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Nutrient Uptake, Physiological Characters, And Yield Component Of Situbagendit Rice Variety On Nitrogen And Phosphor Dosage With Applications Of Vesicular Arbuscular Mycorrhiza On Rainfed Lowland Rice

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Abstract

Nutrient uptake, physiological characteristics and yield of rice situbagendit variety are influenced by differences in nitrogen and phosphorus doses with the application of vesicular arbuskular Mycorrhiza in rainfed lowland rice. The aim of this study was to determine the effect of nitrogen and phosphorus doses on situbagendit rice variety in rice fields that were given vesicular arbuskular Mycorrhiza. The research design used was Randomized Completely Block Design with 2 factors and 3 replications. The first factor was dosage nitrogen a.i. 0; .45; 90; 135 kg/ha. The second factor was 0; 25; 50; 75 kg/ha. The research was conducted in the rice field in the village of Demangan, Sambi, Boyolali, Central Java, Indonesia, 113 m above sea level. The results indicated that Nitrogen fertilization at 135 kg / ha increases nitrogen, phosphorus and potassium uptake and there is a correlation between nitrogen, phosphorus and potassium uptake. Starting with a nitrogen dose of 90 kg / ha increases the leaf area duration and there is a correlation between LAI, LAD and NAR. Phosphorus fertilization at a dose of 50 kg / ha increases grain weight per plot and per hectare and there is a correlation between the weight of 1000 grain, grain weight per plot and grain weight per hectare.

Keywords: nutrient uptake, physiological characters, nitrogen, phosphor, vesicular arbuscular mycorrhiza, rainfed lowland rice

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops in the world (Radwan et al., 2008) and main food crop for more than half of the world's population (Tadesse, et al., 2013). and is a major source of calories for around 60% of the world's population (Meena et al., 2015). The area of rice cultivation in irrigated rice field experienced a lot of deterioration due to the conversion of agricultural land so that expansion was needed on suboptimal lands including rainfed lowland rice.

Rainfed lowland rice has the potential to be used as an area for increasing rice production (Primilestari dan Edi. 2015). Rainfed lowland rice productivity is still quite low, which is around 3.5-4.5 tons / ha (Thamrin et al.,2016). So that the effort to increase the productivity is needed even there are some obstacles such as water stress.

One of the efforts to overcome the problem of water stress is the use of microbial-based technologies, such as Arbuscular Vesicular Mikoriza. This is because mycorrhizae are able to act as a liaison between plant roots and soil moisture, especially during the dry season. Nutrient uptake in the mycorrhizal roots increases better than without mycorrhizae Quilambo (2003), this is caused by the uptake and transportation of nutrients by mycorrhizae. Purwaningsih (2011) added that the increased absorption of nutrients occurs

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by expanding the absorption range due to the presence of external hyphae that can reach 8 cm outside the root system, exploitation to the micro pores due to the small diameter of external hyphae that is less than 20% of the diameter of the root hairs and increase the surface area of the absorption system. Mycorrhiza is able to increase the absorption of the element of phosphorus available by plant root hairs so that the plant has a better metabolism which is characterized by an increase in the growth of plant canopy (Permanasari et al, 2016). This is in line with Pamuna et al. (2013) that the dry weight of corn plants and P uptake that were not given mycorrhizae will increase according to the increase in SP-36 dose. When the concentration of P increases in the soil, the role of mycorrhizae becomes more apparent in absorbing P. Hernandez and Munne Bosch (2015) adding that mycorrhizal application increases absorption and phosphorus content in seeds and stover. P plays an important role in the photosynthesis cycle, P is important in the activation of Ribulose 1.5 bisphosphate carboxylase oxygenase (Rubisco) and the Calvin cycle.

Therefore in this study examines the role of mycorrhizae in rainfed lowland rice that is applied nitrogen and phosphorus fertilizer and whether the application of mycorrhizae can save the use of nitrogen and phosphorus fertilizers

Method

This research was carried out in rainfed lowland rice field in the village of Demangan, Sambi, Boyolali, Central Java, Indonesia.. Rice seeds come from the Paddy Seed Center in Tegalgondo, Klaten, Central Java, Indonesia. Other ingredients are straw, cow manure, urea, SP36, KCl.

This study used a complete randomized block design with two factors and repeated three times. Factor 1: dosage of urea (0; 45; 90; 135 kg/ha). Factor II: dosage phosphorus (0. 25; 50; 75 kg/ha). The planting was done using 3 seeds thenataged 2 seedlings, 14 days was selected and left 1 plant. KCl fertilizer at a dose of 50 kg / ha.

The parameters observed were nitrogen uptake, phosphorus uptake, potasium uptake, leaf area index, leaf area duration, net assimilation rate, weight of 1000 grains, weight of grains per plot and weight of grains per hectare

The statistical analysis was done using standard ANOVA SAS 9.1 program. If there is a significance differences among the treatment then followed by Duncan Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Result And Discussion

Before the research, an analysis of the physical and chemical properties of paddy fields was done. The results of the analysis of physical and chemical properties of the soil before research in the field are presented in Table 1. The results of analysis of the physical and chemical properties of the soil indicate that the loam texture. The composition of the fraction of the soil texture composition is very influential on the ability of the soil to pass water, or the permeability of the soil. The macro nutrient level was quite good except for the low total N, each N total 0.16% (low), P available 8.28% (medium), and K available 0.82 me/100 g (high) CEC 26.27 me/100g) high (Table 1.).

Table 1. Soil analysis before research

Physical and chemical character	Bulk density (g/cm3)	Gravity (g/cm3)	pH H2O	Texture	Organic matter (%)	Total N (%)	Avalable P (ppm)	Avalable K (me/100 g)	CEC (me/100 g)

Value	1.20	2.10	6.45	Loam	6.28	0.16	8.28	0.82	26.27
Praise	-	-	Neutral		High	Low	medium	High	High

Nutrient Uptake

Nutrient absorption is the ability of plants to extract nutrients from the soil and turn them into plant parts (Makarim et al., 1999; Masganti, 2003). The higher the ability of plants to absorb nutrients, the higher the yield obtained (Masganti, 2011).

The result of data analysis showed that nutrient uptake was affected by the interaction between nitrogen dosage and phosphorus dosage. The highest nitrogen uptake is 19,250 µg/mm2/sec resulting from the treatment of nitrogen dosage 135 kg/ha and phosphorus dosage 75 kg/ha (Table 2). The more fertilizer is given, the higher the nutrient uptake. Increased nutrient absorption by rice with increased fertilizer dosage has also been reported by Singh and Namdeo (2004). Nutrient uptake in addition to being influenced by nutrient supply in the soil is also influenced by the use of mycorrhizal fungi. This is consistent with the statement of Cavagnaro et al. (2012), Lee et al. (2012); Narwal et al. (2018) the application of mycorrhizal fungi increases nitrogen uptake and N levels in seeds, stover and plants. Hawkins et al. (2000) reported the presence of mycorrhizae assisting uptake of glutamic acid and glycine and nitrogen transport from its source to host

Nitrogen uptake had a positive correlation with phosphorus uptake (r = 0.829 **) and potassium uptake (r = 0, 852 **) (Table 3). Increasing nitrogen uptake in plants will result in absorption of other elements including nutrients, phosphorus and potassium as well. This is because nutrients are transported to the plant in the form of solutions, so that not only nitrogen is transported but other nutrients as well. The process of nutrient uptake is also influenced by the flow of transpiration. The faster the transpiration process, the nutrient uptake in plants also increases.

Phosphorus nutrient uptake is influenced by the interaction between the nitrogen dose and the phosphorus dose (Table 2), the highest phosphorus uptake of 5.821 µg /mm2 /sec is achieved by the interaction between the nitrogen dose of 135 kg/ha with a phosphorus dose of 50 kg/ha, and the lowest phosphorus uptake is achieved by without Nitrogen or 1,150 µg/ mm2/sec.

Without phosphorus fertilizer or 25 kg/ha phosphorus dose, phosphorus uptake is no different in various doses of nitrogen fertilizer. At a dose of 50 kg/ha of phosphorus fertilizer, the highest phosphorus nutrient uptake is at a dose of 135 kg/ha and differs from other nitrogen doses. At 75 kg/ha of phosphorus fertilization, the highest phosphorus uptake is at nitrogen fertilizer of 135 kg/ha and different from 45 kg/ha and without nitrogen fertilization.

Phosphorus uptake is not influenced by the dose of P fertilizer given, the higher the dose of P fertilizer does not indicate an increase in P uptake. The uptake of rice plant phosphorus due to phosphorus fertilization is relatively low, this is thought to be due to a high increase in fertilization so that nutrient uptake decreases and the response of rice plants to absorb the usurur phosphorus decreases. Provision of phosphate fertilizer continuously causes accumulation of P, thereby reducing the response of plants to phosphate fertilization. P accumulation in addition to reducing the efficiency of P can also affect the availability of other nutrients for plants. In plants, P is an important constituent of adenosine triphosphate (ATP) which directly plays a role in the process of storing and transferring energy that is involved in the process of plant metabolism (Doberman and Fairhurst, 2000).

One alternative that can be done to improve the efficiency of P fertilizer absorption is through the use of arbuscular mycorrhizal fungi. This fungus can symbiosis with roots and has an important role in plant growth, both ecologically and agronomically. These roles include increasing the uptake of P and other nutrients, such as N, K, Zn, Co, S and Mo from the soil, increasing drought resistance, improving soil aggregation, increasing soil microbial growth that is beneficial for host growth and protecting plants from root pathogen infections (Bolan, 1991; Permanasari et al., 2016)

According to Quilambo (2003), the efficiency of nutrient uptake in mycorrhizal roots increases better than plants without mycorrhizae. This is caused by the taking and transportation of nutrients by mycorrhizae. Purwaningsih (2011) states that increased absorption of nutrients occurs by expanding the absorption range due to the presence of external hyphae that can reach 8 cm outside the root system, exploitation to the micro pores due to the small diameter of external hyphae that is less than 20% of the diameter of the root hairs and increase the surface area of the absorption system. Setiadi (1986) also states that plants with micororrhizal usually grow better than those without. This is because mycorrhizae can effectively increase the absorption of macro nutrients (N, P, K, Ca, Mg and Fe) and micro nutrients (Cu, Mn and Zn) by plant root feathers so that plants have a better metabolism that marked by an increase in plant canopy growth (Permanasari et al, 2016). This is in agreement with Pamuna et al. (2013) that the dry weight of corn plants and P uptake that were not given mycorrhizae will increase according to the increase in SP-36 dose. When the concentration of P increases in the soil, the role of mycorrhizae becomes more apparent in absorbing P. Nazirah et al. (2018) adds that mycorrhiza is important for plants because it increases phosphorus nutrient uptake and increases drought resistance. Upland varieties including Situbagendit are plants that have positive responses to mycorrhizae

Hernandez and Munne Bosch (2015) added that mycorrhizal application increases the absorption and levels of phosphorus in seeds and stover. P plays an important role in the photosynthesis cycle, P is important in the activation of Ribulose 1.5 bisphosphate carboxylase oxygenase (Rubisco) and the Calvin cycle. Bustami et al. (2012) and Kabir et al. (2013), the use of phosphate fertilizer at a dose of 50 kg/ha in peanuts increased crop dry weight, plant growth rate, leaf area index and harvest index compared to a dose of 25 kg/ha

Potassium nutrient uptake is influenced by the interaction between nitrogen and phosphorus doses. The highest potassium nutrient uptake of 21.32 µg / mm2 / sec achieved a combination of urea fertilizer of 135 kg / ha with 50 kg / ha of phosphorus fertilizer, and the lowest potassium uptake of 6.33 µg / mm2 / sec was achieved by the absence of nitrogen and phosphorus fertilization (Table 2). Potassium nutrient uptake by applying nitrogen fertilizer 135 kg/ha and phosphorus fertilizer 50 kg/ha is not different from administering nitrogen fertilizer 135 kg/ha and phosphorus fertilizer 75 kg/ha. The administration of mycorrhizae increases potassium nutrient uptake in rice plants. K accumulation in rice plants increases with mycorrhizal administration (Rajesh et al., 2011; Baslam et al., 2013).

Potassium nutrient uptake is positively correlated with nitrogen nutrient uptake (r = 0.852 **) and phosphorus nutrient uptake (r = 0.897 **) (Table 3), the more potassium uptake then the uptake of nitrogen and phosphorus also increases.

Table 2. Nitrogen uptake, phosphorus uptake, and potassium uptake as affected by nitrogen dosage and phosphorus dosage with applications of Vesicular Arbuscular Mycorrhiza on Rainfed Lowland Rice

Dosage of nitrogen (kg/ha)	Dosage of phosphorus (kg/ha)	Nitrogen uptake (µg/mm^2/det)	Phosphorus uptake (µg/mm^2/sec)	Potassium uptake (µg/mm^2/sec)
0	0	1,730 g	1,150 f	6,33 e
	25	3,037 fg	1,992 d-f	8,83 c-e
	50	2,267 g	1,707 ef	7,10 de

	75	2,437 g	1,305 f	10,19 c-e
45	0	3,740 fg	2,095 d-f	10,85 c-e
	25	4,433 e-g	2,482 c-f	11,26 c-e
	50	5,200 d-g	3,384 b-d	13,22 b-d
	75	5,130 d-g	1,828 d-f	10,37 c-e
90	0	7,150 c-f	2,172 d-f	11,38 c-e
	25	8,107 c-e	3,040 b-e	11,83 c-e
	50	8,647 cd	3,942 bc	13,54 bc
	75	9,997 bc	2,686 b-f	12,54 b-e
135	0	10,773 bc	2,709 b-f	11,63 c-e
	25	13,320 b	3,714 bc	14,85 bc
	50	17,480 a	5,821 a	21,32 a
	75	19,250 a	4,040 b	18,43 ab

Remarks: The numbers in the same column followed by the same letter are not significantly different according to DMRT 5%

Table 3. The correlation analysis between nitrogen uptake, phosphorus uptake, and potassium uptake as affected by nitrogen dosage and phosphorus dosage with applications of Vesicular Arbuscular Mycorrhiza on Rainfed Lowland Rice

Yield component	Nitrogen uptake	Phosphorus uptake	Potassium uptake
Nitrogen uptake	0	0,829**	0,852**
Phosphorus uptake	0,829**	0	0,897**
Potassium uptake	0,852**	0,897**	0

Note : * = significant different, ** = very significant different, ns= non significant

Physiological Characters

Leaf area index (LAI) is the ratio between leaf surface area and land surface area over grown in the plants (Yoshida, 1981). The leaf area index is closely related to the plant's ability to keep the light from solar radiation which is coming. The LAI value needed to hold 95% of the light comes in the rice canopy for photosynthesis was around 4-8 (Yoshida, 1981), also Rajput et al.(2017) stated that LAI is a photosynthetic area of the plants.

The results of data analysis (Table 4) showed that LAI was influenced by the interaction between nitrogen and phosphorus. The nitrogen dosage increased LAI sampai dosis 90 kg/ha, setelah itu terjadi penurunan LAI. The highest LAI 1,715 resulted from the nitrogen dosage 90 kg/ha and phosphorus dosage 50 kg/ha.

The result of data analysis Leaf Area Duration (LAD) was affected by the interaction between nitrogen dosage and phosphorus dosage (Table 4). Nitrogen dosage increased the LAD to a dose of 90 kg / ha. At a nitrogen dose of 135 kg / ha, the highest LAD was given dosage of 25 kg / ha of phosphorus and was not different from 50 kg / ha or 75 kg / ha of phosphorus. The lowest LAD of 1269 dm2.week-1 was achieved without nitrogen fertilizer or phosphorus fertilizer. This is because the role of these two elements is very important to maintain leaf chlorophyll. According to Gardner (1997) the role of nitrogen is as one of the chlorophyll formation materials and the role of phosphorus is to play a role in the light reaction of the photosynthesis process, precisely in the photophosphorylation process, namely the formation of ATP. ATP is an energy-rich chemical compound that functions as energy for the next process which is the dark reaction.

Net assimilation rate (NAR) is the production of dry matter per unit of leaf area per unit time. This gives an understanding that leaves and light are the determining factors in the formation of assimilation results. The wider the leaf and the more light that can be absorbed, the higher assimilation will be produced. The NAR will increase when all leaves intercept the light and are not shaded by other leaves.

The results of data analysis (Table 4) showed that the nitrogen application can increase the NAR, but the phosphorus application did not increase the NAR. According to Gardner (1997) nitrogen is a raw material for assimilation, the more nitrogen increases the NAR will increase. NAR correlates positively with LAI (0, 311*) but does not correlate significantly with LAD (0.211ns) (Table 5). Aziez et al. (2019) reported that VAM application increases LAI, LAD, and NAR.

Table 4. Leaf area index, leaf area duration, and net assimilation rate as affected by nitrogen dosage and phosphorus dosage with applications of Vesicular Arbuscular Mycorrhiza on Rainfed Lowland Rice

Dosage of nitrogen (kg/ha)	Dosage of phosphorus (kg/ha)	Leaf Area Index	Leaf Area Duration (dm^2/week)	Net Assimilation Rate (x 10^{-6} mg/cm^2/day)
0	0	0,874 d	1.269 g	2.622 a-c
	25	1,393 a-d	2.315 c-f	1.968 bc
	50	1,008 cd	1.611 fg	2.205 bc
	75	1,607 ab	1.890 eg	1.298 c
45	0	1,099 b-d	1.930 d-g	3.140 a-c
	25	1,264 a-d	2.399 b-f	3.195 a-c
	50	1,160 a-d	2.434 b-f	2.470 a-c
	75	1,286 a-d	2.689 a-e	2.494 a-c
90	0	1,494 a-c	3.198 a-c	2.313 a-c
	25	1,454 a-d	2.832 a-d	3.331 a-c
	50	1,715 a	3.457 a	3.817 ab
	75	1,649 ab	3.300 ab	3.116 a-c
135	0	1,002 cd	3.279 ab	1.820bc
	25	1,639 ab	2.978 a-c	3.714 ab
	50	1,494 a-c	3.143 a-c	4.311 a
	75	1,516 a-c	3.426 a	2.971 a-c

Remarks: The numbers in the same column followed by the same letter are not significantly different according to DMRT 5%

Table 5. The correlation analysis between Leaf Area Index, Leaf Area Duration, and Net Assimilation Rate as affected by nitrogen dosage and phosphorus dosage with applications of Vesicular Arbuscular Mycorrhiza on Rainfed Lowland Rice

Yield component	Leaf Area Index	Leaf Area Duration	Net Assimilation Rate
Leaf Area Index	0	0,791**	0,311*
Leaf Area Duration	0,791**	0	$0{,}211^{ns}$
Net Assimilation Rate	0,311*	$0{,}211^{ns}$	0

Note : * = significant different, ** = very significant different, ns= non significant

Yield Components

In the 1000 grains weight parameters there is no interaction between the dose of nitrogen with the dose of phosphorus given. Increasingly the nitrogen and phosphorus dosages given to the mycorrhizal land will not increase the weight of 1000 grains (Table 6). The weight of 1000 grains is influenced by the genetic characteristics of a variety compared to environmental characteristics including fertilizer application. this is supported by Horie et al. (2006) that the weight of 1000 grains tends to be influenced by genetic factors of a variety compared to environmental factors. Weight of 1000 grains reflected the size of quality, i.e. high grain yields are usually small sized but available in large quantities.

Based on data analysis, there is no interaction between the dose of nitrogen and the dose of phosphorus in grain yield per plot. The highest grain yield per plot was achieved with a nitrogen dose of 90 kg / ha and was no different from a dose of 45 kg/ha and 135 kg/ha (Table 6). A nitrogen dosage of 45 kg/ha is no different from no nitrogen fertilizer. This means that the use of mycorrhizae provides enough nitrogen fertilizer at a dose of 45-90 kg / ha. This is supported by and Puspita (2008) mycorrhizal dose of 40 g/polybag in podzolik acid red soil yellow tends to increase soybean growth and yield. Nyimas et al. (2011) states that mycorrhizae have the ability to help host plants absorb nutrients needed for photosynthesis while plants provide photosynthates for the survival of mycorrhizal fungi. Mycorrhizal fungi inoculation can increase N and P nutrient uptake in soybean plants (Mieke et al., 1999), increase P uptake in wheat (Li et al., 2012), increase the efficiency of P fertilizer use and reduce the application of lime to acid soils, and increase crop yields of soybeans, peanuts, green beans, corn, and sweet potatoes (Simanungkalit, 1999). Novriani and Majid (2009) stated that the use of mycorrhizae as a biological fertilizer containing microorganisms would greatly help the process of reducing nutrients absorbed in colloidal soils due to low pH or Al and Fe activity. In the long term the administration of mycorrhizae provides great benefits for soil fertility.

Based on data analysis, there is no interaction between the dose of nitrogen and the dose of phosphorus in grain yield per hectare. The highest grain yield per hectare was achieved with a nitrogen dose of 90 kg / ha and was no different from a dose of 45 kg / ha and 135 kg / ha (Table 6). A nitrogen dose of 45 kg / ha is no different from no nitrogen fertilizer. This is consistent with the role of nitrogen in the photosynthesis process. The more the photosynthesis process increases, the better the growth, the result will be good too.

In the treatment of phosphorus doses, there is no difference in grain weight per hectare at the same nitrogen dose. This is because the land has been given mycorrhizae that can help phosphorus uptake. Kafle et al. (2019) states that the plant's P needs are derived from soil solutions through plant roots especially through root hairs in symbiosis with mycorrhizal fungi

There was a positive correlation between the weight of 1000 grains with grain yields per plot (r = 0.791 **) and grain yields per hectare (r = 0.311 *) (Table 6.). The weight of 1000 grain is related to the size of the seeds, the larger the size of the seeds, it will increase the weight of grain per plot, also the weight of grain per hectare. This is in line with the research of Aziez et al. (2018).

Table 6. Weight of 1000 grains, grain yields per plot, and grain yields per hectare as affected by nitrogen dosage and phosphorus dosage with applications of Vesicular Arbuscular Mycorrhiza on Rainfed Lowland Rice

Dosage of nitrogen (kg/ha)	Dosage of phosphorus kg/(ha)	Weight of 1000 grains (g)	Grain yields per plot (kg)	Grain yields per hectare (ton)
0	0	22,33 a	523,3 bc	2.181 bc
	25	21,67 a	510,0 c	2.125 c
	50	26,67 a	786,7 a-c	3.277 a-c
	75	20,00 a	556,7 a-c	2.319 a-c
45	0	19,67 a	767,3 a-c	3.197 a-c
	25	25,00 a	701,0 a-c	2.920 a-c
	50	19,33 a	768,3 a-c	3.201 a-c
	75	21,33 a	768,7 a-c	3.202 a-c
90	0	18,67 a	847,0 a-c	3.529 a-c
	25	19,67 a	961,3 ab	4.006 ab
	50	20,67 a	729,3 a-c	3.039 a-c
	75	22,67 a	926,7 a-c	3.861 a-c
135	0	18,33 a	940,0 a-c	3.917 a-c
	25	21,33 a	874,7 a-c	3.644 a-c
	50	29,33 a	659,7 a-c	2.749 a-c
	75	19,33 a	988,0 a	4.118 a

Remarks: The numbers in the same column followed by the same letter are not significantly different according to DMRT 5%

Table 7. The correlation analysis between weight 1000 grains, grain yields per plot, and grain yields per hectare as affected by nitrogen dosage and phosphorus dosage with applications of Vesicular Arbuscular Mycorrhiza on Rainfed Lowland Rice

Yield component	Weight 1000 grains	Grain yields per plot	Grain yields per hectare
Weight 1000 grains	0	0,791**	0,311*
Grain yields per plot	0,791**	0	0,211ns
Grain yields per hectare	0,311*	0,211ns	0

Note : * = significant different, ** = very significant different, ns= non significant

Conclusions

It can be concluded that "the Nutrient Uptake, Physiological Characters, and Yield Components of Situbagendit Rice Variety on Nitrogen and Phosphor Dosage with Applications of Vesicular Arbuscular Mycorrhiza on Rainfed Lowland Rice" a.i. Nitrogen fertilization at 135 kg / ha increases nitrogen, phosphorus and potassium uptake and there is a correlation between nitrogen, phosphorus and potassium uptake. Starting with a nitrogen dose of 90 kg / ha increases the Leaf area duration and there is a correlation between LAI, LAD and NAR. Phosphorus fertilization at a dose of 50 kg / ha increases grain weight per plot and per hectare and there is a correlation between the weight of 1000 grain, grain weight per plot and grain weight per hectare.

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