EFFICACY OF DUAL GOLD (S-METOLACHLOR) ON WEED BIOMASS, AND ON THE GROWTH AND YIELD COMPONENTS OF SUGAR BEET (*Beta Vulgaris* L.) CV. CALIFORNIA-KWS

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ABSTRACT

Weed infestation is a major problem and matter of concern as it reduces yield as well as quality of many crops including sugar beet. Manual weeding is very tedious, costly, time consuming and most probably non-availability of trained and skillful labor is another issue. Keeping in view these facts, an experiment was performed to evaluate the efficacy of dual gold on the weed biomass (g m^{-2}) and on the growth and yield components of sugar beet (*Beta vulgaris* L.) cv. California-KWS during 2013-14 and 2014-15. The study was performed using RCBD having five treatments and three replications. The treatments included different application times (pre-emergence application and application after 15, 30 and 45 days after emergence) of dual gold (S-metolachlor) and a control (weedy check). Data were recorded on fresh and dry weed biomasses (g m-^{2}), number of leaves plant^{-1}, leaf area plant^{-1} (cm^2), leaf and root weights plant^{-1} (g), sucrose (%), TSS (%), root and sugar yields (t ha^{-1}). The results showed significant variation among the treatments for all parameters during both years of study. Among the treatments, the dual gold (S-metolachlor) applied as pre-emergence reduced weed fresh and dry biomasses (g m^{-2}) and also enhanced number of leaves plant^{-1}, leaf area (cm^2), leaf and root weight plant^{-1}, sucrose (%), TSS (%), root and sugar yields (t ha^{-1}) during both years. Hence, it is concluded that dual gold (S-metolachlor) applied as pre-emergence is best for eradicating weeds at early stages of growth and hence improving yield and quality of sugar beet under Dera Ismail Khan conditions.

Keywords: Quality, Sugar beet, S-metolachlor, Yield

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INTRODUCTION

Sugar beet (*Beta vulgaris* L.) ranks second most important sugar crops after sugar cane with a production of 30% sugar annually all over the world. In the 2014-18 period, the world sugar beet production area averaged to 4,609,469 ha, of which more than 68% were located in Europe. In this period, the average root yield in the world and Europe was close to 60 t ha^{-1} (FAOStat, 2020). Its roots contain 16-20% sucrose concentration (Paul *et al*., 2019). Sugar beet pulp is used to make high fiber dietary food additives while its syrup is used as a spread for sandwiches, cakes, (sweetening) sauces and desserts. In addition to beet root, the leaves are good source of carbohydrates, protein and vitamin A. In addition, leaves are also beneficial as green manure (Katerji *et al.*, 1997). Loam and clay loam soils are best for its cultivation. Sugar beet once established is tolerant to alkaline conditions. It is comparatively resistant to cold and drought (Ebrahimian *et al.*, 2009).

Agriculture sector has an important role in improving the economic growth of Pakistan. However, the production of agricultural crops is far below in most of the developing nations including Pakistan (Mazhar *et al.*, 2021). The contribution of agriculture sector to GDP is 19.3%, although there is a lot of potential in this sector to enhance its share in GDP with the use of modern agricultural techniques and improved crop productivity (GOP, 2020).

In Pakistan, during 2018-19, sugar beet was cultivated on an area of 5627 hectares with a production of 363733 tons, while in Khyber Pakhtunkhwa, it was cultivated on an area of 1014 hectares with an annual production of 38620 tons (FVC, 2020). It is a good alternative sugar crop in the region. Despite numerous advantages over sugarcane, it is still restricted to Khyber Pakhtunkhwa only but the area under this crop is continuously on decline. Moreover, due to lack of technical knowledge its average yield is also reducing. In Pakistan, the availability of agricultural water is unceasingly declining due to which sugarcane cultivation has become a difficult task in some areas. Under such circumstances, the sugar beet is a suitable solution as it has the potential of giving two-time higher sugar yield per hectare as compared to sugarcane in a short period of 5-6 months. Now only two sugar beet crushing mills (Premier in Charsadda and Al-Moiz in D. I. Khan) are working in Khyber Pakhtunkhwa, while the other two have stopped operation due to shortage of raw material. In a short time, sugar beet provides more financial returns per acre than sugar cane (Iqbal and Saleem, 2015). In Khyber Pakhtunkhwa province, sugar beet is commercially grown mostly in areas of Peshawar, Charsadda, Mardan, and the whole District of D. I. Khan. Generally, its sowing is done in October to November and harvested in April to May. Harvesting cannot be delayed from April to the 1st week of May, as a sudden boost in temperature reduces yield and recovery due to root rot causing huge economic losses to the growers. Despite the suitability of agro-climatic conditions, the productivity of sugar beet in Pakistan is far below as compared to its potential. Inadequate supply of essential nutrients, moisture stress at critical growth stages, conventional agronomic practices and abundant weeds are the key factors responsible for low yield.

Weeds reduce production of crops by competing with crops for water, light, nutrients, moisture and space (Anonymous, 2005). Chaudhry *et al*. (2008) reported that when weeds are allowed to grow beyond 50 days after sowing of crop, they reduce grain yield and yield attributes substantially. Work on weed distribution and their management techniques have extensively been done across the world (Boz *et al*., 2000, Pysek *et al*., 2005; Khan *et al*., 2012; Jawad *et al*., 2013; Khaliq *et al*., 2013). Increase in weed density, biomass and species, increases high yield losses (Blackshaw *et al*., 2002). Weeds are one of the biggest limiting factors in crop production, as a result of structural and financial problem, it deteriorates cultural condition of the soil (Farkas, 2006). The chemical weed control in sugar beet not only better, but also more economical than hand weeding and hoeing. s-Metolachlor is chloroacetamide a preplant weed control herbicide but recently, it was also used as post-plant in sugar beet after the crop has two true leaves (Anonymous 2005a, b) but both can cause sugar beet injury under certain conditions in pre and post application (Bollman *et al*., 2008). Use of herbicides is more economical as hand weeding is very costly and have damaging effect on beet crop. Sugar beet crop cultivated in field needed both pre- and post-emergence application of herbicide depending on weed infestation of the field and cultural practices (Mobarak, 2013).

Various types of herbicides are available in the market but their proper and judicious application is still lacking and it needs to be improved. Keeping in view the above-mentioned facts obtained from the past literature, this research was designed to look at the efficacy of dual gold (s-Metolachlor) on weed biomass (g^{-2}) and on the growth and yield components of sugar beet (*Beta vulgaris* L.) under Dera Ismail Khan conditions.

MATERIALS AND METHODS

A field experiments was performed at Horticulture research area, Faculty of Agriculture, Gomal University D. I. Khan during session 2013-14 and 2014-15. The study was performed in RCB Design having five treatments and replicated thrice. The field was ploughed to a fine tilth before planting and plotting was made according to the experimental treatment. The plot size was 4 m × 3 m (12 m^2) with 50 and 20 cm inter and intra-row spacing, respectively. Spacing of 0.6 and 1 m were allocated between plots and blocks, respectively. The hybrid cv. California-KWS seeds were obtained from Al-Moiz Sugar Mills, D. I. Khan and were planted on ridges on 15th October and 17th October, respectively. Dual gold 960EC (S-metolachlor) @ 2 L ha^{-1} was used a solo herbicide. Treatments included pre-emergence application and application at 15, 30 and 45 days after emergence and a weedy check. Plots were irrigated immediately after planting and then fortnightly. Recommended doses of N.P.K fertilizers were given at the rate of 120, 100 and 75 kg ha^{-1}, respectively (Ahmad *et al*., 2010). Two third of N, all P and K were applied before ridge making while rest of N was applied before earthen up of ridges. Urea, TSP and SOP were the source of NPK.

Table. 1. Description of herbicide used for the experiment

Common name	Trade name	Chemical name
S-metolachlor	Dual Gold 960 EC	[2-chloro-6-ethyl-N-(2-methoxy-1-methylethyl) acet-o-toluidide]

Soil analysis

Soil of the experimental plot was clay loam in texture. Soil physico-chemical characteristics were determined before sowing. The detail is given in Table 2.

Table 2: Soil Physicochemical properties of the experimental area.

Soil analysis	2013	2014
EC (ds m^{-1})	4.07	4.06
pH	7.6	7.7
Texture	Clay loam	Clay loam
Saturation (%)	56	55
Organic matter (%)	0.62	0.63
N (%)	0.04	0.06
P ppm	8.00	8.02
K ppm	250	256

Source. Soil Chemistry Laboratory Agriculture Research Institute, Ratta Kulachi, D. I. Khan (KPK), Pakistan.

Weather

Monthly averaged meteorological data i.e. mean temperature; total rainfall and relative humidity of the trial (from sowing to harvesting) are shown in Fig. 1.

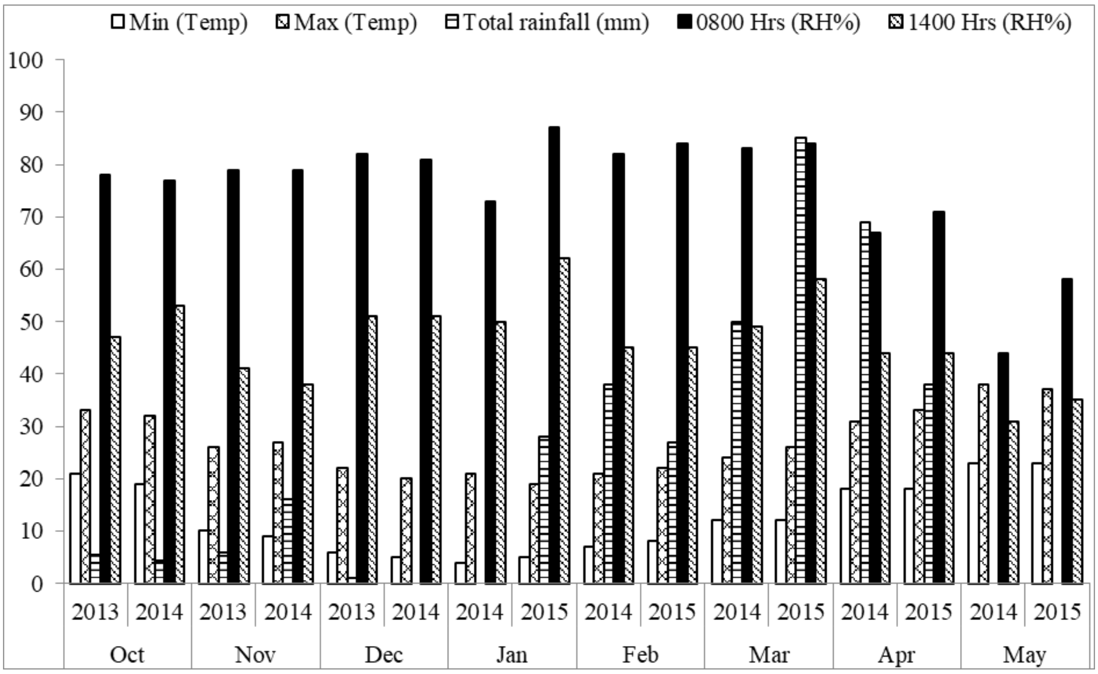

Fig. 1 Meteorological data of spot from October to May (2013-14 and 2014-15)

Data recorded

Data on the following parameters were recorded:

Fresh weed biomass (g m^{-2}): It was measured by taking weeds in one square meter area of each treatment were removed, weighed and averaged.

Dry weed biomass (g m^{-2}): Weeds from $1m^2$ were cut at the ground level and weighed then sun dried for 72 hours to record the dry weight.

Number of leaves $plant^{-1}$: Ten plants from each replication were taken randomly to count leaves and mean was calculated.

Leaf area $plant^{-1}$ (cm^2) was determined as per Ahmad *et al*. (2010.

Leaf and root weight $plant^{-1}$: Ten plants were taken at random from each replication at maturity to determine leaf and root weights by a digital scale (0.01 g precision) and mean was calculated.

Total soluble solids% (TSS%) was assessed using hand refractometer as per A.O.A.C (2005).

Sucrose (%): Sucrose % was determined by Lane and Eynon method as described in A.O.A.C (2005).

Root Yield (t ha^{-1}): At harvest, roots were separated, cleaned and weighed in kilogram (kg), then were converted to estimate root yield ton ha^{-1} as below:

$$\text{Root yield (ton ha} - 1) = \frac{\text{Root yield (kg)} \times 10000}{1000 \times \text{Plot size}}$$

Sugar yield (t ha^{-1}): It was calculated by using following equation

$$\text{Sugar yield} = \frac{\text{Root yield} \times \text{sucrose\%}}{100}$$

Statistical Analysis

All data was subjected to analysis of variance (ANOVA) as stated by Steel and Torrie (1997) using Statistics 8.1 software. Mean values of treatments were compared by using Fisher's protected LSD test and judged at $P \leq 0.05$ levels.

RESULTS AND DISCUSSION

Weeds flora

The following weeds were present in sugar beet field (Table 3).

Table 3. Weeds found in sugar beet crop during 2013-14 and 2014-15.

English Name	Botanical Name
Lamb's quarter	*Chenopodium album* L.
White sweet clover	*Melilotus alba* L.
Wild oat	*Avena fatua* L.
Little canarygrass	*Phalaris minor* Retz.
Purple nutsedge	*Cyprus rotundus* L.
Bermuda grass	*Cynodon dictylon* L.
Field bind weed	*Convolvulus arvensis* L.
Indian clover	*Melilotus indica* L.
Dock broad Leaf	*Rumex dentatus* L.
Wild onion	*Asphodelius tenuifolius* L.
Libbein	*Euphorbia helioscopia* L.

Fresh weed biomass (g m^{-2})

Different application times of Dual gold (S-metolachlor) affected ($P \leq 0.05$) fresh weed biomass (g m^{-2}) during 2013-14 and 2014-15 (Table 4). Maximum fresh weed biomass (1318.3 & 1185.0 g m^{-2}) was found in T1 followed by T5 (1267.7 & 1170.0 g m^{-2}), T4 (1206.3 & 1144.0 g m^{-2}) and T3 (1135.0 & 1131.7 g m^{-2}) while minimum fresh weed biomass (496.7 & 491.3 g m^{-2}) was registered in T2 during both years. Bezuidenhout and Reinhardt (2002), Khan *et al*. (2003), Jacob (2003), Hassan *et al*. (2010), Ali *et al* (2017) and Chang *et al*. (2021) reported similar results in various crops.

Dry weed biomass (g m^{-2})

Dry weed biomass (g m^{-2}) was affected ($P \leq 0.05$) due to different Dual gold (S-metolachlor) application times during 2013-14 and 2014-15 (Table 4). The lowest dry weed biomass (152.67 & 147.67 g m^{-2}) was recorded in T2 and the highest dry weed biomass (430.0 & 408.67 g m^{-2}) was found in T1 followed by T5 (412.33 & 399.67 g m^{-2}), T4 (395.0 & 385.33 g m^{-2}) and T3 (373.67 & 359.33 g m^{-2}) during both years. These results corroborate the findings of Abdullah *et al*. (2008) and Saleem *et al.* (2015) who recorded minimum dry biomass in the treatment where Dual gold was applied as pre-emergence. Chang *et al*. (2021) reported similar results in barley.

Number of leaves plant^{-1}

The number of leaves plant^{-1} improved ($P \leq 0.05$) due to Dual gold (S-metolachlor) application times during 2013-14 and 2014-15 (Table 4). The maximum leaf count (38.53 & 43.47) was recorded in T2 followed by T3 (37.73 & 42.70), T4 (36.53 & 40.53) and T5 (36.17 & 39.47) while lowest (33.87 & 38.13) was noticed in T1 during both years. It might be due to reduced competition between weeds and the sugar beet plants resulting in increased water absorption and fertilizers from the soil, ultimately enhance vegetative growth. The results agree with Jursik *et al.* (2008), Baloch *et al.* (2013), Mobarak (2013) and Hameed *et al.* (2017).

Leaf area plant^{-1} (cm^2)

Leaf area plant^{-1} (cm^2) differed ($P \leq 0.05$) due to Dual gold (S-metolachlor) application times during 2013-14 and 2014-15 (Table 4). Significantly maximum leaf area (486.03 & 486.74 cm^2) was observed in T2 followed by T3 (476.42 & 479.06 cm^2), T4 (465.72 & 475.99 cm^2) and T5 (445.99 & 468.42 cm^2) and the lowest leaf area (424.02 & 434.42 cm^2) was observed in T1 during both years. Leaf area has a massive role in the canopy closure of the crop and restricting the weeds, hence yield will be directly affected by its size and indirectly weeds also (Gregory *et al*., 1994; Roggenkamp, 1997). The findings might be due to superior leaf number and size in pre-emergence application due to minimum competition between beets and weeds for nutrition. The results are in line with Hassan *et al.* (2010) and Khan (2002) who reported least leaf area of maize in weedy check.

Leaf weight plant^{-1} (g)

Leaf weight plant^{-1} (g) differed ($P \leq 0.05$) due to Dual gold (S-metolachlor) application times (Table 4). Significantly maximum leaf weight plant^{-1} (386.90 & 385.44 g) was observed in T2 followed by T3 (384.61 & 384.33 g), T4 (382.46 & 383.80 g) and T5 (377.06 & 382.55 g) while lowest leaf weight plant^{-1} (360.32 & 380.62 g) was observed in T1 during both years. The result might be due to better leaf growth and size with pre-emergence application of S-metolachlor due to better weed control, lowering the competition between crop-weed for nutrition. The results agree with Jursik *et al.* (2008), Rasha (2010) and Mobarak (2013).

Table. 4 Effect of dual gold (S-metolachlor) on Fresh and Dry weed biomasses (g m^{-2}), Number of leaves plant^{-1}, Leaf area plant^{-1}(cm^2), Leaf weight plant^{-1}(g)

Treatments	Fresh weed biomass (g m^{-2})	Dry weed biomass (g m^{-2})	Number of leaves plant^{-1}	Leaf area plant^{-1} (cm^2)	Leaf weight plant^{-1}(g)
Year 2013-14					
T$_1$	1318.3 a	430.00 a	33.87 c	424.02 e	360.32 c
T$_2$	496.7 e	152.67 e	38.53 a	486.03 a	386.90 a
T$_3$	1135.0 d	373.67 d	37.73 a	476.42 b	384.61 ab
T$_4$	1206.3 c	395.00 c	36.53 b	465.72 c	382.46 ab
T$_5$	1267.7 b	412.33 b	36.17 b	445.99 d	377.06 b
LSD	37.691	11.868	1.0330	2.6426	8.3949
Year 2014-15					
T$_1$	1185.0 a	408.67 a	38.13 e	434.42 e	380.62 e
T$_2$	491.3 c	147.67 d	43.47 a	486.74 a	385.44 a
T$_3$	1131.7 b	359.33 c	42.70 b	479.06 b	384.33 b
T$_4$	1144.0 b	385.33 b	40.53 c	475.99 c	383.80 c
T$_5$	1170.0 a	399.67 a	39.47 d	468.42 d	382.55 d
LSD	20.003	9.3954	0.5064	0.8077	0.1635

Means sharing similar letters do not differ ($P \leq 0.05$)

T1=Control (weedy check), T2=Pre-emergence, T3=15 days after emergence, T4=30 days after emergence, T5=45 days after emergence.

Root weight plant^{-1} (g)

Dual gold (S-metolachlor) application times affected ($P \leq 0.05$) root weight plant^{-1} (g) significantly during 2013-14 and 2014-15 (Table 5). Highest root weight plant^{-1} (1276.8 & 1298.4 g) was observed in T2 followed by T3 (1267.5 & 1284.4 g), T4 (1259.8 & 1283.8 g) and T5 (1236.4 & 1282.8 g) while minimum root weight plant^{-1} (1158.6 & 1169.8 g) was observed in T1 during both years. It might be due to the efficacy of S-metolachlor controlling weeds at early stage of the growth resulting higher element accumulation in roots. Findings are in alignment with Salehi *et al.* (2006), Hassan *et al.* (2010), Mobarak (2013) and Merga and Alemu (2019).

Sucrose (%)

Weed treatments affected ($P \leq 0.05$) sucrose contents during both years as illustrated in Table 5. The highest sucrose% (16.32 & 16.47) was found in T2 followed by T3 (16.23 & 16.32), T4 (16.11 & 16.28) and T5 (15.99 & 16.23) and minimum sucrose% (15.90 & 15.87) was registered in T1 during both years. The result might be due to quality of crop produced under weeds free field. The results are in alignment with Fayed *et al.* (1999), Bosak and Mod (2000), Alaoui *et al.* (2003), Khan *et al.* (2006) and Mobarak (2013).

Total Soluble Solids (TSS%)

Different weed treatments affected ($P \leq 0.05$) the TSS% during both years as shown in Table 5. The highest TSS%

(18.51 & 18.73) was found in T2 followed by T3 (18.45 & 18.65), T4 (18.40 & 18.60) and T5 (18.33 & 18.47) while minimum TSS% (18.27 & 18.37) was registered in T1 during both years. The results agree with those reported by Bosak and Mod (2000), Khan *et al.* (2006) and Mobarak (2013).

Root yield (t ha^{-1})

Root yield (t ha^{-1}) was affected ($P \leq 0.05$) due to different weed treatments during 2013-14 and 2014-15 (Table 5). Significantly highest root yield (62.27 & 64.28 t ha^{-1}) was found in T2 followed by T3 (62.17 & 63.62 t ha^{-1}), T4 (60.97 & 63.39 t ha^{-1}) and T5 (60.67 & 62.70 t ha^{-1}) while minimum root yield (58.45 & 60.45 t ha^{-1}) was found in T1 during both years. The increase in root yield might be due to effective weed control in pre-emergence application as weeds are major hindrance in yield. The results agree with Khan *et al.* (2006), Salehi *et al.* (2006), Odero *et al.* (2010) and Mobarak (2013). Similarly, Khatam *et al.* (2013) reported significantly maximum grain yield in Dual Gold treatments. Chang *et al*. (2021) reported similar results in barley.

Sugar yield (t ha^{-1})

Data regarding sugar yield (t ha^{-1}) show significant variation due to different weed treatments during 2013-14 and 2014-15 (Table 5). Significantly highest sugar yield (10.16 & 10.59 t ha^{-1}) was found in T2 followed by T3 (9.88 & 10.38 t ha^{-1}), T4 (9.82 & 10.32 t ha^{-1}) and T5 (9.70 & 10.18 t ha^{-1}) while minimum sugar yield (9.30 & 9.59 t ha^{-1}) was found in T1 during both years. The results might be due to improved root yield and decreased weed biomass (g m^{-2}). The results agree with Alaoui *et al.* (2003), Khan *et al.* (2006), Salehi *et al.* (2006) and Mobarak (2013).

Table 5. Effect of dual gold (S-metolachlor) on Root weight plant^{-1}(g), Sucrose%, TSS%, Root and Sugar yield (t ha^{-1})

Year 2013-14					
Treatments	**Root weight plant^{-1}(g)**	**Sucrose%**	**TSS%**	**Root yield (t ha^{-1})**	**Sugar yield (t ha^{-1})**
T_1	1158.6 d	15.90 d	18.27 c	58.45 d	9.30 c
T_2	1276.8 a	16.32 a	18.51 a	62.27 a	10.16 a
T_3	1267.5 ab	16.23 ab	18.45 ab	62.17 a	9.88 b
T_4	1259.8 b	16.11 bc	18.40 b	60.97 b	9.82 b
T_5	1236.4 c	15.99 cd	18.33 c	60.67 c	9.70 b
LSD	15.000	0.1250	0.0654	0.1644	0.2794
Year 2014-15					
T_1	1169.8 e	15.87 d	18.37 e	60.45 e	9.59 e
T_2	1298.4 a	16.47 a	18.73 a	64.28 a	10.59 a
T_3	1284.4 b	16.32 b	18.65 b	63.62 b	10.38 b
T_4	1283.8 c	16.28 bc	18.60 c	63.39 c	10.32 c
T_5	1282.8 d	16.23 c	18.47 d	62.70 d	10.18 d
LSD	0.2493	0.0740	0.0257	0.1003	0.0527

Means sharing similar letters do not differ ($P \leq 0.05$)

T1=Control (weedy check), T2=Pre-emergence, T3=15 days after emergence, T4=30 days after emergence, T5=45 days after emergence

CONCLUSION AND RECOMMENDATIONS

The study has revealed that dual gold (S-metolachlor) suppressed weed growth in sugar beet field which in turn improved root and sugar yield. As a result, it can be deduced that applying dual gold as a pre-emergence is the most effective for controlling of weed and improving yield and quality of sugar beet. However, further research work needs to explore more weed management strategies to control weeds and to enhance the yield of sugar beet crop in the area.

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