.80	39.42	25.40	27.56	29.55
T 10	-1.295	0.647	0.514	-0.264	0.488	-0.192	1.156	10.42	4.18	10.10	3.67	39.98	39.58	39.21	34.60	37.34	39.58
T 11	-0.337	-0.259	1.179	-0.105	0.732	0.043	-0.800	3.73	2.54	2.63	0.97	40.57	40.22	39.88	61.46	64.32	66.72
T 12	-0.627	0.090	-0.464	0.837	0.671	0.752	0.176	5.44	2.78	4.88	1.75	40.27	39.87	39.49	51.13	53.34	55.26
T 13	-2.354	1.462	-0.268	0.237	-0.749	0.224	-0.435	18.91	7.30	18.38	6.73	39.13	38.56	38.03	0.00	0.00	0.00

Table 7: Superiority Index measures for Nano treatments formulations based on BLUE and BLUP effects

Code	PRVG	HMPRVG	W 1	W 2	W 3	W 4	W 5	W 6	WAASB	Meanu	GAIu	Hmu	SIMu	SIGu	SIHu	PRVGu	HMPRVGu
T 1	1.001	1.000	0.93	0.92	0.90	0.91	0.89	0.88	0.87	40.89	40.49	40.11	59.97	61.19	62.20	1.002	1.002
T 2	1.012	1.010	1.22	1.11	1.06	1.03	1.02	1.00	0.99	41.26	40.86	40.46	69.09	69.62	70.04	1.011	1.010
T 3	1.033	1.030	1.79	1.61	1.54	1.51	1.48	1.46	1.44	41.74	41.33	40.93	75.18	75.18	75.18	1.024	1.022
T 4	1.019	1.015	1.84	1.74	1.69	1.66	1.63	1.60	1.57	41.61	41.21	40.80	68.87	69.01	69.03	1.021	1.018
T 5	0.990	0.990	0.07	0.11	0.13	0.14	0.14	0.17	0.17	40.62	40.27	39.93	64.62	67.40	69.89	0.996	0.996
T 6	1.007	1.007	0.02	0.05	0.08	0.09	0.09	0.09	0.09	40.88	40.50	40.13	73.96	75.53	76.96	1.002	1.002
T 7	1.014	1.013	0.63	0.56	0.57	0.56	0.55	0.54	0.53	41.22	40.84	40.47	76.03	77.29	78.44	1.011	1.010
T 8	1.017	1.016	0.48	0.48	0.47	0.46	0.47	0.46	0.46	41.10	40.72	40.36	73.74	75.44	76.95	1.008	1.007
T 9	0.988	0.981	2.18	2.12	2.06	2.01	1.97	1.92	1.89	40.00	39.57	39.17	14.27	15.30	16.33	0.981	0.977
T 10	0.980	0.978	1.30	1.22	1.18	1.16	1.14	1.12	1.12	40.17	39.80	39.45	33.66	36.13	38.35	0.985	0.984
T 11	0.995	0.995	0.34	0.33	0.36	0.36	0.37	0.36	0.37	40.64	40.26	39.90	61.71	63.57	65.28	0.996	0.996
T 12	0.987	0.986	0.63	0.56	0.56	0.57	0.57	0.57	0.57	40.50	40.10	39.74	53.66	55.30	56.87	0.992	0.992
T 13	0.957	0.951	2.35	2.25	2.16	2.10	2.06	2.02	1.99	39.59	39.11	38.67	0.00	0.00	0.00	0.970	0.965

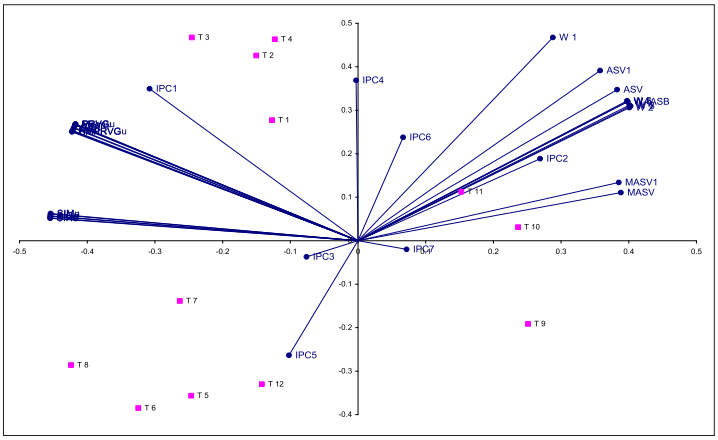

Figure 1: Biplot analysis of Nano treatments and adaptability measures for wheat yield

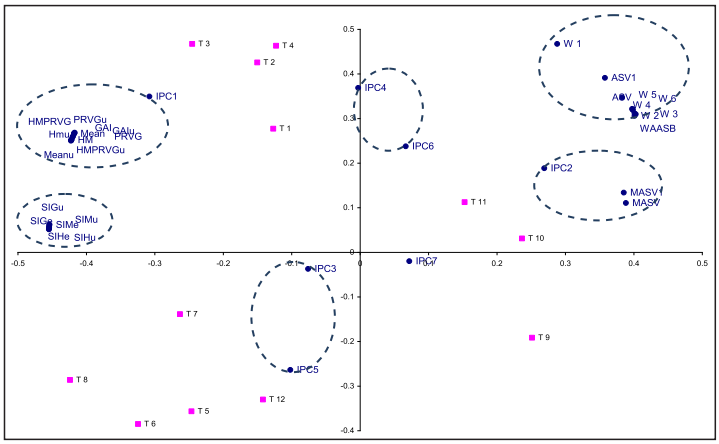

Figure 2: Clustering pattern amongconsidered measures and nano urea formulations treatments

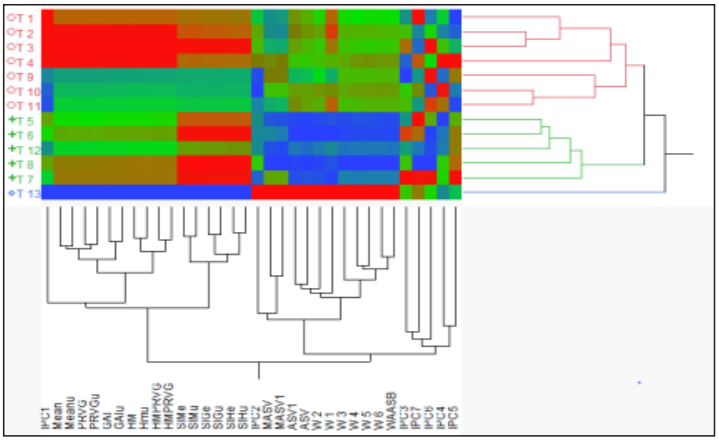

Figure 3: Multivariate hierarchical clustering as per Ward's method of treatments vis-a-vis adaptability measures for wheat yield

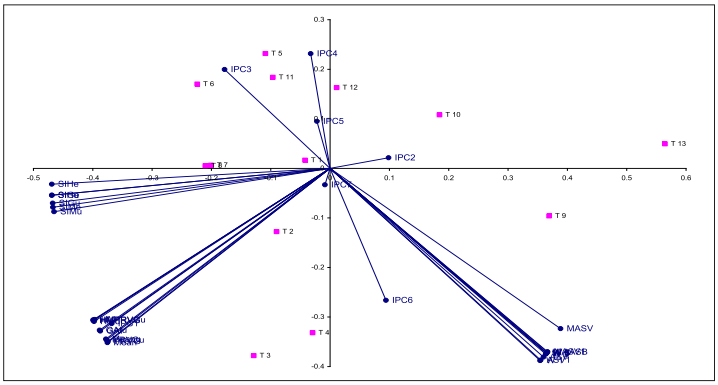

Figure 4: Biplot analysis of Nano urea formulations treatments and adaptability measures for thousands grains weight

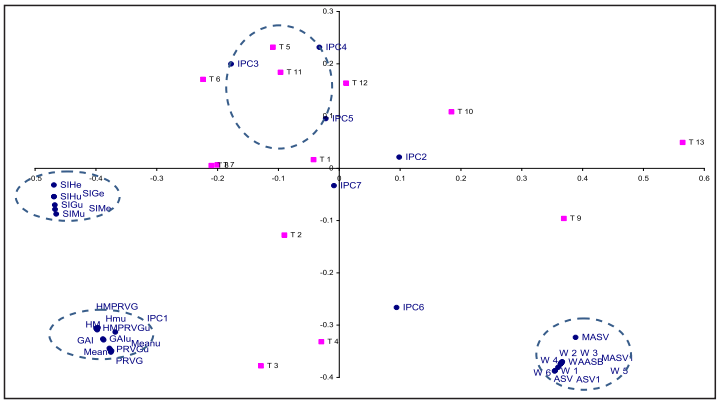

Figure 5: Clustering pattern amongconsidered measures and nano urea formulations treatments

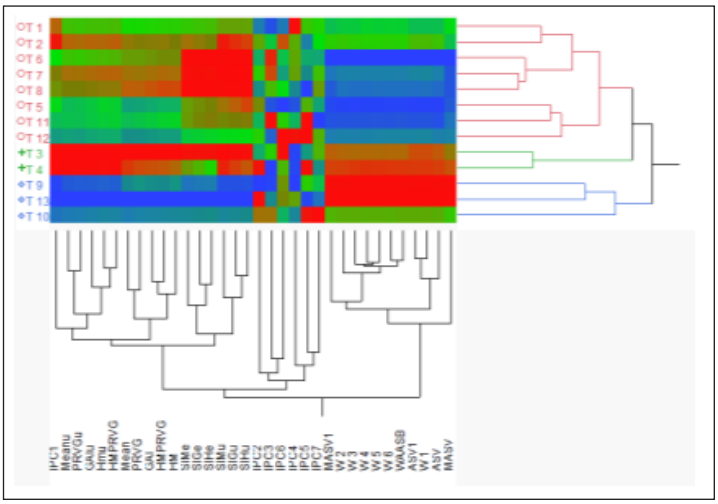

Figure 6: Multivariate hierarchical clustering as per Ward's method of treatments vis-a-vis adaptability measures for thousands grains weight

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