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Combined effects of drought stress and NPK foliar sprays on growth, nutrient uptake and yield in wheat

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Abstract
Wheat can be grown under irrigated and limited irrigation conditions in India. To study the response of NPK foliar sprays on wheat under water stress condition especially for newly released wheat variety NIAW 1415 (*Netravati*), a field experiment for three years (2013-14 to 2015-16) was conducted at Agricultural Research Station, Niphad, Dist. Nashik, Maharashtra. The main treatments were comprised of different irrigation levels i.e. one irrigation at Tillering stage (40-42 days after sowing (DAS), two irrigations at Crown Root Initiation and Boot stage (20-22 and 60-65 DAS) and three irrigations at Crown Root Initiation, Tillering and Boot stage (20-22, 40-42 and 60-65 DAS). The sub treatments were absolute control, recommended dose of fertilizer (RDF), RDF + 3 water sprays, 75% of RDF + 3 NPK foliar sprays (19:19:19 N:P_2O_5:K_2O) and 100% of RDF + 3 NPK sprays. The results of three years experimentation revealed that, irrigating the wheat variety NIAW 1415 (*Netravati*) with three irrigations at 20-22, 40-42 and 60-65 DAS along with 100% of RDF + 3 NPK sprays produced significantly higher grain (40.53 q ha^{-1}) and straw (61.45 q ha^{-1}) yields over rest of the treatments. Soil nutritional status was also improved due to different nutrient management treatments over initial status of experimentation.

Keywords: wheat, niaw 1415, irrigation, RDF and foliar sprays

Introduction
In India, wheat is second most important cereal crop after rice. In Maharashtra it occupies second position next to sorghum. It is cultivated on an area of about 9.19 lakh ha with the total production of 15.09 lakh metric tons having the average productivity of 1641 kg/ha as against the national productivity of 3318 kg ha^{-1} (Anonymous, 2018) [1].

Drought stress is one of the factors among abiotic stresses that drastically affect crop production around the globe (Shahbaz *et al*., 2011) [8]. Exposure to drought stress poses serious challenges for the survival of plants, because it results in impaired germination and seedling growth (Ashraf *et al*., 2006) [3] and affects plant growth (Xu *et al.*, 2007) [12], and reduced harvestable yield of plants (Nawaz *et al.*, 2012) [11].

Foliar application of nitrogen has more effect on yield and yield components of wheat because it is more effective as minimum losses involved in foliar spray. (Sud *et al*., 1990) [9]. Foliar application gives guarantee for the availability of nutrients to crops for obtaining higher yield. (Arif *et al*, 2006) [2].

In many agricultural production systems, phosphorus (P) has been identified as the most deficient essential nutrient after nitrogen (N). Nutrient inputs into production systems have increased as a result of the need for high yielding crops to sustain the growing population around the world. Phosphorus originates from the weathering of soil minerals and other stable soil geologic materials and exists in both inorganic and organic forms of which the inorganic fraction is dominant. (Mosali *et al*., 2006) [6].

Potassium is free to travel and to wheel and deal within the plant almost at well. It should not be surprising that a shortage of potassium can result in loss of crop yield, quality and profitability. Foliar spray of potassium in combination with nitrogen and some micro-nutrients like zinc had significant effect on grain yield of wheat (Eman and Mogied, 1998).

Materials and Methods
A field experiment on wheat (cv. NIAW 1415) with irrigation levels and fertilizer management including foliar nutrient sprays was conducted at Agricultural Research Station, Niphad, Dist.

Nasik (MS) during *rabi* 2013-14 to 2015-16 after soybean (*kharif*) as a general crop. The soil of the experimental site was clayey in texture having pH 8.02, EC 0.52 dSm^{-1}, medium in organic carbon (0.42), low in nitrogen (189 kg ha^{-1}), low in phosphorous (11.59 kg ha^{-1}) and high in potassium (458 kg ha^{-1}). The experiment was laid in split plot design with three irrigation levels (one irrigation at Tillering stage (40-42 days after sowing (DAS), two irrigations at Crown Root Initiation and Boot stage (20-22 and 60-65 DAS) and three irrigations at Crown Root Initiation, Tillering and Boot stage (20-22, 40-42 and 60-65 DAS) as main treatments and five fertilizer levels (Absolute control, Recommended Dose of Fertilizer (RDF), RDF+ 3 Water Sprays, 75% RDF+ 3 NPK sprays and 100% RDF + 3 NPK sprays as sub treatments and replicated three times. Three sprayings of 19:19:19 foliar grade fertilizer @ 2 per cent were given at tillering stage (40-45 days after sowing), boot stage (60-65 DAS) and grain filling stage (80-85 DAS).

Results and Discussion

Irrigation levels

The data from Table 1 revealed that irrigating the wheat crop (cv NIAW 1415) at 20-22, 40-42, 60-65 DAS (A_3) produced significantly higher grain (39.68 q ha^{-1}) and straw (61.74 q ha^{-1}) yields with higher thousand grain weight (41.77 g). The wheat variety NIAW 1415 (Netravati) is released in Peninsular Zone mainly for limited irrigation condition. Shabbir *et al* (2015) [7] reported that limited water supply significantly reduced germination, growth and uptake of N, P and K. Supplemental foliar fertilization of these macronutrients alone or in different combinations significantly improved the water relations, gas exchange characteristics and nutrient contents in both the genotypes.

Fertilizer levels

Regarding fertilizer application, 100% RDF + 3 NPK sprays (B_5) produced significantly higher grain (40.53 q ha^{-1}) and straw (61.45 q ha^{-1}) yields with higher thousand grain weight (43.00 g) over rest of the treatments. However, the interaction effect was non-significant. Emam and Borjian (2000) [5] reported that wheat cultivars responded differently to the rate of foliar N feeding so that, over the growth stages, Marvdasht cultivar produced significantly greater grain yield (+19%) by application of 8 kg N ha^{-1}, whereas, the Phalat cultivar had greater grain yield (+27%) when it was supplied by 16 kg N ha^{-1}. Increase in grain yield was mainly due to an increase in number of grains per ear. The fertile ears m^{-2} and mean grain weight were not significantly affected by foliar urea feeding, however, the harvest index and biological yield were increased. The pre-anthesis foliar feeding with urea resulted in higher yields as compared with later applications. Also the early foliar urea feeding increased the harvest index from 42.4 to 46.9 per cent at 32 kg N ha^{-1} in Marvdasht cultivar.

Soil analysis data after harvest of wheat (Table 2) revealed that, there were no significant changes in pH, organic carbon and available phosphorous due to different irrigation levels. The nitrogen and potassium content were influenced due to irrigation levels. Higher values of nitrogen and potassium were observed in the one irrigation treatment over rest of irrigation treatments. While in sub plot treatments, significantly higher values of nitrogen and potassium were observed due to application of recommended dose of fertilizers. Narimani *et al* (2010) [10] reported that all fertilizer treatments imposed positive effects on spike length and kernel protein content, but Zn had highest positive effect on them (13.4% and 9.6% compared to check, respectively). All fertilizer treatments imposed positive effects on test weight, but Cu had highest positive effect on it (6.1% compared to check).

Table 1: Wheat grain, straw yield and thousand grain weight

Treatments	Yield (q ha^{-1})		'000' grain wt (g)
A) Irrigation levels (Main Plot)	**Grain**	**Straw**	
1. One irrigation (40-45 DAS)	30.41	46.52	39.46
2. Two irrigations (20-22, 60-65 DAS)	35.67	52.12	40.70
3. Three irrigations (20-22, 40-42 and 60-65 DAS)	39.68	61.74	41.77
SE±	0.32	0.81	0.31
CD at 5%	1.30	3.29	1.26
B) Fertilizers (Sub Plot)			
1.Control	25.36	37.59	37.87
2.GRDF	37.33	56.28	40.61
3. GRDF+ 3 Water Sprays	38.19	57.65	41.00
4. 75% GRDF+ 3 NPK sprays	34.86	54.05	40.72
5. 100% GRDF+ 3 NPK sprays	40.53	61.45	43.00
SE±	0.39	1.14	0.58
CD at 5%	1.15	3.37	1.73
C) Interaction A X B			
SE±	0.72	1.83	0.70
CD at 5%	NS	NS	NS

Table 2: Soil nutrient status after harvest of wheat

Treatments	pH	EC (dSm^{-1})	OC (%)	N (kg ha^{-1})	P	K
A) Irrigation levels (Main Plot)						
Initial nutrient status (start of expt)	8.44	0.43	0.55	200.04	19.40	346.33
1. One irrigation (40-45 DAS)	8.47	0.37	0.55	204.51	19.55	338.93
2. Two irrigations (20-22, 60-65 DAS)	8.49	0.38	0.53	192.10	19.67	340.33
3. Three irrigations (20-22, 40-42 and 60-65 DAS)	0.03	0.008	0.003	1.79	0.25	0.33
SE±	0.01	0.031	0.011	7.21	NS	1.30
CD at 5%						

B) Fertilizers (Sub Plot)						
1.Control	8.44	0.36	0.53	168.37	14.73	296.67
2.GRDF	8.45	0.40	0.52	209.13	19.91	365.33
3. GRDF+ 3 Water Sprays	8.51	0.42	0.53	208.96	22.60	371.22
4. 75% GRDF+ 3 NPK sprays	8.45	0.42	0.57	208.42	22.66	355.22
5. 100% GRDF+ 3 NPK sprays	8.49	0.36	0.56	199.54	17.81	320.89
SE+	0.03	0.013	0.007	5.60	0.95	8.92
CD at 5%	NS	0.039	0.02	16.45	2.78	26.72
Interaction A X B						
SE+	0.007	0.017	0.006	4.00	0.56	0.72
CD at 5%	0.14	0.07	NS	NS	NS	NS

Table 3: Nutrient uptake by wheat crop

Treatments	N	P	K
	(kg ha^{-1})		
A) Irrigation levels (Main Plot)			
1. One irrigation (40-45 DAS)	103.94	28.45	121.86
2. Two irrigations (20-25, 60-65 DAS)	118.40	30.58	135.91
3. Three irrigations (20-25, 40-45 and 60-65 DAS)	140.23	33.83	164.14
SE+	2.71	1.46	1.63
CD at 5%	10.95	NS	6.57
B) Fertilizers (Sub Plot)			
1.Control	61.72	16.90	109.87
2.GRDF	125.22	24.57	130.79
3. GRDF+ 3 Water Sprays	132.78	33.17	145.89
4. 75% GRDF+ 3 NPK sprays	138.12	39.26	149.13
5. 100% GRDF+ 3 NPK sprays	146.43	40.85	167.50
SE+	3.63	1.77	2.79
CD at 5%	10.67	5.21	1.18
C) Interaction A X B			
SE+	6.07	3.27	3.64
CD at 5%	NS	NS	NS

Table 4: Economics of wheat cultivation

Treatments	Cost of cultivation (Rs ha^{-1})	Gross monitory returns (Rs ha^{-1})	Net monitory returns (Rs ha^{-1})	B:C ratio
A) Irrigation levels (Main Plot)				
1. One irrigation (40-45 DAS)	44127	55906	11779	1.26
2. Two irrigations (20-25, 60-65 DAS)	45713	65630	19917	1.43
3. Three irrigations (20-25, 40-45 and 60-65 DAS)	47274	73111	25837	1.54
SE+	-	-	123	0.02
CD at 5%	-	-	498	0.07
B) Fertilizers (Sub Plot)				
1.Control	41508	46497	4989	1.12
2.GRDF	46777	68707	21930	1.46
3. GRDF+ 3 Water Sprays	47177	70316	23139	1.48
4. 75% GRDF+ 3 NPK sprays	45724	64242	18518	1.40
5. 100% GRDF+ 3 NPK sprays	47338	74651	27313	1.57
SE+	-	-	315	0.02
CD at 5%	-	-	925	0.06
C) Interaction A X B				
SE+	-	-	276	0.04
CD at 5%	-	-	NS	NS

Conclusion

The response of irrigation and NPK foliar sprays -i.e. three irrigations at 20-22, 40-42 and 60-65 DAS along with recommended dose of fertilizers (120:60:40 N:P_2O_5:K_2O kg ha^{-1} + FYM @ 10 t ha^{-1}) and 3 NPK sprays of 19:19:19 foliar grade fertilizer @ 2 per cent at tillering (40-45 DAS), boot (60-65 DAS) and grain filling stage (80-85 DAS) recommended for higher yield of newly released wheat variety NIAW 1415 (Netravati) under water stress condition.

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