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Effect of balanced fertilization on growth, yield and nutrient uptake by dual purpose barley (*Hordeum vulgare* L.) varieties

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Abstract
A field experiment was conducted during *rabi* season of 2013-14 to study effect of balanced fertilization on growth, yield and nutrient uptake by dual purpose barley varieties at the instructional farm, Rajasthan college of agriculture, Udaipur. The experiment was laid out in RBD (Factorial) with 14 treatment combinations replicated thrice. The treatment consisted of seven balanced fertilization (no fertilization, N, NP, NPK, NPKS, NPKZn, NPKSZn) applied at recommended level and two varieties (RD 2715, RD 2552). The results indicated that after green fodder cutting dual purpose barley variety RD 2552 recorded significantly higher growth, yield attributes and productivity in terms of grain, straw and biological yield by 2.2, 6.3 and 8.4 q ha^{-1} respectively over variety RD 2715.The variety RD 2552 also registered highest quantum of N, P, K, S and Zn by grain and straw as compared to RD 2715. The crop under the influence of N, NP, NPK, NPKS, NPKZn and NPKSZn at recommended level significantly increased yield attributes, yield and nutrient uptake over no fertilization. Among balanced fertilization, conjoint application of NPKSZn significantly increased grain, straw and biological yield by 5.5, 9.4 and 15.1 q ha^{-1}, respectively over NPK fertilization. This nutrient combination was found at par with NPKS which increased yield parameter by 4.0, 6.8 and 11.2 q ha^{-1}, respectively over NPK. Further nutrient combination NPKSZn also accumulated higher quantum of N, P, K, S and Zn by grain and straw over NPK. The magnitude of difference between NPKSZn- NPKS and NPKS- NPKZn was not significant in this regard.

Keywords: Dual purpose barley, varieties, balanced fertilization, growth, yield, uptake

Introduction
Presently, the country is facing a net deficit of green fodder (35.6%), dry fodder (10.95%) and concentrated feeds (44.0%). Presently availability of green fodder is 460 million tonnes and dry fodder availability is 394 million tonnes (IIWBR, 2019-20) [5]. Feed and fodder are two most important components of animal output. The gap between demand and supply of fodder can be reduced by adopting high yielding fodder crops as well as proper agronomic techniques. In these areas barley can be grown as dual purpose crop (Godara *et al*. 2019) [4]. Barley is used as animal feed at the vegetative stages or cut before maturity and either feed directly or used for silage. It is highly efficient in utilization of water and nutrients in limiting conditions, has high capacity for tillering and regrowth after cutting and additional capacity for large accumulation of biomass. The crop can give one cut at 55 DAS thus on an average 180-240 and 24-35 q ha^{-1} of green fodder and grains here produces from dual purpose barely. Thus selection of a suitable variety for any specific area is one of the most important factor to achieve highest production because different varieties have different qualities and perform in a different way in diverse conditions (Kumar *et al.* 2017) [7]. Despite the application of recommended quantities of major nutrients, the increase in yield is not encouraging. This indicates that in addition to major nutrients, there is need to supply secondary and micro nutrients. In major areas, the application of N and P fertilizers are generally practiced in barely crop but presently addition of K, S and Zn are also considered to be an integral part of balanced fertilization to achieve higher efficiency. Therefore balanced use of fertilizer would be a major step for enhancing barley productivity (Chaplot, 2014) [2]. Among mineral nutrient, N is an integral part of chlorophyll, it is also associated with the activity of every living cell. P nutrition play key role in plant metabolism, biochemical processes, transfer and storage of energy as ADP and ATP, permits conversion and transmission of genetic characters as it is a constituent of DNA and RNA. K activate the enzyme in protein and carbohydrate metabolism and imparts resistance to plant against fungal and bacterial diseases.

S play in important role in formation of amino acid, synthesis of protein and chlorophyll formation. Zn play outstanding role in synthesis of chlorophyll, Protein and also regulate water absorption and involved in synthesis of IAA, GA and RNA (Chandrasekaran *et al.* 2010) [1]. Therefore in the recent years micronutrients are considered as one of the constraints in the optimum production of barley crop. An attempt has been made to study the impact of balanced fertilizers on the dual purpose barley varieties.

Materials and Methods

A field experiment was laid out at the Instructional Farm, Rajasthan College of Agriculture, Udaipur during *rabi* season of the year 2013-14. The soil of the experimental field was clay loam in nature, slightly alkaline in reaction (pH 7.8), medium in available nitrogen (295.3 kg ha^{-1}) and phosphorus (16.6 kg ha^{-1}) and high in available potassium status (275.3 kg ha^{-1}) the experiment consists of 14 treatment comprising combination of two varieties (RD 2715 and RD 2552) and seven balanced fertilization system (no fertilizer (control), 60 kg N ha^{-1} (N), N + 20 kg P_2O_5 ha^{-1} (NP), NP + 20 kg K_2O ha^{-1} (NPK), NPK +40 kg S ha^{-1}(NPKS), NPK + 5 kg Zn ha^{-1} (NPKZn and NPKSZn). These were evaluated in RBD (Factorial) with three replications. The seed were sown in furrows opened at 22.5 cm apart and seeds were placed at a depth of 4-5 cm using seed rate of 100 kg ha^{-1}. The sources of N, P, K, S and Zn were urea, DAP, MOP, gypsum and zinc sulphate respectively. The whole quantity of P, K, S, Zn and half dose of N were drilled in furrow before sowing. The remaining half dose of N were applied in two equal splits *i.e.* at 30-35 DAS and just after first cutting. The barley varieties as per treatment were sown on 25^{th} November. The crop was irrigated thrice *i.e*. at 30, 55 and 95 DAS. The crop was harvested first for green fodder at 55 DAS, after harvesting green fodder, applied N and irrigation which was raised for grain purpose.

Results and Discussion

Varieties

A perusal of data (Table 1 & 2) reveals that after green fodder cutting dual purpose barley varieties RD 2552 produced significantly higher plant height, total tillers and dry matter accumulation by 8.2, 10.3 and 10.2 per cent as compared to variety RD 2715. The better performance of variety RD 2552 after green fodder cutting seems to have increased interception, absorption and utilization of radiant energy thereby resulting in higher accumulation of photosynthates and finally dry matter. Among dual purpose barley varieties, RD 2552 recorded significantly higher effective tillers m^{-1} row, ear length, grains ear^{-1}, grain weight ear^{-1} and test weight by12.2, 3.6, 3.2, 2.1 and 3.2 per cent, respectively compared to variety RD 2715. The significant improvement In these parameters in variety RD 2552 manifested in increased productivity in terms of grain, straw and biological yield by 2.2, 6.3 and 8.4 q ha^{-1} respectively over variety RD 2715. Since barley yield formation is a complex process and interaction governed by complementary interaction between source (photosynthesis and availability of assimilates) and sink component (storage organ), in the present study, the higher yield of variety RD2552 may be attributed to its higher biomass accumulation due to higher number of tillers, plant height, DMA and good yield attributes. The findings fall in line of Kharub *et al.* (2013) [6]. Further varieties RD 2552 registered highest concentration of N, P, K, S and Zn status in grain and straw over variety RD 2715. Thereby RD 2552 accumulated highest quantum of N, P, K, S and Zn by grain and straw over RD 2715. The corresponding increases were 15.5, 8.6, 10.5, 14.4, 13.4 and 18.3, 28.2, 13.1, 21.9, 20.2, per cent by grain and straw respectively. The greater availability of nutrients with variety RD 2552 seems to have critical concentration at cellular level and fulfilled their requirement for profuse plant growth and there efficient translocation towards sink components. The results are in accordance with the findings of Choudhary and Chaplot (2015) [3].

Balanced fertilization

Data (Table 1 & 2) reflects that after green fodder cutting application of N, NP, NPK, NPKS, NPKSZn and NPKSZn at recommended level significantly increased growth, yield attributes, yield content and uptake of nutrient over no fertilization. The corresponding increases in grain and straw yield was to the tune of 28.0, 36.8, 44.0, 59.8, 49.4, 65.1 and 19.8, 23.9, 34.6, 50.1, 41.1, 55.7 per cent, respectively. Aforesaid fertility level significantly increased biological yield by 22.8, 28.6, 53.7, 44.2 and 60.2 per cent, respectively. Further the magnitude of difference between N and NP as well as between NP, NPK and NPKZn was not significant. Among balanced fertilization, conjoint application of NPKSZn significantly improved plant height, total tillers and DMA after green fodder cutting over NPK and NPKZn fertilization. This nutrient combination was closely followed by NPKS. The results further indicated that various yield attributes *viz*., effective tillers, ear length, grains/ear, grain weight / ear and test weight were significantly higher when crop was fertilized with NPKSZn in balanced ratio. Consequently, this nutritional programme significantly enhanced grain, straw and biological yield by 5.5, 9.4 and 15.1 q ha^{-1} over NPK fertilization. The balanced fertilization involving nutrient combination of NPKS proved next in order and enhanced grain, straw and biological yield by 4, 6.8 and 11.2 q ha^{-1} over NPK but remained at par with NPKZn. The adequate supply of photosynthates due to higher photosynthetic efficiency at ear emergence might have enhanced number of flowers and their fertilization resulting in higher number of grains ear^{-1}. Further greater assimilating surface at reproductive development and improvement in nutritional conditions of grain seems to have congenial environment for grain growth. Since grain weight ear^{-1} is dependent on number of grains ear^{-1} and weight of individual grain, thus highest grain weight ear^{-1} could be ascribed to the improvement in both these parameters. Hence significant increase in grain yield under NPKSZn fertilization seems to be due to exploitation of crop genetic potential up to highest level. The results are corroborated with the findings of Singh *et al.* (2012) [8].

The plant analysis revealed that application of NPKSZn accumulated highest quantum of N, P, K, S and Zn by grain and straw at harvest over NPK. The corresponding increase were 24.0, 22.2, 20.3, 21.5, 23.8 per cent by grain and 23.7, 22.3, 17.6, 23.6 and 23.5 per cent by straw, respectively. This nutrient combination was closely followed by NPKS fertilization. The magnitude of difference between NPKS and NPKZn was not significant. The positive influence of conjoint application of NPKSZn on nutrient status of plants seems to be due to their increased availability in root zone. These results are in close agreement with the findings of Chaplot (2014) [2].

Table 1: Effect of dual purpose barley varieties and balanced fertilization on yield attributes and yield

Treatments	Growth after green fodder cutting (at harvest)			Yield attributes					Yield (q ha^{-1})		
	Plant height (cm)	Total tillers (m^{-1} row length)	Dry matter accumulation (g 0.5 m^{-1} row length)	Effective tillers (m^{-1} row length)	Ear length (cm)	Grains ear^{-1}	Grain weight ear^{-1}	Test weight (g)	Grain	Straw	Biological
Varieties											
RD 2715	83.8	104.5	78.3	82.9	9.22	30.8	0.574	34.6	35.6	55.7	91.3
RD 2552	90.7	115.3	86.3	93.8	9.55	31.8	0.586	35.7	37.8	61.9	99.7
SEM	1.34	2.70	1.51	1.91	0.13	0.14	0.002	0.15	0.72	1.14	1.41
CD	3.90	7.85	4.39	5.56	0.37	0.42	0.007	0.43	2.09	3.32	4.11
Balanced fertilization											
No fertilizer	70.1	76.1	64.6	58.8	5.29	27.0	0.500	31.7	26.1	44.5	70.6
N	81.0	96.8	73.9	78.7	9.17	30.6	0.570	34.5	33.4	53.3	86.7
NP	85.0	105.8	78.3	86.6	9.77	31.2	0.581	35.1	35.7	55.1	90.8
NPK	88.2	112.5	82.6	89.6	9.92	31.6	0.590	35.3	37.6	59.9	97.5
NPKS	96.5	129.3	93.1	102.3	10.97	32.8	0.606	36.6	41.7	66.8	108.5
NPK Zn	91.3	116.7	87.4	95.5	10.59	32.1	0.598	36.0	39.0	62.8	101.8
NPKSZn	98.7	131.5	96.1	106.9	11.37	33.5	0.616	366.9	43.1	69.3	112.5
S.Em	2.51	5.05	2.83	3.58	0.24	0.27	0.005	0.27	1.34	2.14	2.64
CD	7.29	14.69	8.22	10.41	0.69	0.78	0.014	0.80	3.91	6.22	7.68

Table 2: Effect of dual-purpose barley varieties and balanced fertilization on nutrient uptake

Treatments	Nutrient uptake (kg ha^{-1})									
	Nitrogen		Phosphorus		Potassium		Sulphur		Zinc	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Varieties										
RD 2715	60.2	14.0	14.3	3.36	27.2	68.4	38.7	21.5	0.754	0.818
RD 2552	69.5	16.5	15.5	4.31	30.0	77.3	44.3	26.2	0.855	0.983
SEM	1.24	0.36	0.33	0.09	0.61	1.41	0.95	0.49	0.017	0.019
CD	3.61	1.06	0.95	0.26	1.76	4.09	2.75	1.43	0.051	0.055
Balanced fertilization										
No fertilizer	41.1	9.6	9.7	2.30	17.6	50.5	25.4	14.6	0.484	0.588
N	55.7	13.2	12.9	3.21	25.0	63.7	36.1	20.6	0.702	0.791
NP	61.7	14.0	14.4	3.59	27.0	66.2	39.4	21.8	0.760	0.823
NPK	66.0	15.6	15.3	3.95	29.6	75.7	42.8	24.6	0.819	0.912
NPKS	77.3	18.3	17.5	4.70	34.3	85.3	50.0	28.7	0.954	1.056
NPK Zn	70.2	16.8	16.1	4.24	31.0	78.7	44.8	26.5	0.900	1.007
NPKSZn	81.9	19.3	18.7	4.83	35.6	89.9	52.0	30.4	1.014	1.126
S.Em	2.32	0.68	0.61	0.17	1.13	2.63	1.77	0.92	0.033	0.035
CD	6.74	1.98	1.78	0.49	3.29	7.64	5.15	2.67	0.096	0.103

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