Original Research Article

Influence of different levels of Phosphorus and Potassium in combination with biofertilizers on growth of Cowpea [*Vigna unguiculata* (L.) Walp]

Abstract

During the kharif season of 2018, a field experiment titled "Influence of different levels of Phosphorus and Potassium in combination with biofertilizers on the growth of Cowpea [*Vigna unguiculata* (L.) Walp]" was carried out at the crop research farm of the Division of Agronomy, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir. The soil in the experimental field had the texture of clay loam, was neutral in reaction (pH = 6.9), had low available nitrogen, low available phosphorus, medium available potassium, and medium organic carbon.The experiment was laid in RBD design having nine treatments and threereplications. The results of the experiment revealed that the growth of the crop was significantlyinfluenced by different treatments and among different treatments, application of RDF (30 N, 60P_2O_5, 30 K_2O) kg ha^{-1}+ seed inoculation with PSB + KSB significantly recordedmaximum plant height (86.18 cm), leaf area index(3.62), dry matter production (16.20 q ha^{-1}) and it also significantly increased the numberofeffectiverootnodulesperplantofcowpea.

Keywords: Cowpea, growth, biofertilizers, root nodules, phosphorus, potassium

Introduction

Pulses are produced on 28.14 million hectares in India, with an annual yield of 21.93 million tonnes and an average productivity of 780 kg ha^{-1} (Agricultural Statistics at a Glance, 2021). Pulses are farmed on 16.14 thousand hectares in J&K, with an annual yield of 101 thousand quintals (DES, 2020-21).

Pulses are a key source of dietary protein, and they have the unique potential to maintain and restore soil fertility through biological nitrogen fixation and the addition of a large number of residues to the soil. Pulse crops leave a good amount of nitrogen in the soil, up to 30 kg ha^{-1} (Reddy and Reddy, 2010). Cowpea [*Vigna unguiculata* (L.)], also known as lobia in India, is a major Kharif pulse crop produced for vegetable, grain, fodder, and green manuring. It is known as vegetable meat since it is high in protein and contains a variety of other nutrients. The crop produces so much vegetative growth and covers the ground that it prevents soil erosion in trouble areas and may subsequently be harvested for green manure.

Nutrients have a critical function in improving pulse seed yield. Phosphorus, like nitrogen, is a vital nutrient. The available phosphorus in Indian soils ranges from low to medium. Only around 30% of applied phosphorus is available to crops, with the remainder transformed to insoluble phosphorus. Its shortage is the most critical single factor causing low cowpea production on all types of soils. Phosphorus and potassium are two of the most important macronutrients for plant growth and development, and soluble P and K fertilisers are often used to restore lost minerals and increase output (Han and Lee, 2006).Phosphorus is the second most essential plant nutrient overall, but it is especially vital for pulses due to its function in root multiplication and hence atmospheric nitrogen absorption. Phosphorus is a component of ATP and ADP and is involved in metabolic and enzymatic reactions (Singh and Ali, 1994). Potassium is rarely given to pulse crops due to high K content in soils, particularly soils with high K-bearing clay minerals such as illite (Pasricha and Bahl, 1996). Potassium application controls the use of other nutrients in the plant system.

Biofertilizers are preparations containing live or latent cells of efficient strains of nitrogen fixing, phosphate solubilizing, or cellulolytic microorganisms used for application to seed or composting areas with the goal of increasing the number of such microorganisms and accelerating those microbial processes that augment the availability of easily assimilated nutrients by plants. Biofertilizers are capable of solubilizing rock K and converting insoluble rock P material into soluble forms suitable for plant development. Seed inoculation with PSB culture boosts mung bean green pod production above uninoculated control (Vaisya *et al.* 1983).Phosphate-solubilizing bacteria are both aerobic and heterotrophic. Many microorganisms have been investigated, and inoculants of Bacillus megatherium, Pseudomonas straita, Pseudomonas extremorientalis, and Bacillus polymixa have been shown to be acceptable and readily accessible for seed inoculation. These bacteria solubilize phosphate in the soil, making it available to plants for healthy development. They can solubilize 20-30% of insoluble phosphate and may boost crop production by 10-30% under favourable conditions (Tilak and Annapurna, 1993).As a result, seedlings infected with phosphate and potassium solubilizing bacteria inoculants may save a significant amount of administered phosphorus and potassium. Mineral potassium solubilization by microorganisms, which improves crop development and production when combined with a less expensive supply of rock potassium, may be more helpful and environmentally practicable than soluble K. (Rajan *et al.* 1996).

The information on the combined influence of phosphorus and potassiumwithbacterialinoculationismeagerandverylittleworkhasbeendoneintemperatehilly region ofKashmir. Thereforean experiment "**Influence of different levels of Phosphorus and Potassium in combination with biofertilizers on growth of Cowpea [*Vigna unguiculata* (L.) Walp]"** wasconductedatWaduraCampusof Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir.

Materials and Methods

The experimentwasconductedatCropResearch FarmofDivision ofAgronomy, Faculty of Agriculture Wadura Sopore, Sher-e-Kashmir University ofAgricultural Sciences & Technology of Kashmir during *Kharif* 2018. Climatically the experimental site falls in temperate zone of ~~north western~~north-westernHimalayacharacterizedbyhotsummersandverycoldwinters. the soil of the experimental field was clay loam in texture, medium inorganiccarbon,lowinavailablenitrogen,lowinavailablephosphorusandmediuminavailablepotassium with neutralpH. The experiment comprised of nine treatment combinations *viz.*, T_1: (Control), T_2: (PSB+KSB), T_3: 100%RDF(30N,60P_2O_5,30K_2O)kgha^{-1}, T_4: 100% (P_2O_5, K_2O) of RDF + seed inoculation with PSB, T_5: 100% (P_2O_5, K_2O) of RDF + seed inoculation with KSB, T_6: 100%(P_2O_5,K_2O)+seedinoculationwithPSB+KSB, T_7: 100%P_2O_5+75%K_2OofRDF+seedinoculationwithKSB, T_8: 75%P_2O_5+100%K_2OofRDF+seedinoculationwithPSB and T_9: 75%(P_2O_5,K_2O)ofRDF+seedinoculationwithPSB+KSB. The experiment was laid out in RBD. The test variety used in the experiment was Shalimar Cowpea-1.

Plant height was measured at 20-day intervals from the base of the plant to the apex of the flag leaf on five randomly selected and marked plants in each plot (5 each in the penultimate rows of a plot). The height was calculated as an average and reported in cm. The leaf area of five randomly selected plants from each plot at 20-day intervals was calculated as a ratio of total leaf area to total land area. Two plants in each plot were removed from the ground and gathered at 20-day intervals from the planting date to the harvesting stage. After sun drying for 4-5 days, the plant samples were oven dried to a consistent weight at 60-65degrees Celsius.The dry weight of plant samples was measured in grammes and then converted to q ha^{-1}. In each plot, five plants were chosen at random during maximum flowering and skillfully uprooted in wet soil. Water was used to wash away the soil mass that contained the plant roots. The number of healthy pink nodules was counted, and the mean value was recorded as the effective number of nodules plant^{-1}.

Results and Discussion

Table 1 shows the data on cowpea plant height at 20-day intervals during the trial. The gradual increase in plant height as influenced by various experimental treatments is likewise graphically illustrated in Fig. 1. The use of RDF (30 N, 60 P_2O_5, 30 K_2O) kg ha^{-1}+ seed inoculation with PSB + KSB significantly increased maximum plant height (86.18 cm) compared to other treatments.The harvest stage of the control treatment had the shortest plant height (73.18 cm). A significant effect on the increase in plant height in cowpea with the application of NPK may be attributed to the fact that nitrogen, as an essential constituent of plant tissue, favours rapid cell division and enlargement, which, together with an adequate amount of phosphorus and potassium, aids in rapid cell division and cell size development.A larger population of the targeted organisms means more chances of infection and, as a result, the creation of more healthy and effective root nodules with higher leghaemoglobin content. As a result of the improved soil environment, plant roots proliferated, allowing them to draw more water and nutrients from deeper layers. As a result of the increased availability of nutrients, synthesis of more carbohydrates and their translocation to different plant parts resulted in increased vegetative growth, including reproductive structures.These results corroborate with the findingsof Sammauria *et al.* (2009)and Choudhary and Yadav(2011).FurthermicroorganismsenhancethePavailabilitytoplantsbymineralizing organic P in soil and by solubilizing precipitated phosphates (Kang*etal*.,2002).TheresultsareinaccordancewiththefindingsofPinjari(2007).

Table 2 shows that the data on cowpea leaf area index at 20-day intervals was significantly affected by different treatments, except at 20 days after sowing. Fig. 2 graphically depicts the gradual rise in leaf area index as impacted by various treatments. The leaf area index grew until 80 days after seeding, when it began to decline. The application of RDF (30N, 60 P2O5, 30 K2O) kg ha-1 + seed inoculation with PSB + KSB resulted in a significantly higher leaf area index (3.62) at 80 days after sowing than the other treatments.The lowest LAI (2.14) was reported in the control treatment at 80 days after planting. Nitrogen is a necessary component of proteins, enzymes, and cholorophyll, and it has been shown to impact leaf development and expansion, resulting in an enhanced leaf area index. The availability of an appropriate amount of phosphorus in plants results in improved effectiveness of chlorophyll during photosynthesis, which leads to improved plant development. Adequate potassium availability is critical for improved crop development and enhances the source-sink relationship, resulting in increased agricultural production. Potassium is an enzyme cofactor that aids in the translocation mechanism and increases the mobility and usage of other elements.Seed inoculation with PSB and KSB increases soil physicochemical and biological qualities while also releasing suitable amounts of phosphate and potassium. The findings are consistent with those of Rasool *et al.* (2015). Furthermore, the leaf area index was maximum at 80 DAS and thereafter dropped till harvest.Table 3 and Fig. 3 show the treatment effects on dry matter accumulation q ha^{-1} at 20-day intervals of growth at 20, 40, 60, 80, and 100 days after planting and harvest. Data analysis revealed that dry matter production increased with crop development up to harvest, with the amount of increase more than doubling from 40 to 60 days following planting in all treatments. When compared to other treatments, the application of RDF (30N, 60 P_2O_5, 30 K_2O) kg ha^{-1} + seed inoculation with PSB + KSB resulted in the highest dry matter yield (16.20 q ha^{-1}).However, the control treatment recorded the least amount of dry matter (10.68 qha^{-1}). The rise in periodic dry matter accumulation with nitrogen management approaches may be linked to an increase in plant height and leaf area index, which resulted in greater light interception by crop, accumulating more photosynthates and so producing more dry matter. Furthermore, seed inoculation with PSB and KSB may have boosted nutrient availability, notably phosphorus and potassium, as well as delivered the minerals in a balanced proportion, which improved the physical characteristics. Choudhary and Yadav (2011) and Jat *et al.* (2013) also observed similar findings.The findings in Table 4 show that with the application of different fertility levels, there was a significant increase in the number of effective root nodules per plant of cowpea. However, the treatment 100% RDF + seed inoculation with PSB + KSB recorded significantly more effective nodules plant-1 than the other treatments. The rise in the number of nodules $plant^{-1}$ might be attributed to an increase in phosphorus, potassium, and PSB and KSB inoculation. These findings are consistent with those of Patel *et al.* (2007), and Navsare *et al.* (2016).

Conclusion

It is evident from the results that thatthe application of 100%RDF (30N. $60P_2O_5$, $30K_2O$) kg ha^{-1}+ seed inoculation with PSB + KSB recorded significantly higher growth parameters *viz.*, plant height, leaf area index and dry matter accumulation and also effective root rootnodules per plant. So it is concluded that for obtaining the higher growth of maize it should be applied with 100%RDF (30N. $60P_2O_5$, $30K_2O$) kg ha^{-1}+ seed inoculation with PSB + KSB.

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Table1:Effectofdifferentfertilitylevelsonplantheight(cm)at20daysintervalofcowpea.

TREATMENTS	**Daysaftersowing**					
	20	**40**	**60**	**80**	**100**	**Harvest**
Control	10.29	17.42	37.28	62.23	71.45	73.18
PSB+KSB	10.56	17.63	37.98	63.21	72.44	74.66

100%RDFP&K	11.63	19.02	39.76	65.52	75.13	77.18
100%RDFP&K+PSB	12.16	20.38	40.06	67.57	77.83	79.30
100%RDFP&K+KSB	12.27	20.12	40.19	67.54	77.97	79.36
100%RDF+PSB+KSB	13.63	21.85	43.78	70.23	85.47	86.18
100%P+75%K+KSB	11.21	19.21	39.50	65.60	75.83	77.44
75%P+100%K+PSB	11.16	19.12	39.85	65.61	75.02	77.15
75%P&K+PSB+KSB	10.87	18.45	38.33	64.49	74.34	75.21
SEm±	**0.34**	**0.41**	**0.47**	**0.56**	**0.63**	**0.91**
C.D(p≤0.05)	**1.02**	**1.25**	**1.39**	**1.70**	**1.90**	**2.76**

Table2:Effectofdifferentfertilitylevelsonleafareaindexofcowpeaat20daysinterval

TREATMENTS	**Daysaftersowing**					
	20	**40**	**60**	**80**	**100**	**Harvest**
Control	0.13	0.82	1.48	2.14	1.93	1.75
PSB+KSB	0.14	1.35	1.86	2.55	1.95	1.78
100%RDFP&K	0.16	1.79	2.12	3.05	2.46	2.34
100%RDFP&K+PSB	0.17	1.82	2.20	3.11	2.58	2.46

100%RDFP&K+KSB	0.17	1.81	2.19	3.08	2.55	2.43
100%RDF+PSB+KSB	0.19	1.96	2.81	3.62	3.04	2.96
100%P+75%K+KSB	0.15	1.62	2.04	2.84	2.34	2.12
75%P+100%K+PSB	0.14	1.61	2.03	2.82	2.31	2.11
75%P&K+PSB+KSB	0.14	1.54	1.96	2.79	2.13	1.96
SEm±	**0.011**	**0.025**	**0.139**	**0.095**	**0.216**	**0.019**
C.D($p \leq 0.05$)	**NS**	**0.075**	**0.422**	**0.287**	**0.635**	**0.057**

Table3:Effectofdifferentfertilitylevelsondrymatteraccumulationofcowpea(q ha^{-1})

TREATMENTS	**Daysaftersowing**					
	20	**40**	**60**	**80**	**100**	**Harvest**
Control	0.22	3.11	8.51	10.62	11.38	11.68
PSB+KSB	0.22	3.18	8.72	10.87	11.53	11.75
100%RDFP&K	0.23	4.14	10.28	12.53	14.14	14.48
100%RDFP&K+PSB	0.24	4.25	10.53	12.81	14.72	14.87

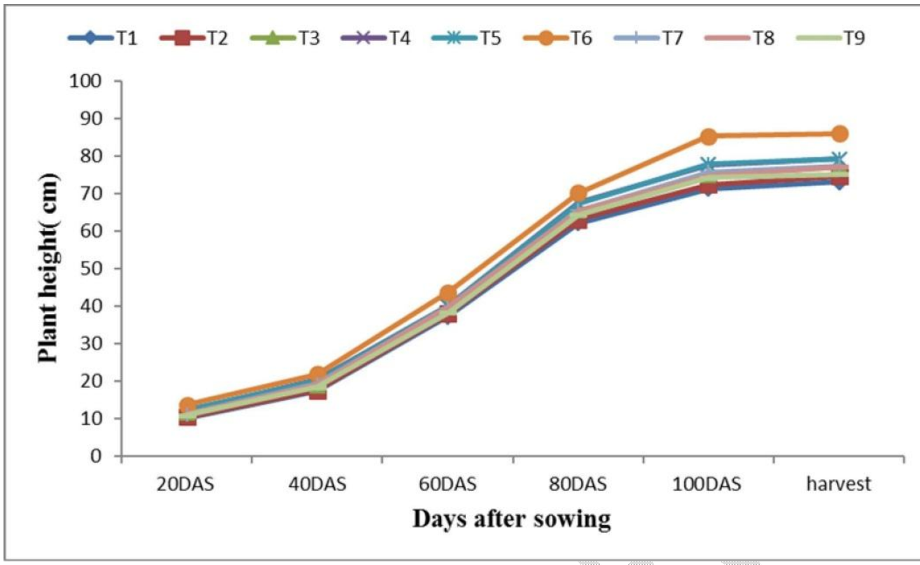
100%RDFP&K+KSB	0.25	4.21	10.51	13.79	14.69	14.83
100%RDF+PSB+KSB	0.26	5.11	11.56	13.96	15.96	16.20
100%P+75%K+KSB	0.25	3.87	10.14	11.99	13.60	13.73
75%P+100%K+PSB	0.23	3.85	10.14	11.94	13.54	13.69
75%P&K+PSB+KSB	0.23	3.71	9.74	11.55	13.48	13.55
SEm±	**0.02**	**0.27**	**0.31**	**0.36**	**0.66**	**0.42**
C.D(p≤0.05)	**NS**	**0.84**	**0.96**	**1.09**	**1.19**	**1.28**

Table4:Effectofdifferentfertilitylevelsontotalandeffectiveroot nodulesat flowering stageofcowpea

Treatments	Totalrootnodules	Effectiverootnodules
Control	12.14	8.63
PSB+KSB	12.40	8.68
100%RDF(P&K)	17.00	12.28

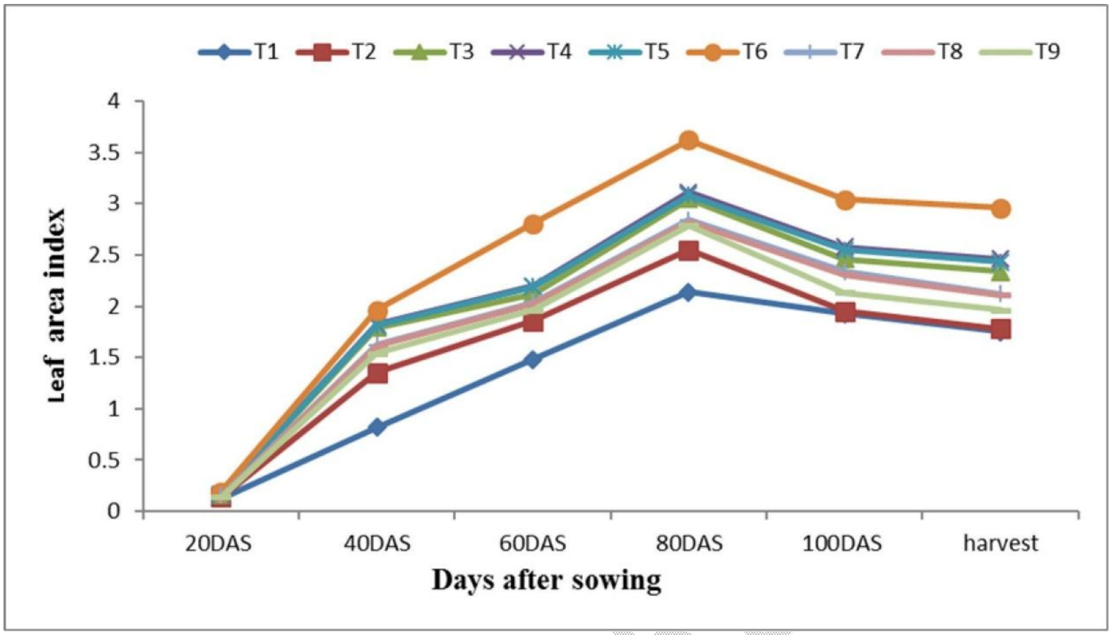
100%RDF(P&K)+PSB	21.00	16.28
100%RDF(P&K)+KSB	21.15	16.21
100%RDF(P&K)+PSB+KSB	24.96	20.58
100%P+75%K+KSB	16.55	11.23
75%P+100%K+PSB	16.48	11.44
75%(P&K)+PSB+KSB	16.98	11.10
SEm±	0.27	0.12
C.D($p \leq 0.05$)	**0.82**	**0.37**

Fig.1:Influenceofdifferentfertilitylevelsonplantheight(cm)ofcowpeaatdifferent intervals (DAS)



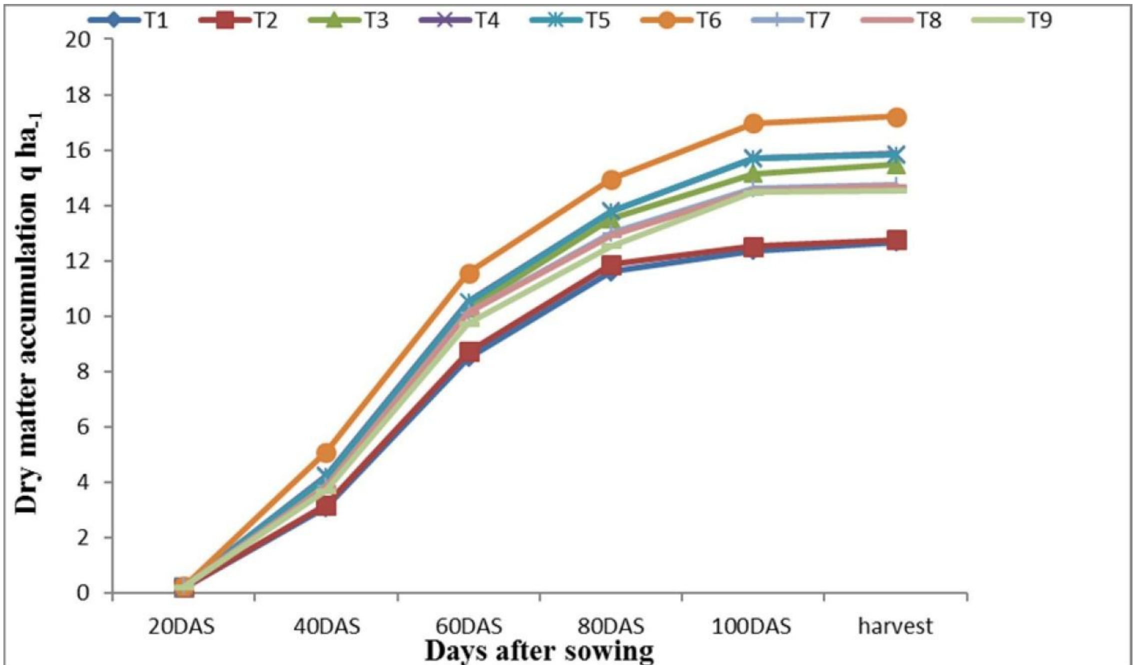
T_1: (Control), T_2: (PSB+KSB), T_3: 100%RDF(30N,60P_2O_5,30K_2O)kgha^{-1}, T_4: 100% (P_2O_5, K_2O) of RDF + seed inoculation with PSB, T_5: 100% (P_2O_5, K_2O) of RDF + seed inoculation with KSB, T_6: 100%(P_2O_5,K_2O)+seedinoculationwithPSB+KSB, T_7: 100%P_2O_5+75%K_2OofRDF+seedinoculationwithKSB, T_8: 75%P_2O_5+100%K_2OofRDF+seedinoculationwithPSB and T_9: 75%(P_2O_5,K_2O)ofRDF+seedinoculationwithPSB+KSB.

Fig.2:Influenceofdifferentfertilitylevelsonleafareaindexofcowpeaatdifferentintervals(DAS)



T_1: (Control), T_2: (PSB+KSB), T_3: 100%RDF(30N,60P_2O_5,30K_2O)kgha^{-1}, T_4: 100% (P_2O_5, K_2O) of RDF + seed inoculation with PSB, T_5: 100% (P_2O_5, K_2O) of RDF + seed inoculation with KSB, T_6: 100%(P_2O_5,K_2O)+seedinoculationwithPSB+KSB, T_7: 100%P_2O_5+75%K_2OofRDF+seedinoculationwithKSB, T_8: 75%P_2O_5+100%K_2OofRDF+seedinoculationwithPSB and T_9: 75%(P_2O_5,K_2O)ofRDF+seedinoculationwithPSB+KSB.

Fig.3:Influenceofdifferentfertilitylevelondrymatteraccumulationofcowpea (qha^{-1})



T_1: (Control), T_2: (PSB+KSB), T_3: 100%RDF(30N,60P_2O_5,30K_2O)kgha^{-1}, T_4: 100% (P_2O_5, K_2O) of RDF + seed inoculation with PSB, T_5: 100% (P_2O_5, K_2O) of RDF + seed inoculation with KSB, T_6: 100%(P_2O_5,K_2O)+seedinoculationwithPSB+KSB, T_7: 100%P_2O_5+75%K_2OofRDF+seedinoculationwithKSB, T_8: 75%P_2O_5+100%K_2OofRDF+seedinoculationwithPSB and T_9: 75%(P_2O_5,K_2O)ofRDF+seedinoculationwithPSB+KSB.