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Study of Optimal Sowing Date and Rate of Buckwheat in the Semiarid Zone of Northern Kazakhstan

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Abstract: The buckwheat is considered as one of the critical products in agriculture. The main objective is to propose an optimal swing condition to enhancing its productivity and making the most appropriate environmental condition for its growth. Timely carrying out agro technical actions is necessary for taking stable yield in the changing climatic conditions. Based on cultivation technology, determining the further growth and development of plants in climatic conditions of a semiarid zone are the sowing date and sowing rate. According to our experiment results, optimal sowing date of buckwheat in a semiarid zone of Northern Kazakhstan is May, 30 where the sowing rate is 3.0 million of germinated seeds/hectare (90 kg ha^{-1}). The findings demonstrated the efficiency of proposed method. On the average, for 2012-2014 the greatest yield was harvested 0.8 t ha^{-1}.

Key words: Buckwheat, sowing date, sowing rate, vegetation period, economic and valuable signs, yield

INTRODUCTION

The buckwheat (*Fagopyrum esculentum*) taxonomically does not belong to cereal crops, however, because of similarity in cultivation and use, it is usually grouped together with cereals (Kim *et al*., 2004). Buckwheat grain is one of the optimal low gluten sources, quickly digestible, rich in potassium, high-quality food, phosphorus, zinc, calcium, iron in (Dietrych, 2006; Vojtiskova *et al*., 2012). B1, B2, B3, B6 and C vitamins (Bonafacia *et al*., 2003; Lebiedzinska and Szefer, 2006). Buckwheat flour has a high concentration of protein, cellulose, lipids, minerals and vitamins (Steadman *et al*., 2001; Hung *et al*., 2009). Buckwheat is only one which contains a high content of rutin (quercetin-3-rutinosid) (Yadav *et al*., 2004).

The leading world producers of buckwheat are China, Kazakhstan, Ukraine and Russia (Li and Zhang, 2001). The buckwheat is also cultivated in Slovenia, Brazil, Hungary, Austria, Nepal and Poland (Yadav *et al*., 2011). Crop yield of buckwheat in these countries strongly fluctuates. In China reported a harvest yield of 2.5 t ha^{-1} (Prasad *et al*., 2006). Rao *et al*. (2006) stated 2001 kg of yield in Poland in a 2 year research of buckwheat quantitative characteristics. In Serbia, the highest yield of a buckwheat was proposed 2.6 t ha^{-1} (Popovic *et al*., 2014). On an average, according to FAO, yield of buckwheat in the world is 1.8 t/acre. In Kazakhstan, the total area of buckwheat in the Republic reached 180-200 thousand hectares at an average yield of 0.41 t ha^{-1} (Burton *et al*., 2006). According to statistical data in 2013 gross yield of buckwheat in Kazakhstan was made 83.5 thousand tons at total sowing area of 82.4 thousand ha. Analyzing literature, we drew a conclusion that one of the limiting factors of increase in production of such universal culture as the buckwheat is it's low crop yield and respectively low economic profitability of its output. At the same time, the difference in yield of a buckwheat by years is testified to the buckwheat sensitivity to climatic parameters (Michalova *et al*., 1998; Morishita and Tetsuka, 2001; Skousen and Venable, 2008).

However, in the case of buckwheat cultivation, taking into account it's biological features as well as soil-weather of the region of cultivation, even at adverse conditions it is possible to take stable high yields (Foster *et al*., 2009). Thus, for increasing of crop yield it is necessary to look for an improvement of cultivation technology. One of the agrotechnical methods, as a result of the correct application, there is a possibility to combine time of the passing of the most important phases of crops vegetation with favorable moments of the summer period which is the choice of optimum terms of sowing date and sowing rate (Inoue *et al*., 1998). The sowing time such a fundamental element for producing is a vital importance

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because of its main impacts on plant genotype for exploiting its highest production potential. Due to the unpredictability of meteorological conditions, the sowing date is the essential element of cultivation technology which is strongly influencing a buckwheat yield that is proved by some researchers (Petersen *et al.*, 2004). The sowing rate is also one of the basics of an agrotechnology. The basis of yield receiving is provided with some emergency seeds and this factor has enormous importance especially in relief takes place in droughty years (Oliveira *et al.*, 2014).

The optimum sowing rate provides the best area of nutrition for all plants and guarantees the most productive process of the photosynthetic apparatus. Thus, to increase the yield of a buckwheat by studying of optimum sowing date and sowing rate in the conditions of a semiarid zone of Northern Kazakhstan in 2012-2014 there carry out the field experiments which results presented in this study.

MATERIALS AND METHODS

The research program: Field trials carry out on the experimental field of Shokan Ualikhanov Kokshetau State University; the previous crop was Springer canola (Brassica Na Pusan Nua). The experimental treatments were laid out in a systematic block modelvia 3 replicates, the total zone of one treatment is 6 m^2. Sowing was carried out manually, according to the scheme of experience: three sowing date-May 20, 25 and 30 with 3 sowing rates 2.8, 3.0 and 3.2 million of germinated seeds/hectare; sowing depth 7 cm. General recommendations for the sowing of cereal crops in the conditions of Akmola region were taken as control: May 25 with sowing rate 3.0 millions of germinated seeds. The soil of the field treatments-ordinary, carbonate, heavy-loamy chernozem. Characteristics of the experimental area are presented as humus -5%, P_2O_5 -1.62 mg/100 g and K_2O_5 -48.5 mg/100 g of the soil. The sum of cations on 100 g/soil is made 50 mg/eq in the topsoil (0-20 cm) pH 7.2.

During of the vegetation period, there were carried out two mechanical inter row cultivations. During the summer period in the experimental field, there were carried out the phenological observations; it was investigated economic and valuable features of buckwheat in the conditions of a semiarid zone.

Research methodology: The Hydrothermal Coefficient (HTC) was applied for the estimation of dryness of territories. It is calculated according to the formula, offered by G.T. Selyaninov in 1928:

$$\text{HTC} = \sum r,\ \sum t \times 0.1 \quad (1)$$

Where:

- Σr = The sum of precipitation for the vegetation periodwith a temperature over 10°C (mm)
- Σt = The sum of active temperatures, higher 10°C at the same period

According to G.T. Selyaninov, HTC quantity for June-August is >1.6 and it is characterized excessively wet zone; 1.6-1.3 forest, humid region; 1.3-1.0 forest steppe (subhumid) 0.7-0.4-very arid zone (dry steppe) 0.4 and less-very severe drought (the desert and the semi-desert). The hydrothermal coefficient can not be applied for an estimation of winter, autumn and spring when it is observed average daily temperature which is below 0°C. For the vegetation period, the phenological observations were made on phases of development of plants by the methodology of state grade testingmethod. It is noted the following phenological phases: shoots, branching, budding, flowering, fructification, ripening. Completeness of shoots was determined in a phase of full shots on permanent quadrats by the square 0.25 m^2 with recalculation on 1 m^2 and reducing the average result, in percent a ratio with some the sowed seeds, according to the determined sowing rates. In the subsequent, on these permanent quadrates, there were determined a density of haulm stand and safety of plants before harvesting.

Field germinability was determined in a percentage ratio between some plants in a phase of full shoots to the number of the sowed seeds. The density of plants before harvesting was made by calculation of some plants in permanent quadrates 0.25 m^2 with recalculation on 1 m^2. Safety of plants was determined before harvesting by calculation of the quantity of plants in permanent quadrats by the square 0.25 m^2. Data was compared in a percentage ratio to some shoots. Percent of the survival rate of plants was determined by a ratio of some plants before harvesting to the number of the sowed seeds. For determination of yield structure on each variant from four permanent quadrates with the size of 0.25 m^2 there was selected the shelf material. The biological yield of a buckwheat can be determined by simple recalculation of an average seed yield from permanent quadrats on 1 ha. The yield structure of a buckwheat cconsists of some plants of a unit of the square, the number of seeds at a plant and the weight of 1000 grains. The biological yield was counted by multiplication of these structural elements and division of result on 10,000. Mathematical processing of the received results is presented by the dispersive analysis (ANOVA) and correlation. For analytical processing, there was used the software IBM SPSS Statistics 19.0.

RESULTS AND DISCUSSION

Analysis of meteorological conditions: The buckwheat is the seed, demanding a significant amount of moisture (Kalinova and Moudry, 2003; Inoue *et al*., 1998) and sure temperatures (Halbrecq *et al*., 2005; Omidbaigi and Mastro, 2004). The analysis of HTC during vegetation allows revealing the provision with the moisture of buckwheat, depending on temperature during vegetation Table 1. According to HTC data, meteorological conditions of a semiarid zone sharply fluctuate not only by years but also and on months of the vegetation period. Thus, in 2012 at the sum of temperatures 556.0°C, the sum of precipitation for June was made 148.7mm, therefore HTCwas exceeded 2.7 it is characterized by June 2012 which was excessively superfluous humid. Interestingly, that further because of sustained drought and high temperatures, in July and in August 2012 HTC was sharply fell to 0.4 and 0.5, respectively that characterizes these months as very droughty. HTC exceeding, higher 1.6 without any regularity is also observed in the next years: in July-August, 2013 (4.1, 3.3) and in July 2014 (3.6). Very low HTC indicators were registered in June 2013 0.2 and in August 2014 0.3. Comparing sharp fluctuations of HTC in different months, in different years, it can be concluded that meteorological conditions of a semiarid zone can sharply change not only by years but also during the vegetation season. As it was proved, earlier (Omidbaigi and Mastro, 2004) ecological and meteorological conditions have a huge effect on quality and quantity of products during the vegetation period of plants. Thus, it is necessary to do the careful analysis for the choice of the optimum period of showing for such moisture-thermophilic culture as buckwheat.

Economic and valuable signs of a buckwheat: Completeness of shoots, field germinability, the density of plants before harvesting, safety and survival ratio of plants are referred to some the economic and valuable signs, defining further yield of cultures Table 2. Thanks to the greatest completeness of shoots on the variant with sowing date May 30 and with sowing rate 2.8, 3.0, 3.2 millions of germinated seeds/hectare (232, 238, 249) on these variants there is also observed the highest percent of field germinability: 83, 79 and 78%, respectively. We assume that it is connected with a more optimum ratio of heat and moisture in initial stages of vegetation that confirms HTC analysis Table 1. In June 2012 and 2014 HTC was 2.67 and 1.1 it demonstrates that these months were humid and at the same time warm. In these variants the highest safety of plants is noted further 74, 76 and 77% and survival rate 61, 60 and 60%. The average value of these data on safety exceeded the sowing date May 20, for 2.9%, conceding to control for 1.1%; on the survival rate of plants is exceeded both sowing dates for 3.3 and 2% accordingly, at the same time these results are statistically significant ($p<0.05$). The correlation analysis shows a high correlation between sowing rate and completeness of shoots (r -0.7) and also between the sowing date and survival rate of plants (r -0.8).

Vegetation period: The vegetation period is one of the essential elements of cultivation of buckwheat as in the conditions of a semiarid zone it is possible both recurrence of late summer frosts and early coming of autumn frosts. In Western Europe sowing takes place when there are no more risks of late spring frosts, usually in May or June (Seong *et al*., 1998) and harvest has to be completed before the first Autumn frosts[35].Thus, the buckwheat needs to be sown in warm time and with such calculation that it will be able to ripen before the beginning of frosts. According to the results of our researches, the sowing date has exerted an impact on duration of some vegetation phases Table 3. In comparison with control, the late sowing date May, 30, allows reducing the period sowing-shoots by one day. Further, the given tendency is observed at phases shoots-branchings (on average for 2 days) and fruitification-ripening (for 2 day). We assume that acceleration of these phases is connected with warmer temperatures as at the end of May the beginning of June. When the plants of late sowing date were down into the warmer soil and also with an optimum temperature (20-22°C) at the end of July-beginning of August when on this variant were entered into a maturing phase. The correlation analysis was not shown an essential interrelation between the sowing date and duration of growth phases and developments of buckwheat. At the same time, our data are confirmed by in at which the sowing date is rendered undoubted effect on germinability of seeds and the period of vegetation. The seeds, sowed at different times were sprouted only in 10-14 day while the summer crops were sprouted in 5-8 day (Dozorov *et al*., 2015). Growth and development of a buckwheat take place quicker in more optimum summer temperatures (25-30°C) that are proved by in (Pecio and Wielgo, 1999). In conditions of Hungary show that various grades of buckwheat from Greece, Germany, Slovenia and Poland were shown the average vegetation period was 80-90 day in 2004-2007 (Sugimoto and Sato, 1999).

Table 1: Meteorological conditions during the experimental years

The sum of precipitation and temperatures by years	Months June	July	August	Totally for the Summer period
Precipitation, 2012	148.70	023.3	026.0	0198.0
Precipitation, 2013	008.40	211.4	153.1	0372.9
Precipitation, 2014	054.30	128.9	016.2	0199.4
Sum of temperatures, 2012	556.00	612.0	514.0	1682.0
Sum of temperatures, 2013	427.00	512.0	463.0	1402.0
Sum of temperatures, 2014	490.00	363.0	541.0	1394.0
HTC 2012	002.67	000.4	000.5	0001.2
HTC 2013	000.20	004.1	003.3	0002.7
HTC 2014	001.10	003.6	000.3	0001.4

Table 2: Influence of terms of sowing dates and sowing rates on the economic and valuable signs of a buckwheat

Sowing date	Sowing rates	Comple teness of shoots	Fieldge rminability	Density of plants before harvesting (PCs m^{-2})	Safety of plants	Survival rate of plants
20.05	Average (2.8)	226.5	81.5	160.5	71	58
	Dispersion	000.5	00.5	00.5	00	00
	Average (3.0)	231.5	76.5	172.5	74	57
	Dispersion	000.5	00.5	000.5	00	00
	Average (3.2)	245.5	77.5	179.5	73	56
	Dispersion	000.5	00.5	000.5	00	00
25.05	Average (2.8)	218.0	77.5	163.5	75	59
	Dispersion	000.0	00.5	000.5	00	00
	Average (3.0)	216.5	72.5	176.5	81	59
	Dispersion (k)	000.5	00.5	000.5	00	00
	Average (3.0)	246.5	76.5	182.5	74	57
	Dispersion	000.5	00.5	000.5	00	00
30.05	Average (2.8)	231.5	83.5	171.5	74	61
	Dispersion	000.5	00.5	000.5	00	00
	Average (3.0)	238.5	78.5	180.5	76	60
	Dispersion	000.5	00.5	000.5	00	00
	Average (3.2)	248.5	78.5	192.5	77	60
	Dispersion	000.5	00.5	000.5	00	00

Table 3: Duration of phases of a buckwheat vegetation*

Sowing date	Sowing rate	Sowing shoots	Shoots branching	Branching budding	Flowering fruitification	Fruitification ripening	Vegetation period
20.05	Average	9.000	14.3333	10.0000	18.3333	39.6667	91.3333
	Dispersion	0.000	02.3330	01.0000	01.3330	01.3330	01.3330
25.05	Average	9.000	14.3333	10.6667	16.3333	40.3333	90.6667
	Dispersion (k)	0.000	00.3330	02.3330	00.3330	00.3330	04.3330
30.05	Average	8.000	13.3333	11.3333	17.6667	38.6667	89.0000
	Dispersion	0.000	01.3330	00.3330	01.3330	00.3330	01.0000

*The mean differences is significant at the 0.05 level

Crop yield: The conducted early studies are shown that the sowing date has a significant influence on the yield of buckwheat. By our experimental data, it is seen that terms of sowing date and planting rate have an impact on economic and valuable signs that it was reflected in elements of yield structure and respectively for a buckwheat yield Table 4. In the years of research (2012-2014) buckwheat crops of early sowing dates (May 20 and 25) and with sowing rate 2.8-3.0 million of germinated seeds/hectare had been got under a June drought and high temperature. In this regard completeness of shoots in these variants was the smallest (217-232 pieces/m^2). Precipitation at the beginning of June was created favorable conditions for germination of seeds at the late sowing date (May, 30). Intense precipitation (HTC from 3.3-4.1) was promoted to the lengthening of the vegetation period of buckwheat in a variant with sowing date May, 30. However, the time of a fructification and seeds ripening provided with optimum temperature conditions and solar radiation that influenced the formation of seeds (on average 14 fruits on one plant). Whereas in variants with sowing date May, 20 the number of fruits on the one plant was less on four pieces/plant and at control on May, 25 on 2-3 pieces/plant. Data on some fruits on a plant are statistically significant ($p<0.05$) and highly correlates with the sowing date (r-0.9). The weight of 1000 seeds on average was varied 30.4-31.5g. In experiences, the highest rate of the weight of 1000 seeds was shown by variants in April, August and in September (37.5, 35.2, 38.0 g), respectively.

In noted that crops in the middle of March are formed the highest harvest of the weight of 1000 seeds. Thus,

Table 4: Elements of yield structure of buckwheat and biological yield (average for 2012-2014)

Sowing date	Sowing rate	No. of plants before harvesting (pieces/m)	No. of seeds for one plants. pieces/plant	The weight of 1000 seeds (g)	Biological yield. t/ha
20.05	Average (2.8)	161.5	11.0	31.3500	0.550
	Dispersion	000.5	00.0	00.0050	0.000
	Average (3.0)	171.5	10.0	31.2500	0.540
	Dispersion	000.5	00.0	00.0050	0.000
	Average (3.2)	178.5	11.0	30.3500	0.600
	Dispersion	000.5	00.0	00.0050	0.000
25.05	Average (2.8)	164.5	12.0	30.5500	0.610
	Dispersion	000.5	00.0	00.0050	0.000
	Average (3.0)	176.5	13.0	30.5000	0.690
	Dispersion (k)	000.5	00.0	00.0200	0.000
	Average (3.2)	181.5	12.0	30.7500	0.670
	Dispersion	000.5	00.0	00.0050	0.000
30.05	Average (2.8)	172.5	15.0	31.4500	0.810
	Dispersion	000.5	00.0	00.0050	0.000
	Average (3.0)	182.0	15.0	31.5500	0.860
	Dispersion	002.0	00.0	00.0050	0.000
	Average (3.2)	191.5	14.0	31.1500	0.840
	Dispersion	000.5	00.0	00.0050	0.000

The mean differences is significant at the 0.05 level

the greatest yield of buckwheat (0.81-0.86 t ha^{-1}) was harvested on variant May 30 with seeding rate 3.0 million of germinated seeds/hectare. At the same time data of biological yield are statistically significant ($p<0.05$) and they show high correlation with the sowing date (r-0.9). Some foreign experiences confirm our studies. In claimed that in China the best sowing date is late May in comparison with early April, early and the end of June, the harvest was made 2.1 t ha^{-1} (Hore *et al*., 2002). In Western Europe also the optimal sowing date is a period from the middle of May till Julyv (Hu, 2003). In experiences, among variants of early May, late April, early June, late May and late June, the best sowing date for a buckwheat is noted as late May with crop yield of 2.1 t ha^{-1}. However, the planting date is changed, depending on the region of cultivation. Studying the buckwheat characteristics at seven sowing times in shows that the best sowing date is June, 25 as during this period there is formed the largest number of branches and the highest content of dry matter as well as rutin. In have determined August as the most suitable sowing time in India. In experiences, the best sowing dates are July and August.

CONCLUSION

In conditions of a semiarid zone of Northern Kazakhstan the late sowing date (May, 30) reduces the vegetation period of buckwheat on average by three days. The highest completeness of shoots and safety of plants are fixed on a variant of sowing date May, 30 with sowing rate 3.0 million of germinated seeds and is made 79 and 76% respectively. To enhance the higher safety of plants (76%) and also a higher number of formation of seeds/plant (14 pieces/plant) the variant sowing date May 30 with sowing rate 3.0 million of germinated seeds within 3 year of research was shown the highest stable crop yield by years (0.82, 0.78 t ha^{-1}; 0.86 ton ha^{-1}) and on average in 3 years (2012-2014) 0.8 t ha^{-1}.

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