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Effect of Soil Moisture Content and Integrated Nutrient Approaches on Productivity and Economics of Barley Genotypes

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ABSTRACT

A field experiment was conducted during *rabi* season of 2013-14 and 2014 -15 in farmer's field at model watershed, Neeralkatti village, Dharwad district of Karnataka to assess the performance of barley genotypes to INM and *in-situ* moisture conservation practices. Significantly higher soil moisture content on volumetric basis was recorded in broad bed and furrow (BBF) at 0-15 and 15-30 cm depth at all the growth stages compared to flat bed. Significantly higher grain yield was obtained with genotype DWRB-73 sown on BBF with the application of RDF (50:25:0 N:P_2O_5:K_2O kg ha^{-1} + 7 t ha^{-1} FYM) *i.e.* (BBF x DWRB-73 x RDF, 2122 kg ha^{-1}) compared to rest of the interactions except it was on par with genotype DWRB-73 planted on BBF with the application of 75% N through urea + 25% N through vermicompost and recommended P through inorganics (2060 kg ha^{-1}). Crop grown on broad bed and furrow recorded significantly higher gross returns, net returns and benefit cost ratio (Rs. 37401 ha^{-1}, Rs. 19244 ha^{-1} and 2.1, respectively) compared to farmers' practice.

Key words *In-situ moisture conservation practices, barley genotypes, INM, BBF, economics*

Barley (*Hordeum vulgare* L.) is a widely adapted, drought, salt and cold tolerant cereal grain and has played a significant role in revolutionizing agriculture. Barley was among the first domesticated crops and it was grown in the "Fertile Crescent" 10,000 yr ago. Barley is the fifth most produced crop and fourth most produced cereal in the world. A considerable improvement in characteristics, such as seed dormancy, seed vigor and resistance to rusts and scald has been made by barley breeders to increase its yield per unit area. Barley has many health benefits and is largely used in malting. It has a wide range of global adaptations from high latitudes and altitudes to the deserts. It is a major source of food for large population of cool and semi-arid areas of the world, where wheat and other cereals are less adapted. In European countries, it is used as the only breakfast food, whereas the people of Nepal, Tibet and Bhutan use it as a staple food. The most important uses of barley in India include green feed to livestock and poultry, as malt for manufacture of beer and other liquors like brandy, whisky etc. Sometimes barley is mixed with wheat or gram and then ground to flour for preparing better quality chapaties. Barley is used for manufacturing of liquors in western countries.

A significant cause of low crop production and crop failure in rainfed agriculture in the tropics is low and erratic rainfall. However, in many areas crop and land management do not optimise water flow along the rooting zone of the crop. Thus, poor yields are related to an insufficiency of soil moisture rather than to an insufficiency of rainfall. Tropical and subtropical rainfed agriculture depends on an adequate supply of water in the rooting zone of the soil. It has been estimated that soil water limits crop production in approximately three-quarters of the world's arable soils and is the main factor responsible for low yields in the seasonally dry and semiarid tropics and subtropics. Especially in the subtropical and tropical agro-ecological zones with restricted, irregular or markedly seasonal rainfall with annual precipitation from 400 to 1000 mm. But also in areas, where seasonal shortages of rainfall can limit crop productivity, it is necessary to give more attention on the efficient capture of precipitation *in- situ* and improve the soil moisture content of the rooting zone. An understanding of the hydrological cycle is essential for the effective management of rainwater and soil water.

MATERIAL AND METHODS

A field experiment was conducted during *rabi* season of 2013-14 and 2014 -15 in farmer's field at model watershed, Neeralkatti village, Dharwad district of Karnataka at 15^{0} 33^{1} 31.61^{11} N latitude and of 74^{0} 54^{1} 39.64^{11} E longitude with an altitude of 672 m above the mean sea level on deep black soil. The experiment was laid out in split-split plot design with three replications involving two *in-situ* moisture conservation practices *viz.* L_1: broad bed and furrow (BBF), L_2: farmer's practice (flat bed) as main plots, two genotypes as sub plots *viz.* G_1: DWRB – 73 which is characterised as two row barley with grain/malting ability and G_2: BH - 902 which was characterised as six row barley with fodder and grain ability and five integrated nutrient management practices *viz.* N_1: RDF (50:25:0 N:P_2O_5:K_2O kg ha^{-1} + 7 t ha^{-1} FYM), N_2: 75% N through urea + 25% N through FYM and recommended P through inorganic, N_3 : 50% N through urea + 50% N through FYM and recommended P through inorganic, $N_{4:}$ 75% N through urea + 25% N through vermicompost and recommended P through inorganic, $N_{5:}$ 50% N through urea + 50% N through vermicompost and recommended P through inorganic as sub-sub plots. The soil of the experimental site was medium black clay with pH (7.62), EC (0.54 dS m^{-1}), organic carbon content was (0.52 %), available N (260 kg ha^{-1}), P_2O_5 (15 kg ha^{-1}) and K_2O (304 kg ha^{-1}). The mean annual rainfall for the past 62 years at the Main Agricultural Research Station, Dharwad which is

Table 1. **Soil moisture content (cm) at 0 – 15 cm and 15-30 cm depth as influenced by integrated nutrient management under *in-situ* moisture conservation practices (Poole data of 2013-14 and 2014-15)**

Treatment	Soil moisture (cm) at 0 - 15cm depth			Soil moisture (cm) at 15-30 cm depth		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
Main plot (Land management) – L						
L_1	4.54 a	3.43 a	2.36 a	4.83 a	4.03 a	2.75 a
L_2	3.74 b	2.68 b	1.93 b	3.97 b	3.09 b	2.24 b
S.Em ±	**0.03**	**0.02**	**0.02**	**0.03**	**0.03**	**0.03**
Sub Plot (Genotypes) – G						
G_1	4.17 a	3.03 a	2.18 a	4.40 a	3.51 a	2.45 a
G_2	4.13 a	2.99 a	2.10 a	4.38 a	3.53 a	2.46 a
S.Em ±	**0.02**	**0.03**	**0.02**	**0.03**	**0.03**	**0.05**
Sub sub (INM) – N						
N_1	4.14 a	3.06 a	2.16 a	4.42 a	3.55 a	2.51 a
N_2	4.13 a	3.10 a	2.15 a	4.39 a	3.55 a	2.43 a
N_3	4.15 a	3.02 a	2.12 a	4.39 a	3.57 a	2.55 a
N_4	4.05 a	2.96 a	2.15 a	4.41 a	3.50 a	2.39 a
N_5	4.07 a	2.93 a	2.05 a	4.35 a	3.43 a	2.39 a
S.Em ±	**0.07**	**0.06**	**0.03**	**0.07**	**0.06**	**0.05**
Interaction (L x G x N)						
$L_1G_1N_1$	4.62 a	3.43 ab	2.39 ab	4.80 a-d	3.97 a	2.84 ab
$L_1G_1N_2$	4.48 a	3.63 ab	2.40 a	4.73 a	4.13 a	2.55 e
$L_1G_1N_3$	4.58 a	3.40 ac	2.34 ab	4.74 a-d	3.97 ab	2.74 bc
$L_1G_1N_4$	4.46 a	3.31 ab	2.33 ac	4.65 a-c	4.03 ab	2.69 cd
$L_1G_1N_5$	4.48 a	3.18 a	2.32 a-f	4.78 a-g	3.73 ab	2.57 e
$L_1G_2N_1$	4.44 a	3.47 a	2.40 a	4.85 a	4.15 a	2.68 cd
$L_1G_2N_2$	4.47 a	3.28 a	2.30 ad	4.89 a-f	3.86 ab	2.81 ab
$L_1G_2N_3$	4.65 a	3.38 a	2.31 ab	4.97 ab	4.08 ab	2.88 a
$L_1G_2N_4$	4.27 ab	3.21 ab	2.30 a-e	4.86 a-g	3.81 ab	2.74 bc
$L_1G_2N_5$	4.33 ab	3.30 b-d	2.29 a-c	4.74 a-e	3.91 a-c	2.60 de
$L_2G_1N_1$	3.97 bc	2.75 d	2.08 c-g	4.28 d-g	3.14 a-d	2.37 f
$L_2G_1N_2$	3.76 cd	2.64 cd	1.97 e-g	3.87 fg	3.00 cd	2.11 ij
$L_2G_1N_3$	3.80 cd	2.74 cd	2.03 c-g	4.08 c-g	3.16 bd	2.27 fg
$L_2G_1N_4$	3.75 cd	2.68 d	2.08 d-g	4.14 g	2.94 a-d	2.08 ij
$L_2G_1N_5$	3.80 cd	2.59 d	1.82 fg	3.97 e-g	3.06 d	2.26 gh
$L_2G_2N_1$	3.53 d	2.59 d	1.77 fg	3.77 g	2.95 d	2.16 hi
$L_2G_2N_2$	3.81 cd	2.83 d	1.94 b-g	4.07 b-g	3.22 d	2.23 gh
$L_2G_2N_3$	3.58 cd	2.55 d	1.79 g	3.79 e-g	3.06 d	2.30 fg
$L_2G_2N_4$	3.73 cd	2.64 d	1.89 e-g	3.97 b-g	3.23 d	2.05 j
$L_2G_2N_5$	3.69 cd	2.67 d	1.76 d-g	3.90 fg	3.01 d	2.11 ij
S.Em ±	**0.14**	**0.12**	**0.06**	**0.15**	**0.12**	**0.10**

The means followed by the same lower case letters in a column do not differ significant by DMRT
DAS: Days after sowing
L_1: BBF G_1: DWRB –73
L_2: Farmer's Practice G_2: BH - 902
N_1:RDF (50:25:0 N:P_2O_5:K_2O kg ha^{-1}+ 7 t ha^{-1} FYM)
N_2:75% N through urea + 25% N through FYM and recommended P through inorganics
N_3:50% N through urea + 50% N through FYM and recommended P through inorganics
N_4: 75% N through urea + 25% N through Vermicompost and recommended P through inorganics
N_5: 50% N through urea + 50% N through Vermicompost and recommended P through inorganics

Table 2. Grain yield, straw yield and economics of barley genotypes as influenced by integrated nutrient management under *in-situ* moisture conservation practices (Poole data of 2013-14 and 2014-15)

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Gross return (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B :C
Main plot (Land management) – L					
L_1	1757 a	3377 a	37401 a	19244 a	2.1 a
L_2	1556 b	3142 b	33257 b	15351 b	1.9 a
S.Em ±	**32.5**	**38.4**	**666.4**	**666.4**	**0.04**
Sub Plot (Genotypes) – G					
G_1	1888 a	3200 b	39763 a	21692 a	2.2 a
G_2	1415 b	3311 a	30706 b	12635 b	1.7 b
S.Em ±	**13.9**	**16.1**	**281.6**	**281.6**	**0.02**
Sub sub (INM) – N					
N_1	1775 a	3392 a	37748 a	17419 b	1.9 b
N_2	1674 b	3280 b	35695 b	19997 a	2.3 a
N_3	1521 c	3106 c	32544 c	14477 c	1.8 b
N_4	1724 ab	3335 ab	36716 b	20186 a	2.2 a
N_5	1565 c	3163 c	33469 c	13738 c	1.7 c
S.Em ±	**17.5**	**19.8**	**356.5**	**356.5**	**0.02**
Interaction (L x G x N)					
$L_1G_1N_1$	2122 a	3456 bc	44545 a	24091 b	2.2 c
$L_1G_1N_2$	2019 b	3341 c-e	42430 b	26607 a	2.7 a
$L_1G_1N_3$	1854 c	3164 f-h	39061 b	20869 c-e	2.1 cd
$L_1G_1N_4$	2060 ab	3397 b-d	43288 a	26633 a	2.6 a
$L_1G_1N_5$	1909 c	3223 e-g	40192 b	20336 de	2.0 de
$L_1G_2N_1$	1634 cd	3570 a	35195 cd	14741 gh	1.7 gh
$L_1G_2N_2$	1535 de	3455 bc	33167 de	17344 f	2.1 cd
$L_1G_2N_3$	1381 f	3279 d-f	30005 f	11813 ij	1.6 hi
$L_1G_2N_4$	1591 cd	3508 ab	34305 cd	17650 f	2.1 cd
$L_1G_2N_5$	1427 f	3337 c-e	30961 f	11105 j	1.6 hi
$L_2G_1N_1$	1904 c	3221 e-g	40086 b	19882 e	2.0 de
$L_2G_1N_2$	1805 c	3104 g-i	38047 b	22474 b-d	2.4 b
$L_2G_1N_3$	1658 d	2941 j	35045 cd	17103 f	2.0 de
$L_2G_1N_4$	1857 c	3164 f-h	39122 b	22717 bc	2.4 b
$L_2G_1N_5$	1695 d	2987 ij	35812 c	16206 fg	1.8 fg
$L_2G_2N_1$	1438 ef	3321 de	31166 ef	10962 j	1.5 ij
$L_2G_2N_2$	1339 f	3222 e-g	29137 f	13564 hi	1.9 ef
$L_2G_2N_3$	1189 g	3043 h-j	26062 g	8120 k	1.5 ij
$L_2G_2N_4$	1389 f	3270 d-f	30147 f	13742 hi	1.8 fg
$L_2G_2N_5$	1230 g	3105 g-i	26912 g	7306 k	1.4 j
S.Em ±	**35.0**	**39.5**	**713.0**	**713.0**	**0.04**

The means followed by the same lower case letters in a column do not differ significant by DMRT

DAS: Days after sowing

L_1: BBF G_1: DWRB –73

L_2: Farmer's Practice G_2: BH - 902

N_1:RDF (50:25:0 N:P_2O_5:K_2O kg ha^{-1}+ 7 t ha^{-1} FYM)

N_2:75% N through urea + 25% N through FYM and recommended P through inorganics

N_3:50% N through urea + 50% N through FYM and recommended P through inorganics

N_4: 75% N through urea + 25% N through Vermicompost and recommended P through inorganics

N_5: 50% N through urea + 50% N through Vermicompost and recommended P through inorganics nearer to experimental field was 721.0 mm. Rain received during *kharif*-2013 and 2014 helped to store moisture in soil during *rabi* season.

Broad bed and furrow (BBF) was formed by using tropicultor 10 days before sowing of *kharif* crop (soybean). The BBF dimensions were 150 cm from furrow centre to centre of the adjacent furrow with raised bed of width 120 cm and height 15 cm. The farmyard manure and vermicompost were applied 10 days before sowing of the crop as per the treatment. Recommended dose of fertilizer 50:25:0 N, P_2O_5, K_2O kg ha^{-1} was applied in the form of urea and diammonium phosphate. Entire N and P_2O_5 were applied as basal. The barley varieties “DWRB - 73” and “BH – 902” were sown at a seed rate of 50 kg ha^{-1} as per the treatments. The soil moisture content on volume basis was worked out by the formula.

Soil moisture content (cm) = Per cent moisture x Bulk density x depth / 100.

The data collected from the experiment subjected to statistical analysis as described by Gomez and Gomez, (1984). Further statistically analysed data were subjected to DMRT. The means followed by the same lower case letters did not differ significant.

RESULTS AND DISCUSSION

Soil moisture content on volumetric basis

The soil moisture content on volumetric basis is differed significantly with respect to broad bed and furrow (BBF) and farmer’s practice. Among the land management practices (*in-situ* moisture conservation practice) *i.e.,* broad bed and furrow recorded significantly higher soil moisture content at 0-15 cm and 15-30 cm soil depth at 30 DAS (4.54 and 4.83 cm, respectively), 60 DAS (3.43 and 4.03 cm, respectively) and at harvest (2.36 and 2.75 cm, respectively) compared to farmer’s practice at 0-15 cm soil depth (3.74, 2.68 and 1.93 cm at 30 DAS, 60 DAS and at harvest, respectively) and 15-30 cm soil depth (3.97, 3.09 and 2.24 cm at 30 DAS, 60 DAS and at harvest, respectively) (Table 1). The substantial highest moisture in these treatments appears to be due to increased opportunity time for the rainwater to stand *in situ* and infiltrate into the deeper layers of soil profile (Mallappa *et al*., 1992). Higher soil moisture under broad bed and furrow was attributed to reduced runoff, soil erosion and higher infiltration rate in the soil. These results are in agreement with the findings of Anjhu George (2014), in barley. The *in situ* moisture conservation practice like broad bed and furrow has been found to be effective in checking the soil erosion and runoff (Selvarajua *et al.,* 1999). Crop yield under rainfed conditions mainly depend on the quantity of rainfall and its distribution that is reflected by the soil moisture content in the profile and supply to the crop at various growth stages. Availability of moisture at critical stages is very important. The results showed that broad bed and furrow recorded significantly higher soil moisture content over flat bed at all the soil depths. Thus, *in situ* moisture conservation practice has resulted in higher soil moisture content in the top 30 cm soil profile compared to flat bed. Similar trend was observed at different soil depths (0-15 cm and 15-30 cm) at all the growth stages of barley crop. This attribute is due to lower changes in soil moisture storage in broad bed and furrow laid out plot compared to farmer’s practice (Flat bed).

Effect of *in-situ* moisture conservation practices, genotypes and INM practices on Productivity

Among the *in-situ* moisture conservation practice *i.e.* broad bed and furrow recorded significantly higher grain yield and straw yield (1757 kg ha^{-1} and 3377 kg ha^{-1}, respectively) compared to farmer’s practice (Table 2). The yield increase was to the extent of 12.9 and 7.4 percent over farmer’s practice. During the individual years of 2013 (13.1 and 7.3%, respectively) and 2014 (12.7 and 7.7%, respectively) also, broad bed and furrow recorded significantly higher grain yield and straw yield compared to farmer’s practice. Similar results were also observed by Anjhu George (2014). This could be attributed to improved performance of growth and yield parameters through adequate availability of nutrients and soil moisture throughout the growing season, which in turn, favourably influenced physiological processes and build up of photosynthates. This is in conformity with the results of Nadaf (2013) wherein BBF method of soil moisture conservation recorded significantly higher seed yield of pigeon pea compared to farmers’ practice. This is also in accordance with the results of Reddy and Sanjeeva (2009) in sorghum + pigeonpea intercropping and Tumbare and Bhoite (2000) in pearlmillet + chickpea intercropping system.

Among the genotypes, genotype DWRB-73 recorded significantly higher grain yield (1888 kg ha^{-1}) compared to genotype BH-902 (1415 kg ha^{-1}) (Table 2). The yield increase was to the extent of 33.4 percent over BH-902. The difference in grain yield might be related to the variation in yield components which in turn, favourably influenced physiological processes and build up of photosynthates. The increased yield of genotype DWRB-73 was mainly due to significant increase in number of productive tillers, spike length and test weight and also greater genetic ability of variety to translocate the photosynthates to economic part. Other factors which indirectly influenced the grain yield are growth attributes *viz*., number of tillers per m row length and total dry matter production at harvest. These results are in concurrence with the findings of Anjhu George (2014) and Ramesh Pal *et al.,* (2013). Crop yield depends not only on the accumulation of photosynthates during the crop growth and development, but also on it’s translocation in the desired storage organs. These intern, are influenced by the efficiency of metabolic processes within the plant. The results are in accordance with Humphreys (1997). BH-902 recorded significantly low yield. This was particularly due to low mean values of several yield components. Genotype BH-902 recorded significantly higher straw yield (3311 kg ha^{-1}) compared to DWRB-73 (3200 kg ha^{-1}) due to its ability to produce higher biomass as it is a dual type variety (Hari Ram *et al.,* 2014). The improvement in the straw yield was to an extent of 3.5 per cent over DWRB-73 (Table 2). This was due to improved growth attributes *viz.* plant height, leaf area and leaf area index. The genotype DWRB-73 had maximum harvest index compared to BH-902 . It was observed that DWRB-73 genotype partitioned more than 9.1 per cent of its total dry mater production towards the economic parts of the plant.

Among the INM practices, significantly higher grain yield (1775 kg ha^{-1}) and straw yield (3392 kg ha^{-1}) was recorded with application of RDF (50:25:0 N:P_2O_5:K_2O kg ha^{-1} + 7 t ha^{-1} FYM) which was on par with the application of 75% N through inorganics + 25% N through vermicompost and recommended P through inorganics (1724 kg ha^{-1}grain yield and 3335 kg ha^{-1} straw yield) followed by the application of 75% N through inorganics + 25% N through FYM and recommended P through inorganics. Whereas, significantly lower grain yield (1521 kg ha^{-1}) and straw yield (3106 kg ha^{-1}) were obtained with the application of 50% N through inorganics + 50% N through FYM and recommended P through inorganics. The grain yield of barley with RDF was more to an extent of 6.0, 16.7, 3.0 and 13.4 percent over N_2, N_3, N_4 and $N_{5,}$ respectively. The factors mainly responsible for variation in the grain yield of barley are due to variations in the performance of yield components *viz.*, productive tillers, spike length, grains per spike and test weight which had direct influence on the grain yield. Other factors which indirectly influenced the grain yield are growth attributes *viz.*, number of tillers and total dry matter production. Variation in the straw yield of barley was due to variations in the performance of growth attributes *viz.* plant height and leaf area index. These results are in agreement with the findings of Roy and Singh (1989), Sharma and Gupta (1994).

Interaction effects revealed that Significantly higher grain yield was obtained with genotype DWRB-73 sown on BBF with the application of RDF (50:25:0 N:P_2O_5:K_2O kg ha^{-1} + 7 t ha^{-1} FYM) (BBF x DWRB-73 x RDF, 2122 kg ha^{-1}) compared to rest of the interactions except it was on par with $L_1G_1N_4$, (2060 kg ha^{-1}) *i.e.* genotype DWRB-73 planted on BBF with the application of 75% N through inorganics + 25% N through vermicompost and recommended P through inorganics. The increase in grain yield with BBF x RDF was due to integrated effect of *in situ* moisture conservation and integrated nutrient management practices and also individual effects of interaction components which might have also contributed for the significance of the interaction (Table 2). The favourable effect of BBF together with RDF in improving the soil fertility might be attributed to more mineralization of nutrients (Sinha *et al.*, 1981 and Dornescu *et al.*, 1992). Significantly higher straw yield was obtained with interaction of genotype BH-902 sown on BBF with the application of RDF (50:25:0 N:P_2O_5:K_2O kg ha^{-1} + 7 t ha^{-1} FYM) (BBF x BH-902 x RDF, 3570 kg ha^{-1}) (Table 2) compared to rest of the interactions except that it was on par with $L_1G_2N_4$, (3508 kg ha^{-1}) *i.e.* genotype BH -902 sown on BBF with the application of 75% N through inorganics + 25% N through vermicompost and recommended P through inorganics. The increase in straw yield with BBF x RDF was due to inherent potential of genotype (BH-902) to produce more biomass as it is dual type variety *i.e.* for both fodder and grain coupled with better storage of moisture with *in situ* moisture conservation practice (BBF), integrated nutrient management practices and also individual effects of interaction components which might have also contributed for the significance of the interaction.

Economics

Crop grown on broad bed and furrow recorded significantly higher gross returns, net returns and benefit cost ratio (Rs. 37401 ha^{-1}, ‘ Rs. 19244 ha^{-1} and 2.1 respectively) compared to farmers’ practice (Rs. 33257 ha^{-1}, Rs. 15351 ha^{-1} and 1.9 respectively) (Table 2). The increase in grain yield obtained with broad bed and furrow has resulted in higher economic returns compared to farmers’ practice. Higher profits were realised due to more uniform and higher yielding crop with BBF (Anjhu George, 2014, Paulpandi *et al.,* 2009 and Kantwa *et al.,* 2006).

Genotype DWRB-73 fetched significantly higher gross return, net return and benefit cost ratio (‘ 39763 ha^{-1}, ‘ 21692 ha^{-1} and 2.2, respectively) compared to BH-902 (Rs. 30706 ha^{-1}, Rs. 12635 ha^{-1} and 1.7, respectively) (Table 2). Higher profit obtained with the genotype DWRB-73 was due to inherent ability of genotype which produced higher grain yield over BH-902.

Among the integrated nutrient management practices, application RDF (50:25:0 N: P_2O_5: K_2O kg ha^{-1} + 7 t ha^{-1} FYM) recorded significantly higher gross return (Rs. 37748 ha^{-1}) which was due to higher grain yield while net return (Rs. 20833 ha^{-1}) and benefit cost ratio (2.2) was higher in application of 75% N through inorganics + 25% N through vermicompost and recommended P through inorganics compared to rest of the integrated nutrient management practices (Table 2). This was due to lower cost of cultivation.

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