# Impact of meteorogical conditions on the need in adaptive perfoming of technological operations of soil tillage and crop sowing

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Abstract. The article discusses the impact of the agrarometeorological conditions on the state of soil and the processes connected with soil tillage and crop sowing. It determines agrotechnological reasons of technological adapting of these operations to enviromental conditions. It sets the terms of qualitative modifications in soil under the impact of agrometeorological conditions within spring and summer-autumn periods

Key words: soil, sowing, agrometeorological conditions, fund of time, variability, technological operation, simulation, indices, complexes of machines, efficiency.

## SETTING OF THE PROBLEM

Agrometeorological conditions infuence the fields soils and hence, cause modifications of the terms of perfoming soils tillage and crop sowing operations. This phenomenon objectively predetermines the need in technological adaptation to the state of objects of labour both in spring and in summer-autumn periods. Therefore, to perform crop sowing operations in time one should employ the adaptive complex of specific machines. Current methods and models of studying efficiency of such complex, unfortunantely, do not allow to calculate systemic and event peculiarities of their functioning and, hence, they need some improvements.

## RECENT RESEARCH AND PUBLICATIONS ANALYSIS

Our research established the fact that the current methods and models of determining parameters of machine complexes at agrarian enterprises are based upon the standard needs in machinery [7, 12, 19] unich, unfortunately, do not allow to estimate adequately the efficiency of adaptive technological systems employed in crop growing [6].

## OBJECTIVES

The article is aimed at generalization of the results of studing the influence of agrometeorological conditions on physical and mechanical state of soils and terms of performing soil tillage and sowing operations.

## MAIN PRESENTATION

A vital requirement for efficient mechanized growing of crops is their timely providing with sound soil conditions for germination and young growth [8, 10]. One may guarantee such conditions by means of mechanized operations influencing the soil structure, density, weeds, hymidity, etc. A particular function here is performed by the natural (physical, chemical and biological) processes which have a serious effect on the agrometeorological conditions of a sigle season. Coming from the said above, agrarian enterprises have to monitor the objects of operations [1] and agrometeorological conditions. They also have to forecast their development to be able to take reasonable decisions concerning mechanized operations and modifying soil state – from one to another. The soil humidity is known to influence the qualitative indices of some field operations, in particlular, soil tillage and sowing. The mentioned above operations should be performed when soil is in the state of physical maturity and (embrittlement and mixing of soils) [2].

On the other hand, crops also have their specific requirements to quantative indices of performing sowing layer, sowing operations[10] and terms of preparing these operations[2, 4, 6]. In case these objective requirements are not satisfied because of the unqualitative and ill-timed operations, the crops will get low yields and, hence, the total output will suffer of technological losses.

Winter finishing and soils drying up provoke the need in starting spring field operations of soil tillage and sowing [4] which should be completed till the moment of formulating necessary hydrothermical conditions within the sowing layer to start crop sowing [10, 11]. The time period between the mentioned above events determines the naturally established fund of time ($t^{e}_{nз}$) for spring field operations. For summer-autumn period fund of time ($t^{o}_{nз}$) is caused by the terms of finishing harvesting operatins of the predecessor and finishing physical maturity of soil in the early winter period. In additon, rainfalls lead to extra-humidity which causes stopping field operations and cutting the fund of time $t_{nз}$. Because of variability of agrometeorological conditions , time of the pointed out operations proved to be a probable quantity within the calendar period and causes stochasticity of the fund of time $t_{nз}$.

The soil state (its moisture, plants remains in structure, etc) and duration of the fund of time $t_{nз}$ influence the content of operations within spring and summer-autumn periods.In particular, the early spring dictates the need in performing the additional operation called "moisture blocking".

Under conditions of medium and late terms of spring it is mostly unreasonable to perform this operation in growing early and medium spring crops because in such situation it is preferable to carry out presowing tillage of soil and not to be late with crop sowing. Under conditions of early spring one must repeat weeding operation( cultivation with harrowing ) when planning to sow late spring crops. In the case of late spring one should prepare the soil for such crops growing by means of pre-saw tillage. Long intervals of rainy weather during summer-autumn season and early winter cause incompletion of field jobs and dictate the needs in correcting the content of spring field operations of the next year.

The agrarian enterprises, thus, should possess complexes of machines giving the opportunity to be adapted to the variability of the state of the objects of labour (the sowing layer of soil) and , in particular, to the fund of time $t_{nз}$. Such adaptive complex of machines is aimed at timely sowing of crops into sound soils both in spring and summer-autumn periods.

However, to illustrate the specific characteristics of adaptive technological systems of agrarian enterprises in the corresponding simulation models and to study the parameters of the systemic efficiency of adoptive complex of machines one should employ specific methods and models [3, 18, 20] allowing to points out the specific impact of the enviromental conditions on the content and course of jobs. One of the stages of carrying out this task is studying and formalization of characteristics of the influence of agrometeorological conditions on the soil state which, in its turn, influences the terms of accompanied performing soil tillage and sowing operations.

System and event analysis of the mentioned above processes prove that these characteristics can be accompanied by the following parameters: 1) time of the start of physical maturity of soils in spring period; 2) time of completion of this maturing in autumn period; 3) duration of fine and rainy weather intervals for each of the periods.

Thus, having the retrospective data base of meteorological stations concerning the terms of the mentioned above events, we get the possibility of constucting variational series of empirical quantities.

Their procession by means of methods of mathematical statistics gives the opportunity to ground the theoretical laws of distributing corresponding indices and, in such a way, to reflect their time characteristics in statistical simulation model of functional technological systems of soils tillage and sowing.

The terms of mentioned above events were determined coming from the data of Volodymyr-Volynskyi meteorological station (Vohlyn region). Having used the information from the accounts (TSH-1, KM-1) of daily observation of atmospherical phenomena and the state of moistering of the upper soil layer (on the depth of 0-2, 2-10sm) [5, 6, 9] we formulated the base of initial data of observation (for the period of 45 years) – 1963-2008.

Having used methods of mathematical statistics we made up the following distributions [13, 14]: 1) time ($\tau_{\varphi}^{n}$) of the start of physical soil maturity in spring period (Fig. 1); (Fig. 2) duration of fine ($t_{nn}$) (Table) and rainy ($t_{nn}$) (Table) intervals for spring (March1-June 5) and summer-autumn periods (Sept.1 - Dec.20); 3) time ($\tau_{\varphi}^{з}$) of comletition of physical maturity of soil in autumn period (Fig. 2).

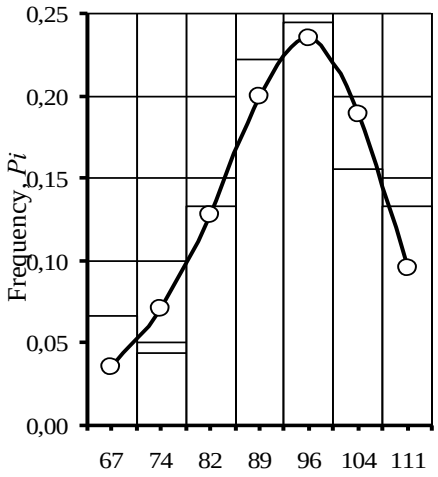


**Fig. 1.** Histogram and theoretic curve of distributing time of physical maturity of soil in spring period

We found, in particular, that the distribution $\tau_{\varphi}^{n}$ (Table) is coordinated with the law of Laplas-Charlier. The confidance interval $\tau_{\varphi}^{n}$ – 63…115 a day. Distribution $\tau_{\varphi}^{з}$ (Table) is coordinated with the normal distribution law [13], the confidence interval – 281…256 a day. Distribution $t_{nn}$, $t_{нn}$ (Table) for spring and summer-autumn periods are coordinated with the law of Welbull [14]. In particular, the confidence interval for the spring period is 1…114 days and for the autumn season is 1…21 days. The confidence interval $t_{нn}$ for the spring season is 1-10 days and for the autumn season – 1…14 days.

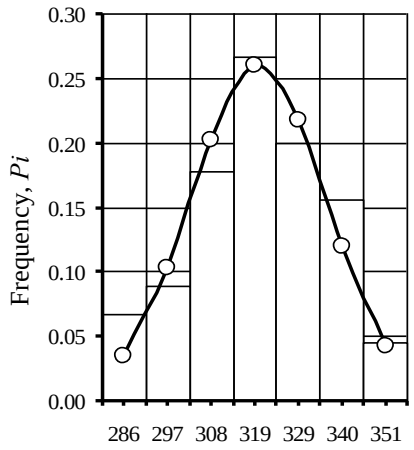


**Fig. 2.** Histogram and theoretic curve of distributing time of completion of time of physical maturity of soil in summer-autumn period

Thus, development of methods and models giving the opportunity to consider specific impact of agrometeorological conditions on the soil state and formulating naturally allowed fund of time for soil tillage and sowing operations is a vital stage in constructing specific simulation models of these operations.

Then, coming from the grounding of the algorith of taking decisions concerning the rationality of performing technological operations under diffirent agrometeorological conditions and unruled trends of their influence on the soil state and formulating duration of naturally allowed fund of time we get the opportunity to carry out computer experiments and to determine a set of integrated functional indices.

The valuable estimates of these indices and their regularities under conditions of various production programmes of agrarian enterprises, variable subjective and agro meteorological conditions as well as indices of adaptive complex of machines give the opportunity to find the correlation allowing to achieve extremum of the functional efficiency.

**Table.** Diffirental functions and estimates of statistical characteristicas of distributions of random quantities.

| Calendar intervals | Differential function of distribution |
|---|---|
| *Spring period* | |
| Time of the start of physical maturity of soils in spring time | $\varphi(t) = 0,033 \cdot e^{-\frac{t^2}{2}} \left\{1 + \frac{A_s}{6} \cdot t \cdot (t^2 - 3) + \frac{E_s}{24}\left[t \cdot (t^2 - 2) - 3 \cdot (t^2 - 1)\right]\right\}$, $t = \frac{x_i - 92,962}{12,191}$, $A_s = -0,514$, $E_s = -0,1$ |
| Fine weather intervals | $f\left(t_{\text{ïî}}\right) = 0,044 \cdot \left(\frac{t_{\text{ïî}} - 1}{24,057}\right)^{0,068} \cdot \exp\left[-\left(\frac{t_{\text{ïî}} - 1}{24,057}\right)^{1,068}\right]$ |
| Rainy weather intervals | $f\left(t_{\text{ïî}}\right) = 0,506 \cdot \left(\frac{t_{\text{ïî}} - 1}{2,375}\right)^{0,202} \cdot \exp\left[-\left(\frac{t_{\text{ïî}} - 1}{2,375}\right)^{1,202}\right]$ |
| *Summer-autumn period* | |
| Fine weather intervals | $f\left(t_{\text{ïî}}\right) = 0,203 \cdot \left(\frac{t_{\text{ïî}} - 1}{5,665}\right)^{0,148} \cdot \exp\left[-\left(\frac{t_{\text{ïî}} - 1}{5,665}\right)^{1,148}\right]$ |
| Rainy weather intervals | $f\left(t_{\text{íî}}\right) = 0,427 \cdot \left(\frac{t_{\text{íî}} - 1}{2,531}\right)^{0,08} \cdot \exp\left[-\left(\frac{t_{\text{íî}} - 1}{2,531}\right)^{1,08}\right]$ |
| Time of completition of physical maturity of soils in autumn periods | $f(\tau_{\hat{o}}^{\varsigma}) = 0,024 \cdot \exp\left[-\frac{(\tau_{\hat{o}}^{\varsigma} - 319,452)^2}{539,002}\right]$ |

## CONCLUSIONS

Stochasticity of agrometeorological conditions and their impact on the soil state cause variability of naturally allowed fund of time and the way of performing soil tillage and crop sowing operations. Analysis of the results of observing the upper layer of soil at Volodymyr Volynskyi meteorological station by means of methods of mathematical statistics gave the opportunities to make a quantitive estimation of characteristics of the influence of agrometeorological conditions on the terms of soil tillage and sowing operations of the corresponding period. Development of methods and models considering influence of agrometeorological conditions on the calendar terms of the mentioned above jobs allows to investigate characteristics and trends of variability of the parameters of efficiency of adaptive technological complexes of machines.

## REFERENCES


1. Ahrarnyi sektor Ukrainy[Agrarian sector of Ukraine]: http://agroua.net.
2. **Bomba M.Ya. and Tomashivskyi Z.M. 1993.** Naukovi i praktychni osnovy obrobitku hruntu [Scentific and practical basics of soil tillage]. – Ivano-Frankivsk: Halychyna. – 148. (in Ukraine).
3. **Buslenko N.P., 1978.** Modelirovanie slozhnykh sistem[Simulation of complex systems]. – Moscow:Nauka. – 357. (in Russia).
4. **Sydorchuk O.V., Lub P.M. and Ivasiuk I.P. 2012.** Vplyv predmetnykh umov na terminy vykonannia hruntoobrobno-posivnykh robit litnio-osinnioho periodu [Impact of the subject conditions on the terms of performing soil tillage and sowing operations of summer-autumn period]. – MOTROL. Commission of motorization and energetics in agriculture. – Lublin. – Vol. 14, №4. – 16–20. (in Poland).
5. **Horodetskyi O.A., Huraluyk I.I. and Larin V.V. 1993.** Meteorologia, metody i tekhnicheskie sredstva nabludieniey [Meteorology, methods and technical means of observation]. – Leningrad: Gidrometeoizdat. – 333. (in Russia).
6. **Gringof I.I., Popova V.V. and Srashnyi V.N. 1987.** Agrometerologia [Agrometeorology]. – Leningrad: Gidrometeoizdat. – 310. (in Russia).
7. **Zavalishyn F.S. 1973.** Osnovy raschota mekhanizirovannych processov v rastienneivodstve [Basics of calculation of mechanized processes in crop growing]. – Moscow: Kolos. –319. (in Russia).
8. **Kirtbaia Yu.K. 1982.** Reziervy v ispolzovonii mashino traktornoho parka [Reserves in the use of machine-tractor park]. – Moscow: Kolos. – 320. (in Russia).
9. **Kleievska V.L. 2010.** Pryzemni meteorolohichni sposterezhennia [Subaerial meteorological observations]: a manual. – Kharkive: Kh Al. – 52. (in Ukraine).
10. **Lykhochvor V.V. 2002.** Roslynnytstvo. Tekhnolohii vyroshchuvannia silskohospodarskykh kultur [Plant growing. Technologies of crop growing]. –Lviv: Ukr. technolohii. – 800. (in Ukraine).
11. **Lubnin M.G. 1983.** Viianiie agrometieorologicheskikh usloviy na rabotu sielskohoziaystviennykh mashyn i orudiy [Impact of agrometeorological conditions on the functioning of a farm machines and equipment]. – Leningrad: Gidrometeoizdat. – 119. (in Russia).
12. **Pastukhov V.I. 2004.** Obhruntuvania optymalnykh Komplexiv mashyn dlia mekhanizitsii polivykh robit [Grounding of optimal complexes of machines for mechanization of field works]: Auther's summary of thesis on the competition of Candidate of technical sciences. – Kharkive national P.Vasylenko technical university of agriculture. – Kharkiv. – 38. (in Ukraine).
13. **Prekladnaia statistika. 1981.** Pravila opredielienia otsenok I dovieritelnykh granits dlia parametrov normalnogo rozpredilenia [Applied statistics.Rules of determining estimates and confidence limits for parameters of normal distribution]: GOST 11.007-74 – Moscow: Izd. standartov. – 20. (in Russia).
14. **Prikladnaia statistika. 1980.** Pravila opreielienia otsenok I dovieritielnykh granits dlia parametrov Viebulla [Applied statistics.Rules of determining estimates and confidence limits for parameters of distribution of Viebull]: GOST 11.007-75-Moscow: Izd. standartov/ – 30. (in Russia).
15. **Sydorchuk A.V., Lub P.M., Ivasiuk I.P. and Ukrainets V.A. 2013.** Soglasovanie sostavliaiushchikh tiekhnologicheskoy sistiemy obrabotki pochvy i posieva ozimykh kulture [Coordination of elements of technological systems of soil tillage and winter crops sowing]. – MOTROL Commission of motorization and energetics in agriculture. – Lublin-Rzeszow, Vol.15, №4. 180-186. (in Poland).
16. **Sydorchuk O.V., Karpa M.I., Tymochko V.O. and Fedosenko S.A. 1990.** Tekhnolohichni vymohy mekhanizovanoho protsesu v roslynnytsivi do tempiv remontu mashyn [Technological requirements of the mechanized process in crop growing to the rates of machines repair] // Pidvyshchennia orhanizatiyno-teknichnoho rivnia remontno-vidnovnykh protsesiv v APK rehionu. – Lviv: Lviv silskohospodarskyi instytut. – P. 84–90. (in Ukraine).
17. **Tymochko V., Kovalchuk Ya. and Padiuka R. 2011.** Orhaniztsiyno-teknolohichni zakhody enerhozberezhennia pid chas zbyrannia oliynykh ta zernovykh kultur [Organization and tchnological measures of energy saving during oil and grain crops harvesting]. – MOTPOL. – Lublin. – Vol 13D. – 22-30. (in Poland).
18. **Truhuba A.M. and Sharybura A.O.** Protsesy upravlinnia intehrovanymy proektamy ahrarnoho vyrobnytstva [Processes of management of integrated projects of agrarian production] – MOTPOL. – Lublin. – Vol 13D. – 37–42. (in Poland).
19. **Finn E.A., 1989.** Optimiztsia ekspluatatsionnukh sistem sielskohoziaystviennoy tiekhniki [Optimiztion of exploitation systems of farm machinery]: Author's summery of thesis on the competition of Doctor of Technical Sciences.- Novosibirsk. – 40. (in Russia)
20. **Yachmeneva V. and Vol's'ka G. 2014.** Factors influencing the enterprise innovation. ECONTECHMOD. An international quarterly journal. Poland, Lublin – Rzeszow. – Vol. 3. No. 1, 133–138.