Original Research Article

Growth and Production of Wheat (*Triticum aestivum* L.) as Influenced by Levels and Methods of N P K Fertilizer Application in Arid Region of Rajasthan

ABSTRACT

A field experiment was conducted at Instructional Farm, Swami Keshwanand Rajasthan Agricultural University, Bikaner during *rabi* season of 2019-20 on Growth and Production of Wheat (*Triticum aestivum* L.) as Influenced by Levels and Methods of N P K Fertilizer Application in Arid Region of Rajasthan. The experiment was laid out with 20 treatment combinations comprising in a split plot design and replicated three times. The results revealed that 100% recommended dose of fertilizer (RDF) resulted in significantly higher growth and yield attributes as well as grain and straw yield over all other fertility levels. Application of 100% RDF recorded significantly maximum gross and net profit (₹ 108568 ha^{-1} and ₹ 76682 ha^{-1}) with B:C ratio of 2.40 over the other applied treatments. Maximum growth and yield attributes as well as grain and straw yield were recorded under three foliar spray of soluble N: P: K over rest of treatments but remained statistically at par with four foliar spray. Gross and net return was highly influenced with foliar fertilization as three and four foliar spray and these accrued significantly higher gross & net returns (₹ 98116 ha^{-1} & ₹ 67326 ha^{-1} and ₹ 99923 ha^{-1} & ₹ 68257 ha^{-1}) with B: C ratio of 2.16 and 2.13, respectively in comparison to rest levels of foliar fertilization.

Key words: Economics, Fertility level, Foliar fertilization, RDF, Wheat and Yield

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is the second most important grain crop in India (ref) and the most important in the world (ref). It is worldwide staple food grain crop, so wheat is called as "King of cereals" (ref). In term of area and production India has second position in the world. In India, wheat is cultivated in 29.58 million hectare with total production of 99.70 million tons, with average yield of 5090 kg ha^{-1} in 2018-19 (GOI 2018-19).

Comment [KYAG1]: The title could be more simple

Comment [KYAG2]: ???

Comment [KYAG3]: Combination of which treatment?

Can you provide a range of different fertilizer concentrations used?

Comment [KYAG4]: What are the others treatments?

Comment [KYAG5]: How did you test this difference?

Comment [KYAG6]: These are estimated values or post-market gains?

Comment [KYAG7]: What is the B:C ratio?

Comment [KYAG8]: What are these attributes?

Comment [KYAG9]: Rephrase this part in two sentences

Comment [KYAG10]: ????

Comment [KYAG11]: Please specify the botanical family of the species

Comment [KYAG12]: Can you provide bibliographic references in this part.
You can follow the following links:

https://doi.org/10.3389/fpls.2015.01017
https://www.phytojournal.com/archives?year=2015&vol=4&issue=3&ArticleId=648
https://doi.org/10.20546/ijcmas.2019.802.375

Comment [KYAG13]: Please rephrase this sentence and provide bibliographic reference. It's grammatically incorrect.
You can rephrase as: "In terms of crops surface area and national production, India is the second largest in the world"

Comment [KYAG14]: Same here.
Please rephrase the sentence. You can rephrase as: "In India, the total wheat crop area was estimated to be 29.58 million hectares in 2018-19, with a national production of 99.70 million tons, and an average yield of 5090 kg ha-1 (GOI 2018-19)".

-It contains starch (60-90 per cent), protein (11-16.5 per cent), fat (1.5-2 per cent), inorganic ions (1.2-2 per cent) and vitamins (B-complex and vitamin E) (Ayala *et al.* 2011). There are number of constraints responsible for reducing wheat productivity, *i.e.* including biotic and abiotic factors. Among abiotic factors, nutrient management is the major constraint for limiting the productivity of wheat (ref). Therefore, to increase crop yields, it is important to adopt proper nutrient management so for increased the yield adopt proper nutrient management. In this way, Ooptimal fertilizer management is necessary to maintain sustainable yields, improve nutrient use efficiency of fertilizers and save fertilizer resources (Chuan *et al.,* 2016).

-There are known several types of fertilizer applications. One of the methods is drilling of fertilizers over the soil surface (Finck, 1982). Another method is a foliar fertilization, also known as foliar feeding.–It is a technique of feeding plants by applying liquid fertilizers directly on the leaves or the stem (Nasiri *et al.,* 2010). The foliar application of nutrients is recognized to be more effective as compared to nutrients application in the soil, soil applied nutrients because of effective utilization by plant and minimum cost per unit area (Narang *et al.,* 1997). The use of Ffertilizers is one of the most important management systemsystems for crops (ref), and but excessive addition of chemical fertilizers in crops is represents a problem major ecological threat because it leads to increase environmental pollution (Savci, 2012). Therefore, the trend started to rely on the initial addition of the codified fertilizer as soil fertilization and replace the complementary fertilizers by foliar fertilization. in This process order contributes to reduce the quantities of fertilizers added while ensuring the benefit of fertilizers (Haytova, 2013). There is also evidence that utilization of nutrients is faster by foliar spray as compare to its basal application, in foliar condition we are able to supply the nutrient immediately the requirement of plants. Considering these above facts, adoption of soil application recommended dose of fertilizer conjunction with foliar fertilization to improve production, productivity, profitability and efficient utilization of nutrient are the need of the hour.

Comment [KYAG15]: What contains these substances? Please specify

Comment [KYAG16]: Provide reference please

Comment [KYAG17]: Provide reference

Comment [KYAG18]: You could provide also some recent bibliographic reference.
For example:
https://doi.org/10.1007/s11104-020-04689-9

Comment [KYAG19]: Provide also recent references. You can see:

https://doi.org/10.1016/B978-0-08-103017-2.00006-4

https://www.researchgate.net/profile/Randeep-Kumar/publication/331132826_The_Impact_of_Chemical_Fertilizers_on_our_Environment_and_Ecosystem/links/5c66ebe492851c1c9de446eb/The-Impact-of-Chemical-Fertilizers-on-our-Environment-and-Ecosystem.pdf

Comment [KYAG20]: I would rephrase this sentence as follows:
"Therefore, the current trend is the initial use of a coded fertilizer to feed the soil, and then replace the complementary fertilizers with foliar fertilization.

Comment [KYAG21]: Already mentioned above

Comment [KYAG22]: Please rephrase.
You could write:
"Given the above considerations, the adoption and application of a recommended dose of fertilizers to the soil in conjunction with foliar fertilization is a current need. This can improve crop productivity and cost-effectiveness, and helps to the rational use of fertilizers."

Comment [KYAG23]: An important paragraph is missing in your introduction. You haven't yet presented the objective of your work.

2. MATERIALS AND METHODS

The field experiment was conducted during the winter seasons of 2019-20 at the Instructional Farm, S. K. Rajasthan Agricultural University, Bikaner (28°38' N, 77°11' E, 228.6 m above mean sea-level)., to study the growth and production of wheat as influenced by levels and method of N P K fertilizer application in arid region ~~in split plot design with three replications.~~ The soil of the experimental site was loamy sand, with bulk density of 1.55 g cm^{-1}. It had 0.15% organic carbon, 92.26 kg $KMnO_4$ oxidizable N ha^{-1}, 14.68 kg 0.5 N $NaHCO_3$ extractable P ha^{-1}, 207.06 kg 1.0 N NH_4OAC-exchangeable K ha^{-1}, 8.3 pH and 0.13 dSm^{-1} electrical conductivity at the start of the experiment.

The experiment was conducted in a split plot design with three replications. The treatments consisted of four fertility levels in the main plot and five spray-level for foliar fertilization with soluble N P K in the sub plots. The four treatments were: F_0 - control, F_1 - 50% recommended dose of fertilizer (RDF), F_2 - 75% recommended dose of fertilizer (RDF), and F_3 - 100% recommended dose of fertilizer (RDF). The five spray-level for foliar fertilization were: S_0- control (no spray), S_1- one spray (60 DAS), S_2- two spray (45 & 60 DAS), S_3- three spray (45, 60 & 75 DAS), and S_4- four spray (45, 60, 75 & 90 DAS).

-Crop was sown on November 26 ~~November~~ and harvested on April 01st ~~April~~ in the cropping season 2019-20. Half N and full dose of P and K through urea, diammonium phosphate and muriate of potash, respectively were applied at the time of sowing and the remaining N was applied in two split doses *viz,* 1st and 2nd irrigation time. Foliar fertilization was applied as soluble N: P: K (19:19:19) fertilizer at different crop growth stages. Five plants were selected randomly from the second row of each plot for the measurements of the plant height, the spike length, the spikelets $spike^{-1}$ & the grain $spike^{-1}$ and per meter row length area were selected after leaving the first row of each plot for the measurement of plant stand, dry-matter accumulation and effective tillers. After harvesting, threshing, cleaning and drying, the grain yield was recorded. Net returns of the crop were computed on the basis of grain and straw yield, their prevailing market prices and cost of cultivation. In order to test the significance of variance in experiments, the data obtained for various treatment effects were statistically analysed using the F-test as per procedure described by Panse and Sukhatme (1985). The results are presented at 5% level of significance (P= 0.05) for making comparison between treatments.

Comment [KYAG24]: Remove this part in the Introduction section

Comment [KYAG25]: How did you get this data?

Comment [KYAG26]:

Comment [KYAG27]: What is the fertilizer?

Comment [KYAG28]: I find this description a bit confusing.
You have mentioned 20 treatments in the summary but it is difficult to perceive them as you describe.
I think that a table form would be more interesting to describe all the treatments.

Comment [KYAG29]: Please better phrase this sentence
November 26 of which year? And April 1 of which year?
Is it one crop cycle or two?

Comment [KYAG30]: It is important to specify these growth stages in case someone wants to use your protocol

Comment [KYAG31]: With regard to the previous comment: at what stage of growth these plants were selected?

Comment [KYAG32]: How many rows were there, and why were you interested in the second row?
Don't you think that a descriptive diagram of the study plot is needed to better support your statements?

Comment [KYAG33]: The sentence is quite long. Can you rewrite this part in another sentence

Comment [KYAG34]: Can you explain why you made these measurements?

Comment [KYAG35]: When were these operations conducted? Relate to the crop cycle you mentioned above.
We are interested to know how you recorded the grain yield

Comment [KYAG36]: This part should be completely reworked. What did you test exactly? It seems in my understanding that you should compare treatments based on their observed performance. Please say it more clearly. Specify the type of F-test you used, the cited reference is too old.

3. RESULTS AND DISCUSSION

Effect of RDF levels: - Application of 100 % RDF recorded maximum growth and yield attributes. Plant stand of wheat at 20 DAS and harvesting stage could not influence due to fertility levels (Kumar and Satyvan, 2017). The highest values of plant height and dry-matter accumulation at different crop growth stages were registered at 100% RDF, which were significantly higher than the rest of treatments (). Application of 100, 75 and 50 per cent RDF increased the dry matter production to the tune of 19.23, 13.99 and 8.60 per cent at harvesting stage over control, respectively. The plant height and dry matter accumulation increased in 100 per cent RDF might be due to higher N uptake, leading to increased protein synthesis, cell division and cell enlargement which in turn are elaborated into protoplast and thus increased plant height and dry matter accumulation. These results are ~~in close conformity with the findings of~~ supported by Hashim *et al.,* (2015) and Choudhary (2017) findings. Yield attributes namely effective tillers per meter row length, spike length, grain/ spike and test weight were found significantly higher with 100 % RDF over rest of treatments (). Number of effective tillers increase with application of 100, 75 and 50 per cent RDF was in the order of 73.39, 62.40 and 40.00 per cent over control. Probably this increase in number of effective tillers per meter row length is due to the better supply of photosynthates from leaves to effective tillers. (Chaturvedi *et al.,* (2006). Significantly highest grain, straw and biological yield were obtained with application of 100 % RDF as compared to control, 50 and 75 per cent RDF. Application of 100 per cent RDF increases grain and straw yield to the tune of 76.11, 20.16 & 7.95 and 63.66, 16.65 & 7.34 % over control, 50 and 75% RDF. Grain yield of any crop is combined effects of all attributing characters of those crops. If treatments influence attributing characters positively, it reflects as higher grain yield. Well-nourished plants with higher amounts of fertilization increased the grain and biological yield of wheat which might be due to improvement in yield attributes i.e. increased effective tillers, grain spike^{-1} and spike length (Jat *et al.,* 2014).

Effect of foliar spray: - Foliar fertilization of soluble N P K at different growth stages were gave directly responds to the growth and yield attributes as well as yield of wheat. Plant stand at 20 DAS and harvesting stage recorded statistically at par due foliar fertilization. Plant height and DMA observed significantly higher with the application of three foliar spray over all other treatments but it was recorded statistically at par with four foliar spray. This suggests the quick absorption of nitrogen, phosphorus and potash

Comment [KYAG38]: Where are the values?

Comment [KYAG39]: Is this your result? Or you used this reference to explain what?

Comment [KYAG40]: Specify the results of the statistical analysis you performed

Comment [KYAG41]:

Comment [KYAG42]: This is the first time you have mentioned this term. Maybe talk about it in the methods section

Comment [KYAG43]: According to the bibliographic references provided at the end of the paper, it would be Choudhary et al.

Comment [KYAG44]: Provide the results of statistical analysis

Comment [KYAG45]: And here it would be Chaturvedi 2006 and not Chaturvedi et al. 2006

Comment [KYAG46]: This sentence is not clear

Comment [KYAG47]: This is also the first time that DMA is mentioned. What is it about? You didn't mention it in the methods section

Comment [KYAG48]: You use this term widely, but there is no evidence of statistical testing anywhere

due to foliar spray of soluble N: P: K at different growth stages and helped in expansion of leaf area owing to increased meristematic activity and provided greater photosynthetic surface to intercept more radiant energy and improved the capacity of the plants to utilize more available nutrients and net photosynthesis (Yassen, 2010).

The yield attributes *viz,* effective tillers per meter row length and length of spike of wheat were significantly higher in treated plot than the control. Effective tillers and length of spike were recorded significantly higher with three foliar spray over rest of spray but closely at par four foliar spray. This increase in yield components was mainly due to increasing levels of foliar fertilization that is increase leaf area and photosynthesis process in growth attributes this show high dry matter production and its partition in fruiting parts which in turns give significantly high yield (Bhosale, 2013). Increasing trend found in respect of number of grain spike^{-1}, spikelet spike^{-1} and test weight of wheat but it was not influenced significantly by different foliar fertilization levels. This might be due to spikelet spike^{-1} and test weight is basically a genetic character it was not influenced by levels of foliar fertilization (Kumar S. 2017).
Significantly higher grain yields, straw and biological yield of wheat were recorded with the application of three foliar spray over remaining treatments and it remained statistically similar with four foliar spray of soluble N P K fertilizer. The three foliar spray of soluble N: P: K was increased grain yield of wheat to the trend of 21.53, 15.76 and 10.26 per cent over control, one and two foliar spray of soluble N: P: K fertilizer, respectively. Foliar application of nutrients along with recommended dose of fertilizers increased the yield components due to foliar spray as it facilitates the higher photosynthetic translocation to sink by increasing the photosynthesizing area and its capacity of particular crop~~.~~ (Kumar S. 2017 and Bhosale 2013).
Economics: - Application of 100% RDF recorded the significantly maximum gross and net profit (108568 and 76682 ₹ ha^{-1}) as well as with 2.40 benefit: cost ratio, followed by 75% RDF 100668, 69909 ₹ ha^{-1} and 2.27, respectively. In point of view foliar fertilization, three foliar spray of soluble N: P: K observed the significantly higher gross and net return (98116 and 67326 ₹ ha^{-1}) and maximum benefit: cost ratio 2.16 over rest of the treatments, but it was recorded the statistically at par with four foliar spray of soluble N: P: K (99923 and 68257 ₹ ha^{-1} with 2.13 B:C). (Sharma, 2016 and Bairwa *et al.* 2018~~)~~).

Comment [KYAG49]: The sentence is too long, please split

Comment [KYAG50]: What is the foundation for this statement?

Comment [KYAG51]: Split the sentence

Comment [KYAG52]: Same here. What is the foundation for this statement?

Comment [KYAG53]: This reference form is different to the others

Comment [KYAG54]: Rephrase this sentence

Comment [KYAG55]: What do you mean? Which sink are you talking about?
Can you describe the physiological process that leads to the increase of the photosynthesizing area?

Comment [KYAG56]: Reference form

Comment [KYAG57]: Rephrase

Comment [KYAG58]: Split.
Please rephrase

Comment [KYAG59]: It is difficult to understand where these results come from. In the methods section you talk about calculating net crop returns based on straw yield, their prevailing market prices and cost of cultivation. What are these prices/costs?

Where are the statistical test results that allow you to make these comparisons?

4. CONCLUSION

Hence application of 100% RDF through chemical fertilizers as basal dose and three foliar spray of soluble N: P: K (19:19:19) of wheat was found better nutrient-management practice for higher growth, yield and net returns from wheat crop.

Comment [KYAG60]: The conclusion is too brief. Can you provide the scientific and socio-economic significance of your results? For example, what is the interest for Indian farmers?
What would be expected at the national level if the method you propose were applied

Table: 1. Effect of levels and method of NPK fertilizer application on growth attributes of wheat

Treatments	Growth attributes								
	Plant stand m^{-1} row length		Plant height (cm)			Dry matter accumulation m^{-1} row length (g)			
	20 DAS	Harvest	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest
Fertilizer levels									
F_0	41.17	39.25	38.93	70.01	74.30	19.46	48.34	90.61	110.22
F_1	41.73	39.76	42.25	77.90	81.39	20.25	53.03	99.19	119.69
F_2	42.07	40.06	44.53	83.31	86.70	20.76	55.20	103.11	125.64
F_3	42.22	40.20	46.63	88.25	91.02	21.13	57.35	106.67	131.41
S. Em ±	0.91	0.83	0.54	0.88	1.21	0.40	0.61	0.85	1.64
CD(P=0.05)	NS	NS	1.88	3.03	4.19	NS	2.12	2.93	5.69
Foliar spray @ 1 % N P K									
S_0	41.33	39.39	41.47	69.22	73.64	19.78	49.75	88.89	109.01
S_1	41.57	39.61	41.76	73.77	77.06	19.92	51.14	95.67	116.34
S_2	41.82	39.83	43.84	79.46	82.04	20.53	55.22	100.24	121.61
S_3	42.09	40.08	44.01	88.14	90.90	20.67	55.39	107.02	129.19
S_4	42.20	40.18	44.33	88.75	93.13	21.10	55.91	107.66	132.54
S. Em ±	0.94	0.85	0.72	1.27	0.99	0.94	1.40	1.16	1.38
CD(P=0.05)	NS	NS	2.06	3.66	2.84	NS	4.04	3.34	3.98

Recommended Dose Fertilizer (RDF): - 120: 40: 40 kg ha^{-1}, Foliar spray of N: P: K (19: 19: 19) @ 1%

Comment [KYAG61]: You don't mention anywhere in the text this table

Comment [KYAG62]: Do these data represent averages? If so, please specify

Comment [KYAG63]: You don't make pairwise comparisons between values, so how do you decide whether there is a significant difference or not between two values?

Comment [KYAG64]: Provide the meaning of these terms

Comment [KYAG65]: What are these values? Where are the p-values of the statistical tests you performed?

Comment [KYAG66]: This is the first time you've mentioned it. So it's hard to follow you because what you say here is not in the methods section

Comment [KYAG67]: Please describe briefly the different parameters mentioned in the table and how you obtained these results.

Table: 2. Effect of levels and method of NPK fertilizer application on yield attributes and yield of wheat

Comment [KYAG68]: All comments for Table 1 are applicable to this one

Treatments	Yield attributes					Yield (kg ha^{-1})			Harvest index (%)
	Effective Tillers mrl^{-1}	Spike length (cm)	Spikelet spike^{-1}	Grain spike^{-1}	Test weight (g)	Grain yield	Straw yield	Biological yield	
Fertilizer levels									
F_0	76.36	8.06	14.94	38.52	36.91	2545	3855	6401	39.76
F_1	106.91	8.58	15.38	40.60	38.89	3730	5409	9139	40.83
F_2	124.02	8.97	15.58	40.95	39.97	4152	5878	10180	40.79
F_3	132.41	9.45	15.73	41.17	40.69	4482	6310	10792	41.53
S. Em ±	1.85	0.10	0.19	0.33	0.64	89	108	130	0.74
CD(P=0.05)	6.41	0.34	NS	1.14	2.20	310	375	449	NS
Foliar spray @ 1 % N P K									
S_0	98.03	7.62	15.22	39.54	38.01	3326	4834	8197	40.43
S_1	105.00	8.44	15.27	39.96	38.79	3492	5079	8608	40.44
S_2	109.72	8.98	15.35	40.33	39.21	3666	5245	8949	40.90
S_3	117.51	9.30	15.50	40.75	39.64	4042	5759	9839	40.92
S_4	119.36	9.48	15.70	41.05	39.93	4111	5898	10047	40.94
S. Em ±	1.99	0.17	0.25	0.64	0.68	71	103	132	0.57
CD(P=0.05)	5.74	0.49	NS	NS	NS	204	298	381	NS

Recommended Dose Fertilizer (RDF): - 120: 40: 40 kg ha^{-1}, Foliar spray of N: P: K (19: 19: 19) @ 1%

Table: 3. Effect of levels and method of NPK fertilizer application on economics of wheat

Comment [KYAG69]: All comments for Table 1 are applicable to this one

Treatments	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B C ratio
Fertilizer levels			
F_0	62475	35097	1.28
F_1	90834	61202	2.06
F_2	100668	69909	2.27
F_3	108568	76682	2.40
S. Em ±	1770	1770	0.04
CD(P=0.05)	6125	6125	0.12
Foliar spray @ 1 % N P K			
S_0	81018	52857	1.85
S_1	85072	56034	1.91
S_2	89052	59138	1.96
S_3	98116	67326	2.16
S_4	99923	68257	2.13
S. Em ±	1485	1485	0.03
CD(P=0.05)	4279	4279	0.09

Recommended Dose Fertilizer (RDF): - 120: 40: 40 kg ha^{-1}, Foliar spray of N: P: K (19: 19: 19) @ 1%

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Comment [KYAG70]: Overall, the references do not follow the same format. Please adapt only one format according to the type of bibliography. See the journal requirements.

If you are relying on numbers, these numbers should be used in the text

Comment [KYAG71]: This reference does not exist anywhere in the text

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Comment [KYAG72]: Pages are not numbered throughout the paper