IJPS INTERNATIONAL JOURNAL OF PLANT SCIENCES
e ISSN-0976-593X Volume **12** | Issue 1 | January, 2017 | 56-60

**DOI: 10.15740/HAS/IJPS/12.1/56-60**
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**RESEARCH ARTICLE**

# Direct and indirect effect of the oat (*Avena sativa* L.) component characters on the dry forage production

■ **R. E. KAKAD, D.R. SAPKAL, A. G. IRATKAR AND G. K. THAKARE**

## SUMMARY

Oat (*Avena sativa* L.), one of the important dual purpose crops of the world is grown for food and forage purpose. In India it is exclusively grown as fodder. Sixteen genotypes of oat were grown at the Central Research Farm of Bidhan Chandra Krishi Viswavidyalaya, Gayeshpur, Nadia, W. Bengal in the *Rabi* season of 2010-11 to estimate the direct and indirect effect of the component characters on the dry matter production. Path analysis carried out considering total dry weight per tiller at 50 per cent flowering as the dependent variable revealed in some characters like plant height at 20 days, fresh weight of per tiller at 40 days, dry weight of leaves per tiller at 40 days, total dry weight per tiller at 40 days and total chlorophyll content in spite of negative direct effect, the correlation value was positive. Again in some characters in spite of significantly positive direct effect, the correlation value was negative e.g. fresh weight of leaves per tiller at 50 per cent flowering. But characters like plant height at 40 days, plant height at 50 per cent flowering, fresh weight per tiller at 50 per cent flowering, dry weight of leaves per tiller at 50 per cent flowering, fresh weight of stem per tiller at 50 per cent flowering, dry weight of stem per tiller at 50 per cent flowering and chlorophyll 'a' both direct effect and correlation were positive. In case of dry weight per plant at 20 days, fresh weight of stem per tiller at 40 day, dry weight of stem per tiller at 40 days, dry weight of flag leaf and chlorophyll 'b' there was strong positive direct effect but no correlation could be established with dry weight of stem per tiller at 50 per cent flowering.

**Key Words :** Path analysis, Direct, Indirect effects, Dry forage

**How to cite this article :** Kakad, R.E., Sapkal, D.R., Iratkar, A.G. and Thakare, G. K. (2017). Study of morphological and genetical variabilities for improving forage production in oat. *Internat. J. Plant Sci.*, **12** (1): 56-60, **DOI: 10.15740/HAS/IJPS/12.1/56-60**.

**Article chronicle : Received :** 13.06.2016; **Revised :** 19.11.2016; **Accepted :** 15.12.2016

Inadequate feed during the dry winter (December-April) is one of the biggest constraints to livestock development. Livestock get the most of the green matter from June to September and the quality of forage available during this period could be regarded as more or less adequate, it is different in winter, when rice straw, maize stover and other fibrous crop by-products are important foods because crop residues are of very poor quality. Oat (*Avena sativa* L.), one of the important dual purpose crops of the world is grown for food and forage purpose. In India it is exclusively grown as fodder.The nutritive value of oat forage is high and showed to have dry matter digestibility in excess of 75 per cent when fed to dairy cattle Burgess *et al*. (1972). Cereal straws

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have similar chemical compositions but oat straw has higher digestibility organic matter content (Cuddeford, 1995). Thus, the present study was undertaken to estimate the variability in germplasm and other standard varieties of *Avena sativa* species for different fodder characters. However, to obtain a clear picture of the inheritance pattern of different dry matter yielding attributes the experiment was under taken to study the direct and indirect effect of the component characters on the dry matter production.

## MATERIAL AND METHODS

The field experiment was conducted at the Central Research Farm of Bidhan Chandra Krishi Viswavidyalaya, Gayeshpur, Nadia, West Bengal. Geographically the farm is situated 9.7m above sea level at 23.50N latitude and 810E longitude. The farm has mostly well drained upland soil of new alluvial type with low to medium fertility level. The present experiment was conducted in a plot with medium fertility.

The 16 different genotypes of oat used in this experiment were; NDO-712, NDO-729, JHO-2010-1, JHO-2010-2, UPO-10-1, UPO-10-2, SKO-188, SKO-170, JO-03-97, JO-03-99, ANDO-3, OS-377, OL-1709, KENT, OS-6 and JHO-99-2.

The field lay out was in a Randomized Block Design. There were 16 genotypes grown in 3 replications. The plot size for each genotype in each replication was 3.0 m ×3.0 m. Each plot accommodated 12 rows of 3m length at a distance of 25 cm between rows. The seed rate was 120g/plot. The gap between plots and replications was 0.5m and 1.0m, respectively.

To calculate direct and indirect component effects in oat crop, path analysis was carried out in the research work. Path co-efficient can be defined as the ratio of the standard deviation of the effect due to given cause to the total standard deviation of the effect. The path co-efficient analysis was calculated to estimate direct and indirect contribution of characters with five characters as described by Dewey and Lu (1959) at genotypic level. The following set of simultaneous equations were formed and solved for estimating various direct and indirect effects.

rIy= pIy+rI2 p2y + rI3p3y+ …….. + r11pIy
r2y= r21p1y + p2y+r23p2y ……+ r21pIy
rIy= pI1y+rI2 p2y + rI3p3y+ …….. + pIy

Here, r1y to rIy = correlation co-efficient between causal factor 1 to 1 with
y = dependent character ; r12 to r1-1. I = co-efficient of correlation among causal factors.
P1y to PIy = direct effect of character 1 to I on character y.

## RESULTS AND DISCUSSION

Path co-efficient splits the interrelationship into direct and indirect effects. Pathway revealing genotypic associations of total dry weight per tiller at 50 per cent flowering attributing characters are presented in Table 1.

In the present experiment path analysis was carried out considering total dry weight per tiller at 50 per cent flowering as the dependent variable. There were twenty four independent variables *viz.*, D.GER, PH 20 days age of the crop, PH 40 days age of the crop, PH 50 per cent, FW/P 20, DW/20, TFW/T 40, FWL/T 40, DWL/T 40, FWS/T 40, DWS/T 40, TDW/T 40, TFW/T 50 per cent, FWL/T 50 per cent, DWL/T 50 per cent, FWS/T 50 per cent, DWS/T 50 per cent, FWFL, DWFL, FLA, Ch 'a', Ch 'b', TCh and CP per cent.

Perusal of Table 1 reveals some interesting features; (i) in case of some of the characters, the direct effect was negative but the correlation was positive; (ii) in others, both the direct effect and correlation were positive and (iii) the third situation was in spite of high positive direct effect no correlation could be observed.

The first situation could be recorded in case of plant height at 20 days, total fresh weight per tiller at 40 days, dry weight of leaf per tiller at 40 days, total dry weight per tiller at 40 days and total chlorophyll content. It was observed that a strong negative direct effect of such characters were nullified by the indirect effect of other characters such as in case of PH 20, its negative direct effect was nullified by PH 50 per cent, FWL / T40, TFW / T 50 per cent, DWL/T 50 per cent and Ch 'a' so much so that the correlation value between this character and total dry weight per tiller at 50 per cent flowering was significantly positive. Again, in case of fresh weight per tiller at 40 days, its negative direct effect was negated by many characters but some of the conspicuous ones are, PH 50 per cent, FWL/T 40, FWS/T 40, DWS/T 40, TFW/T 50 per cent, DWL/T 50 per cent and FWS/T 50 per cent which might have contributed indirectly to give an ultimate result of positive correlation. Further, in case of DWL/T 40 it was observed that the direct effect of the character on TDW/T 50 per cent was high and negative but its effect via PH 50 per cent, FW/P20, FWL/T 40, FWS/T 40, DWS/T 40, TFW/T 50 per cent, DWL/T 50

per cent, Ch 'a' and Ch 'b' had been substantially high to revert the negative direct effect and ultimately reveal a significant and positive correlation. Similarly the effect of TDW/T 40 via PH 50%, FWL/T 40, FWS/T 40, DWS/T 40, TFW/T 50 per cent, DWL/T 50 per cent and Ch 'b' on TDW/T 50 per cent had been positive and the direct effect was negative but the correlation value was significant and positive. Therefore, in case of this character also it may be assumed that the indirect effect may have played enough cumulative roles to reveal a positive correlation between these two characters. In spite of negative direct effect a significantly positive correlation was observed in case of total chlorophyll content. In this case the indirect effect of DWL/T 50 per cent, Ch 'a' and Ch 'b' had been positive and high which might have played significant role to reveal the character to produce a significantly positive correlation. Interestingly among the above characters that exhibited significantly positive correlation in spite of negative direct effect the contribution of PH 50 per cent, FWL/T 40, FWS/T40 , DWS/T 40, TFW/T 50 per cent and DWL/T 50 per cent has been common and the contribution of FWS/T40 and DWL/T 50 per cent have been much conspicuous.

There were some characters where both direct effect and correlation values were positive. Such situations could be seen in case of PH 40, PH 50 per cent flowering, FWL/T 40, TFW/T 50 per cent DWL/T 50 per cent FWS/T 50 per cent and DWS/T 50 per cent. It may be mentioned here that in the aforementioned characters, in addition to positive direct effect the effect of this character via PH 50 per cent, FWL/T 40, FWS/T40, DWS/T 40, TFW/T 50 per cent and DWL/T 50 per cent have been positive. Therefore, significantly positive association seems obvious. It may be mentioned that the indirect effect of these same characters played significant role when negative direct effect of a character as describe above was revealed to produce positive correlation. Besides the above characters, the indirect effect of some

**Table 1 : Direct and indirect effects of component characters on total dry matter yield per tiller at 50 per cent flowering**

| Effect of character | FWL/T 50% | DWL/T 50% | FWS/T 50% | DWS/T 50% | FWFL | DWFL | FLA | Ch 'a' | Ch 'b' | TCh | CP% | TDW/T50% (genotypic correlation) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D GER | 0.0341 | -0.9421 | -0.0702 | -0.0371 | 0.1788 | -0.1302 | 0.2448 | -0.1067 | 0.1447 | -0.0175 | 0.0150 | -0.434 |
| PH 20 | -0.0896 | 0.3404 | 0.0927 | 0.0491 | -0.0282 | -0.0166 | -0.1300 | 0.1802 | 0.0072 | -0.1418 | 0.0096 | 0.620* |
| PH 40 | -0.0824 | 0.4131 | 0.0941 | 0.0480 | -0.1023 | 0.1200 | -0.2057 | 0.0427 | -0.1181 | 0.0473 | 0.0515 | 0.707** |
| PH 50% | -0.0656 | 0.3419 | 0.0542 | 0.0351 | -0.0938 | 0.1063 | -0.1462 | -0.0526 | -0.1209 | 0.1217 | 0.0419 | 0.590* |
| FW/P 20 | 0.0938 | -0.1791 | -0.0427 | -0.0067 | -0.0842 | 0.1246 | 0.0825 | -0.3914 | -0.0158 | 0.3406 | 0.0360 | -0.235 |
| DW/P 20 | 0.0764 | 0.0162 | -0.0302 | 0.0093 | 0.0241 | 0.0004 | 0.2717 | -0.1838 | -0.0264 | 0.1943 | 0.0309 | 0.073 |
| TFW/T 40 | -0.0877 | 0.3077 | 0.1089 | 0.0553 | -0.1310 | 0.0874 | -0.3157 | 0.0693 | 0.0975 | -0.1295 | 0.0173 | 0.639** |
| FWL/T 40 | -0.0995 | 0.3005 | 0.1012 | 0.0493 | -0.1082 | 0.0685 | -0.2945 | 0.0322 | 0.1021 | -0.0991 | 0.0179 | 0.591* |
| DWL/T40 | -0.0993 | 0.3903 | 0.0947 | 0.0437 | -0.0674 | 0.0629 | -0.3210 | 0.1063 | 0.1258 | -0.1842 | 0.0098 | 0.650** |
| FWS/T 40 | -0.0305 | 0.1351 | 0.0516 | 0.0227 | -0.3186 | 0.2885 | -0.4756 | 0.0791 | 0.0924 | -0.1366 | -0.0138 | 0.262 |
| DWS/T40 | -0.0061 | -0.0331 | 0.0963 | 0.0402 | -0.1841 | 0.1592 | -0.3424 | 0.0480 | 0.0770 | -0.1043 | -0.0153 | 0.201 |
| TDW/T40 | -0.0924 | 0.3502 | 0.0966 | 0.0431 | -0.0971 | 0.0889 | -0.3526 | 0.0974 | 0.1183 | -0.1724 | 0.0064 | 0.604* |
| TFW/T50% | -0.1039 | 0.4218 | 0.1251 | 0.0613 | 0.0251 | -0.0385 | -0.1886 | 0.2656 | -0.0168 | -0.2185 | 0.0250 | 0.799** |
| FWL/T50% | -0.1462 | 0.3890 | 0.0246 | 0.0047 | 0.1117 | -0.1255 | -0.1182 | 0.1126 | 0.1243 | -0.2022 | 0.0258 | 0.392 |
| DWL/T50% | -0.0909 | 0.6258 | 0.0567 | 0.0392 | 0.0591 | -0.0423 | -0.1615 | 0.4329 | 0.1813 | -0.4900 | -0.0059 | 0.863** |
| FWS/T50% | -0.0230 | 0.2272 | 0.1562 | 0.0834 | 0.0026 | -0.0259 | -0.0813 | 0.2230 | -0.0452 | -0.1484 | 0.0066 | 0.757** |
| DWS/T50% | -0.0080 | 0.2834 | 0.1504 | 0.0866 | -0.0300 | 0.0061 | -0.0452 | 0.2311 | -0.0545 | -0.1436 | 0.0100 | 0.842** |
| FWFL | 0.0340 | -0.0771 | -0.0008 | 0.0054 | -0.4799 | 0.4813 | -0.3703 | -0.0906 | -0.1201 | 0.1373 | 0.0189 | -0.038 |
| DWFL | 0.0368 | -0.0532 | -0.0081 | 0.0010 | -0.4640 | 0.4978 | -0.3831 | -0.1279 | -0.1314 | 0.1705 | 0.0283 | -0.037 |
| FLA | -0.0321 | 0.1878 | 0.0236 | 0.0072 | -0.3301 | 0.3542 | -0.5384 | -0.0332 | 0.1201 | -0.0812 | 0.0031 | 0.227 |
| Ch 'a' | -0.0226 | 0.3717 | 0.0478 | 0.0274 | 0.0597 | -0.0874 | 0.0245 | 0.7287 | 0.0367 | -0.6209 | -0.0527 | 0.546* |
| Ch 'b' | -0.0337 | 0.2107 | -0.0131 | -0.0087 | 0.1071 | -0.1214 | -0.1201 | 0.0497 | 0.5385 | -0.4121 | .-0.0328 | 0.111 |
| TCh | -0.0410 | 0.4251 | 0.0321 | 0.0172 | 0.0914 | -0.1176 | -0.0606 | 0.6273 | 0.3077 | -0.7212 | -0.0600 | 0.511* |
| CP% | 0.0392 | 0.0387 | -0.0108 | -0.090 | 0.0944 | -0.1464 | 0.0178 | 0.3989 | 0.1838 | -0.4497 | -0.0962 | -0.039 |

*Table 1 : Contd……..*

Table 1 : Contd……

| Effect of character | D GER | PH 20 | PH 40 | PH 50% | FW/P 20 | DW/P 20 | TFW/T 40 | FWL/T 40 | DWL/T 40 | FWS/T 40 | DWS/T 40 | TDW/T 40 | TFW/T 50% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D GER | -0.0383 | 0.1371 | -0.0381 | -0.2452 | -0.0231 | 0.0457 | 0.1913 | -0.1376 | 0.0542 | -0.2534 | -0.1140 | 0.0412 | -0.0756 |
| PH 20 | 0.0304 | -0.1728 | 0.0520 | 0.2437 | 0.0227 | -0.0268 | -0.2372 | 0.1692 | -0.0678 | 0.1711 | 0.0985 | -0.0485 | 0.1154 |
| PH 40 | 0.0211 | -0.1300 | 0.0691 | 0.2983 | 0.0117 | -0.0285 | -0.1942 | 0.1394 | -0.0599 | 0.1354 | 0.0564 | -0.0421 | 0.1215 |
| PH 50% | 0.0238 | -0.1066 | 0.0521 | 0.3951 | 0.0131 | -0.0112 | -0.1491 | 0.1218 | -0.0512 | 0.0535 | -0.0239 | -0.0339 | 0.0843 |
| FW/P 20 | -0.0116 | 0.0516 | -0.0106 | -0.0683 | -0.0760 | 0.1043 | 0.1258 | -0.1067 | 0.0475 | -0.1235 | -0.0583 | 0.0352 | -0.1016 |
| DW/P 20 | -0.0148 | 0.0393 | -0.0167 | -0.0375 | -0.0673 | 0.1178 | 0.1162 | -0.1032 | 0.0512 | -0.2223 | -0.1301 | 0.0403 | -0.0827 |
| TFW/T 40 | 0.0278 | -0.1557 | 0.0509 | 0.2239 | 0.0363 | -0.0520 | -0.2632 | 0.1946 | -0.0824 | 0.3298 | 0.1796 | -0.0618 | 0.1314 |
| FWL/T 40 | 0.0269 | -0.1496 | 0.0491 | 0.2455 | 0.0414 | -0.0620 | -0.2614 | 0.1960 | -0.0850 | 0.2903 | 0.1638 | -0.0629 | 0.1287 |
| DWL/T40 | 0.0235 | -0.1327 | 0.0469 | 0.2293 | 0.0409 | -0.0684 | -0.2458 | 0.1886 | -0.0883 | 0.2685 | 0.1626 | -0.0653 | 0.1282 |
| FWS/T 40 | 0.0215 | -0.0654 | 0.0207 | 0.0468 | 0.0208 | -0.0579 | -0.1921 | 0.1259 | -0.0524 | 0.4519 | 0.2271 | -0.0444 | 0.0653 |
| DWS/T40 | 0.0155 | -0.0605 | 0.0138 | -0.0335 | 0.0157 | -0.0545 | -0.1680 | 0.1140 | -0.0510 | 0.3646 | 0.2814 | -0.0437 | 0.0712 |
| TDW/T40 | 0.0240 | -0.1276 | 0.0443 | 0.2040 | 0.0407 | -0.0724 | -0.2476 | 0.1876 | -0.0878 | 0.3052 | 0.1875 | -0.0657 | 0.1253 |
| FW/T50% | 0.0196 | -0.1355 | 0.0570 | 0.2263 | 0.0525 | -0.0662 | -0.2349 | 0.1714 | -0.0769 | 0.2005 | 0.1362 | -0.0559 | 0.1472 |
| WL/T50% | 0.0089 | -0.1060 | 0.0389 | 0.1775 | 0.0488 | -0.0615 | -0.1579 | 0.1334 | -0.0600 | 0.0944 | 0.0118 | -0.0415 | 0.1046 |
| WL/T50% | 0.0119 | -0.0940 | 0.0456 | 0.2158 | 0.0217 | 0.0030 | -0.1294 | 0.0941 | -0.0550 | 0.0976 | -0.0148 | -0.0367 | 0.0992 |
| WS/T50% | 0.0172 | -0.1026 | 0.0416 | 0.1371 | 0.0208 | -0.0228 | -0.1835 | 0.1270 | -0.0535 | 0.1493 | 0.1735 | -0.0406 | 0.1179 |
| WS/T50% | 0.0164 | -0.0980 | 0.0383 | 0.1601 | 0.0059 | 0.0127 | -0.1680 | 0.1117 | -0.0445 | 0.1186 | 0.1308 | -0.0327 | 0.1042 |
| FWFL | 0.0142 | -0.0101 | 0.0147 | 0.0773 | -0.0133 | -0.0059 | -0.0718 | 0.0442 | -0.0124 | 0.3000 | 0.1079 | -0.0133 | -0.0077 |
| DWFL | 0.0100 | 0.0057 | 0.0166 | 0.0843 | -0.0190 | 0.0001 | -0.0462 | 0.0269 | -0.0111 | 0.2618 | 0.0900 | -0.0117 | -0.0114 |
| FLA | 0.0145 | -0.0417 | 0.0264 | 0.1073 | 0.0116 | -0.0595 | -0.1543 | 0.1072 | -0.0526 | 0.3992 | 0.1790 | -0.0430 | 0.0515 |
| Ch ‘a’ | 0.0056 | -0.0427 | 0.0040 | -0.0285 | 0.0408 | -0.0297 | -0.0250 | 0.0086 | -0.0129 | 0.0491 | 0.0185 | -0.0087 | 0.0536 |
| Ch ‘b’ | -0.0103 | -0.0023 | -0.0151 | -0.0887 | 0.0022 | -0.0057 | -0.0476 | 0.0371 | -0.0206 | 0.0775 | 0.0402 | -0.0144 | -0.0046 |
| TCh | -0.0009 | -0.0340 | -0.0045 | -0.0666 | 0.0359 | -0.0317 | -0.0472 | 0.0269 | -0.0225 | 0.0855 | 0.0407 | -0.0157 | 0.0446 |
| CP% | 0.0059 | 0.0173 | -0.0370 | -0.1719 | 0.0285 | -0.0378 | 0.0474 | -0.0365 | 0.0090 | 0.0647 | 0.0449 | 0.0043 | -0.0383 |

Residual effect =0.074 * and ** indicate significance of values at P=0.05 and 0.01, respectively

other characters like DWFL, Ch ‘a’ and Ch ’b’ also had positive indirect effect.

In addition to the above, a third situation as stated earlier could be seen where in spite of positive direct effect of no correlation could be discerned by a character with TDW/T 50 per cent. Such characters were, DW/P 20, FWS/T 40, DWS/T 40, DWFL, Ch ‘b’. In case of these characters it was observed that the indirect effect of some of the characters had been more negative than positive effect of others. As for example it can be seen from Table 1 that the indirect effect of FWS/T 40, DWS/T 40 via FWFL and FLA had been highly negative though indirect effects of some other characters like FWL/T 40 and DWS/T 40 had been positive but it might have happened that the positive effects could not substantiate the negative effects and as a result the positive direct effect could not be reflected in case of correlation. Similar had been the situation in case of the other characters also that exhibited no correlation in spite of having positive direct effect. Arunkumar *et al.* (2004) studied 27 genotypes of oat, path analysis revealed that plant height, tillers per meter and leaves per tiller had positive directs effects on green fodder and dry matter yields in the first cut, while in the second cut only plant height had strong direct effect on green fodder and dry matter yields. Katiyar and Choudhary (1999) reported in oat that the path analysis revealed the highest positive contribution of plant height towards green fodder yield followed by leaf length, leaf: stem ratio and leaf width respectively. Further results indicated that plant height contributed maximum towards green fodder directly and indirectly through leaf length. Pundir *et al.* (2003) reported in oat that path analysis revealed that all the characters had large positive direct effect on green fodder yield via green leaf weight and green stem weight. Shekhawat and Garg (2006) reported in oat that path co-efficient analysis at phenotypic level revealed high direct effect of plant height, tillers per meter, leaf length, leaf width

and stem girth on green fodder yield.

In Sudan grass, dry matter yield was highly and directly affected by the number of leaves, dry matter content, leaf length and green fodder yield; when dry matter yield had a negative direct effect on days to flowering, stem girth, leaf width, crude protein content and plant height (Sunku *et al.*, 2002).

**Conclusion :**

Path analysis was carried out considering total dry weight per tiller at 50 per cent flowering as the dependent variable. The following relations could be obtained from the path analysis

– In spite of significantly negative direct effect of a character the correlation value was positive e.g. height at 20 days, total fresh weight of per tiller at 40 days, dry weight of leaves per tiller at 40 days, total dry weight per tiller at 40 days and total chlorophyll content.

– In spite of significantly positive direct effect of a character the correlation value was negative e.g. fresh weight of leaves per tiller at 50 per cent flowering.

–Both direct effect and correlation were positive e.g. plant height at 40 days, plant height at 50 per cent flowering, total fresh weight per tiller at 50 per cent flowering, dry weight of leaves per tiller at 50 per cent flowering, fresh weight of stem per tiller at 50 per cent flowering, dry weight of stem per tiller at 50 per cent flowering and chlorophyll 'a'.

– Both direct effect and correlation were negative e.g. fresh weight per plant at 20 days, fresh weight of flag leaf and flag leaf area.

– Strong positive direct effect but no correlations due to negative indirect effect of independent characters e.g. dry weight per plant at 20 days, fresh weight of stem per tiller at 40 day, dry weight of stem per tiller at 40 days, dry weight of flag leaf and chlorophyll 'b'.

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